# Proceedings
# of the 59th Annual
# Western Forest Insect Work Conference

## Boulder, Colorado

## April 7-10, 2008

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### Executive Committee

| | |
|---|---|
| Peter Hall | Chair |
| Bruce Hostetler | Acting Secretary |
| Karen Ripley | Treasurer |
| Joel McMillin | Councilor |
| Bill Riel | Councilor |
| Danny Cluck | Councilor |

### Organizational Standing Committees

| | | |
|---|---|---|
| Brytten Steed | Co-Chair | Common Names Committee |
| Ken Gibson | Chair | Founders Award Committee |
| Darrell Ross | Chair | Memorial Scholarship Committee |
| Boyd Wickman | Co-Chair | History Committee |
| Kimberly Wallin | Chair | Memorial Scholarship Fundraising Committee |

### Bolder Conference

| | |
|---|---|
| Program Coordinator | Tom Eager |
| Local Arrangements | Sheryl Costello |
| Registration Coordinator | Ingrid Aguayo |
| Field Trip | Jeff Witcosky |
| | Bob Cain |
| Silent Auction | Steve Cook |
| | Kimberly Wallin |
| Technical Assistance | Brian Howell |
| Poster Session | Leanne Egeland |
| Photographs | Bill Ciesla |
| | Ron Billings |

**The contents of these proceedings are not available for citation or publication without consent of the author. Articles were reformatted but printed approximately as submitted. Authors are responsible for content.**

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# Conference Schedule

| Date | Time | Activity/Title | Moderator |
|---|---|---|---|
| **April 7 (Mon.)** | **15:00 - 20:00** | **Registration** | |
| | **17:00 - 18:00** | **Executive Committee Meeting** | **Peter Hall** |
| | **19:00 - 21:00** | **Opening Mixer** | |
| **April 8 (Tues.)** | **07:00 - 16:45** | **Registration** | |
| | **08:00 - 08:15** | **Welcome to Boulder** | **Sheryl, Ingrid, Tom** |
| | **08:15 - 09:15** | **Initial Business Meeting** | **Peter Hall** |
| | **09:15 - 09:45** | **A Look Back** | **Bob Averill** |
| | **09:45 - 10:15** | **Morning Break/ (Group Photos, B. Schaupp)** | |
| | **10:15 - 10:45** | **Forestry in Colorado: Issues, Challenges, and Opportunities** | **Joe Duda** |
| | **10:45 - 11:20** | **Scholarship Presentation**<br>*Impacts of Thinning Ponderosa Pine on Pine Bark Beetles in Northern Arizona* | **Monica Gaylord** |
| | **11:20 - 12:00** | **Lessons Learned By a Not-So-Old Forest Entomologist** | **John Borden** |
| | **12:00 - 13:30** | **Lunch (On your own)** | |
| | **13:30 - 15:00** | **Breakout I** | |
| | | *1. Assessing the Economic, Ecological and Social Costs of Doing Nothing With Respect to Bark Beetle Outbreaks* | *Andy Eglitis* |
| | | *2. Invasive Forest Insects* | *Bob Rabaglia* |
| | | *3. Western Forest Defoliators* | *Darren Blackford* |
| | | *4. The Interface of Atmospheric Processes and Forest Health* | *Steve Seybold, Iral Ragenovich* |
| | **15:00 - 15:30** | **Afternoon Break / (Group Photos, B. Schaupp)** | |
| | **15:30 - 16:45** | **Graduate Student Presentations** | **Steve Seybold**<br>**Ken Raffa** |
| | **17:00 - 18:00** | **Fun Run** | |
| | **18:00 - 21:00** | **Banquet & Founders Award** | **Boyd Wickman** |

Locations for breakout sessions correspond to the number in front of the session name:
1. Canyon ½ Room 2. Flagstaff Room 3. Trailridge Room 4. Millennium Room

# 2008 WFIWC Schedule (cont.)

| Date | Time | Activity/Title | Moderator |
|---|---|---|---|
| **April 9 (Wed.)** | **07:00 - 9:30** | **Registration** | |
| | **08:00 - 09:30** | **Plenary Session: Bark Beetles, Fuels, and Fire Behavior and Implications for Management** | **Liz Hebertson** |
| | **09:30 - 10:00** | **Morning Break/ (Group Photos, B. Schaupp)** | |
| | **10:00 - 12:00** | **Field Trip to Rocky Mountain Nat'l Park** | |
| | **12:00 - 13:00** | **Lunch (Provided)** | |
| | **13:00 - 17:00** | **Field Trip to Rocky Mountain Nat'l Park** | |
| | **17:00 - 19:00** | **Dinner (On Your Own)** | |
| | **19:00 - 21:00** | **Poster Session, Silent Auction, and Forest Entomology Films** | |
| **April 10 (Thur.)** | **08:00 - 10:00** | **Registration** | |
| | **08:30 - 10:00** | **Plenary Session: The Shifting Status of Aspen throughout the West** | **Susan Gray** |
| | **10:00 - 10:30** | **Morning Break / (Group Photos, B. Schaupp)** | |
| | **10:30 - 12:00** | **Breakout Session II** | |
| | | *1. Verbenone Discussion Group* | *Ken Gibson* |
| | | *2. Wood borers: Trapping Studies and Identification Aids* | *Andy Eglitis* |
| | | *3. Getting the Message Across: Media and Education* | *Dave Steinke, Shawna Crocker* |
| | | *4. Insect-Microbial Symbiosis* | *Diana Six, Ken Raffa* |
| | **12:00 - 13:30** | **Lunch (On your own)** | |
| | **13:30 - 14:30** | **Final Business Meeting** | **Peter Hall** |
| | **14:30 - 15:00** | **Afternoon Break** | |
| | **15:00 - 16:30** | **Breakout Session III** | |
| | | *1. Molecular Techniques and Forest Insects* | *Chris Keeling* |
| | | *2. Remote Sensing* | *Jim Ellenwood* |
| | | *3. Native Plant and Invasive Plant Biological Control* | *Carol Randall* |
| | | *4. Bark Beetle Research Update* | *Dan Miller, Brytten Steed* |
| | **16:30** | **Conference Adjourns** | |
| | **17:00** | **Brewery Tour and Dinner** | |

# Meeting Notes

## Executive Committee Meeting Minutes
## 7 April 2008

The Committee Chair, **Peter Hall,** called the Executive Committee meeting to order at 5:00 pm.

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Attendees:
Peter Hall, Chair
Bruce Hostetler, Acting Secretary
Karen Ripley, Treasurer
Joel McMillin, Councilor
Bill Riel, Councilor
Brytten Steed, Co-Chair, Common Names Committee
Ken Gibson, Chair, Founders Award Committee
Darrell Ross, Past Chair & Chair, Memorial Scholarship Committee
Boyd Wickman, Co-Chair, History Committee
Tom Eager, Chair, 2008 WFIWC Program Committee

The minutes of the 2007 Executive Committee Meeting were read by Acting Secretary Bruce Hostetler. A motion to approve the minutes was made by Tom Eager, seconded by Peter Hall.

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The Committee had a short discussion concerning future joint work conferences with the plant pathologists. It seems that members in both groups are split between continuation of joint meetings in the future. Peter Hall made a motion to let the issue lie until the pathologists approached us with a proposal to have a joint meeting. The motion was seconded by Brytten Steed and approved unanimously.

We need nominees for Conference Chair and for Councilor vice Danny Cluck. Tom Eager and Darrell Ross will chair an ad hoc Nomination Committee for the Chair, and Joel McMillan will chair the ad hoc Nomination Committee for the Councilor position. They will have names of nominees to present at the Final Business Meeting.

Treasurer Karen Ripley read the Financial Report and submitted it to the Executive Committee (**full report is included after the Initial Business Meeting minutes**).

Karen brought up the issue of whether we should list U.S. Federal Tax Information Number on the WFIWC website. That number is needed by U.S. federal employees to pay the registration fee. After some discussion, it was decided that Karen will work with Kathy Sheehan to make it available in a secure manner.

Karen also reported that the new U.S. tax laws require WFIWC to file a tax return each year. This will be additional work for the Treasurer, and could be much more work depending upon the IRS requirements. Karen will check with IRS to see what the requirements are and will fill out this year's return. This will be revisited next year, to determine if the Treasurer might need some additional assistance.

Bill Riel moved to accept treasurer's financial report. Ken Gibson seconded the motion and it was approved unanimously.

The Chair and Councilors will meet with the Treasurer at 5:00 pm on Wednesday to audit the books, and there will be an Executive Committee meeting following.

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**Committee Reports**

**2008 WFIWC Program Committee.** Tom Eager, Committee Chair, indicated that everything is going well for this year's meeting. There has been a scramble for speakers. We have a full agenda for this year's WFIWC. They decided to reduce the number of concurrent sessions, and add some sessions to discuss current Forest Health issues in Colorado. We also will have a field trip to Rocky Mountain National Park. The requirements for number of room rentals in the hotel have been met. Final number of attendees is not in, but appears to be approaching 150. The Conference will come out in black for the 2008 meeting.

**- Founder's Award Committee.** Committee Chair Ken Gibson read and submitted the committee report (**full report is included after the Initial Business Meeting minutes**). The 2008 Founder's Award recipient is Ladd Livingston. Boyd Wickman, the 2007 recipient, will give the Founder's Award address tomorrow. New chair of the committee is Barbara Bentz. There is a need to replace two of the committee member, Barbara Bentz and Staffan Lindgren, this year.

**- Memorial Scholarship Committee.** Darrell Ross, Committee Chair, read and submitted the committee report (**full report is included after the Initial Business Meeting minutes**). Monica Gaylord received the 2007 Memorial Scholarship and will give her presentation at this meeting. There were nine applicants for the award this year. There were highly qualified applicants and the decision was a difficult one. The 2008 Scholarship recipient is Greg Smith; a student working with Staffan Lindgren and Allan Carroll. Brytten Steed made a motion to accept the report. Tom Eager seconded the motion and it was approved unanimously

**- Memorial Scholarship Fundraising Committee.** No report submitted. Steve Cook will be coordinating the silent auction at this meeting.

**- Common Names Committee.** Brytten Steed, Committee Co-chair, gave a summary of this year's committee report (**full report is included after the Initial Business Meeting minutes**). Six new proposals for common names have been submitted to the Entomological Society of America. Of the eleven proposals previously submitted, eight were accepted and three were rejected. The Committee wants people to look at the names in specific groups and come up with proposals for the common names of all appropriate insects within a group. This should help: better identify which insects have official names; evaluate which species warrant a common name; record most common names used for an organism; and, compare names across the group to avoid additional confusion.

**- History Committee Report.** Boyd Wickman, Committee Co-chair, read and submitted the committee report (**full report is included after the Initial Business Meeting minutes**). Boyd Wickman made a motion for the WFIWC Chair to send a letter of thanks to Professor Nathan Bender from the University of Idaho for arrangement of the WFIWC archives and the posting of the material on the library web page. Tom Eager seconded the motion and it was approved unanimously. Following is the wording suggested by the Committee Co-chairs:

> **The Western Forest Insect Work Conference extends its appreciation to Professor Nathan Bender, Head of Special Collections and Archives, University of Idaho, for his recent work on the Western Forest Insect Work Conference materials. He has finished the arrangement of the work conference archives and has updated the library web page. This material has received little attention prior to his efforts. The Conference thanks Professor Bender for the recognition and updating of our archives.**

Boyd Wickman made a motion for the WFIWC Chair to send letters to the directors of the Pacific Southwest and Pacific Northwest Research Stations, USDA Forest Service, encouraging them to approve deposition of the two historic, USDA, Bureau of Entomology photographic collections into a public archive. Tom Eager seconded the motion. It was noted that the current curators of the photo files are Nancy Gillette, PSW, and Jane Hayes, PNW. There was discussion by the committee about which repository might be used. No decisions have been made as to where the collections would go, but there seemed to be agreement that they should not remain with the Research Stations. The motion to write the letter was approved unanimously. Following is the wording suggested by the Committee Co-Chairs:

> **The Western Forest Insect Work Conference encourages the directors of the PSW and PNW Research Stations, USDA Forest Service, to deposit the two historic, USDA, Bureau of Entomology photographic collections into a public archive. Both collections have been relocated several times recently. Their current locations are difficult for the public to access, and need proper storage and security. Any future relocations may result in the complete loss of these images that have both historical and ecological value.**

Because both of them are retired and do not come to many WFIWC meetings, the Co-chairs of the Committee propose that Sandy Kegley, who is more likely to attend the annual WFIWC meetings, be added as an additional Co-chair. Peter Hall indicated that it is within the power of the committee chair to make that decision.

**- North American Work Conference Committee.** Darrell Ross reported that he and Rusty Rhea are serving on the current Committee; the other two conferences (North Central and

Northeastern) have not named committee members as yet. **The North American Insect Work Conference will be in Montreal in 2011**.

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Peter Hall indicated that WFIWC needs a proposal and an offer to hold the meeting in 2009. Connie Mehmel and Karen Ripley have discussed in the past the possibility of holding it somewhere in Washington. Joel McMillan indicated that the Southwest Region might be willing to hold the 2010 meeting in Arizona. The Chair will open the floor for offers and proposals for the 2009 and 2010 meetings at the Final Business Meeting.

Ken Gibson made a motion to adjourn; Karen Ripley seconded; approval was unanimous.
The meeting was adjourned at 6:10 pm.

Respectfully submitted, Bruce B. Hostetler, Acting Secretary

## Initial Business Meeting Minutes
## 8 April 2008

WFIWC Chair Peter Hall called the meeting to order at 8:00 am.

Tom Eager, Ingrid Aguayo, and Sheryl Costello, hosts of this year's meeting welcomed us to Colorado and the 59th annual WFIWC. There are 145 attendees at this year's Conference and we have satisfied our hotel room requirements. They thanked everyone for coming to the meeting even in the face of low travel budgets. They gave special thanks to Brian Howell, Laura Dunning, Leanne Egeland, and Bernard Benton for all their help with the Conference.

Sheila Murray from the Boulder Convention & Visitors Bureau welcomed us to Boulder, and presented some information about the town and the surrounding area.

Bruce Hostetler, Acting Secretary, read the minutes of the Executive Committee Meeting.
Bill Ciesla made a motion to accept the minutes as read. Carroll Williams seconded the motion and the minutes were approved.

The Conference is looking for nominees for Chair, vice Peter Hall, and Councilor, vice Danny Cluck. Anyone interested needs to contact the people on the nominating committees (Darrell Ross, Tom Eager, Bill Riel, or Joel McMillin).

Karen Ripley gave some highlights for the Treasurer's Financial Report. She also said she had sent letters to the families of Dave Schultz and Bill Klein to tell them about the donations made to the Memorial Scholarship fund in honor of their family member. **The full Treasurer's Report is attached at the end of these minutes.**

Karen also indicated that she would go over the books with Chair and Councilors at noon and that anyone who is interested is welcome to participate.

Chair Peter Hall thanked Karen for her great work as Treasurer.

Everyone was reminded that the Silent Auction and Poster Session would be held on Wednesday night, and everyone is encouraged to attend.

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Peter Hall then called for the Committee Reports. Committee representatives presented brief highlights of their reports. The full reports are attached at the end of these minutes.

**Founder's Award Committee**

Ken Gibson announced that the 2008 Founder's Award recipient is Ladd Livingston, and he will be giving his address to the Conference in 2009. Boyd Wickman will be giving his address as the 2007 recipient tonight at the banquet. The new chair of the Founder's Award Committee is Barbara Bentz and Joel McMillin is a new committee member. There is a need for one more committee member to replace Staffan Lindgren.

Peter Hall thanked Ken Gibson for his service and his hard work as chair of the Founder's Award Committee.

**Memorial Scholarship Committee**

Darrell Ross reminded everyone that last year's Memorial Scholarship was awarded to Monica Gaylord and the she would be giving her presentation at this meeting. He then announced that for this year's award there were nine applicants and the decision was very difficult. The 2008 Memorial Scholarship will be awarded to Greg Smith and he will give his presentation at the 2009 WFIWC.

**History Committee**

Boyd Wickman, co-chair of the History Committee, indicated that the website with WFIWC historical information has been developed and is being maintained at the University of Idaho. Boyd indicated that he is working with the Bancroft Library at UC Berkeley to archive west coast Forest Entomology historical information. He as asking for former UC Berkeley students and professors to submit any historical information they have to him so it can be archived.

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The Chair announced that we need venues for the 2009 and 2010 meetings. He also welcomed any volunteers for hosting the meetings after the 2011 North American Forest Insect Work Conference meetings. It was confirmed that the 2009 meeting will be held somewhere in Washington or Oregon in 2009. There is a possibility that the 2010 meeting will be held somewhere in Arizona.

Darrell Ross indicated that he is the WFIWC representative on the NAFIWC organizing committee along with Dan Herms and Rusty Rhea from the Southeastern Conference. Two more representatives will be appointed from the north central and northeastern groups. The 2011 NAFIWC will probably be in Montreal, but that is not certain as yet. If anyone has any concerns or input regarding the meeting, talk to Darrell.

It was brought to the attention of the conference attendees Rudy Lood, who was in his early 80's passed away last year. He had been a longtime technician working with entomologists and flying aerial survey with Region 1, USDA Forest Service, in Missoula, MT.

Known retirements of Conference members include: Dave Bridgwater, Chris Niwa, Bernie Raimo, Bob Acciavatti. Several upcoming retirements include John McClean, Peter Hall (30Sep), Hideji Ono (1Oct).

John McClean said he will be setting up a Chair position at the University of British Columbia; if interested contact McClean.

Peter Hall informed members that he is being replaced as the Provincial Forest Entomologist for British Columbia by Jennifer Burleigh.

There was no new business.

Darrell Ross made a motion for adjournment; Kathy Sheehan seconded the motion and it was approved.

Meeting was adjourned at 8:45 am.

Respectfully submitted, Bruce B. Hostetler, Acting Secretary

## WFIWC Treasurer's Report
## April 2008

**Highlights of 2007:**

- Total interest income from CD's and savings account $1983.81
- Awarded $500 Scholarship to Monica Gaylord
- $14,746.67 surplus from 2007 Boise meeting. Includes $2250 loaned from WFIWC to Boise for facility deposit and includes $110 scholarship donations made during registration. True surplus of $12,386.67. Funds placed in 4 month CD with 2.92% interest rate.

- New contributions to scholarship funds

| | |
|---|---|
| At Boise registration | 110.00 |
| Boise Auction proceeds: | 657.00 |
| For Dave Schultz: | 1200.00 |
| For Bill Klein: | 175.00 |
| For Bill McCambridge | 25.00 |
| Sub-total | 2167.00 |

Wrote letters to Dave Schultz's sister and Bill Klein's children describing our actions (biography on website; special recognition on website; recognition on plaque)

**Assets of WFIWC as of Feb-March, 2008:**

Checking Account $2512.69 (February 29, 2008 Statement)
Savings Account $2145.52 (February 29, 2008 Statement. Will be reduced by $500 on March 10)

CD21976827 Mark McGregor Memorial
$5,290.21 earning 4.79% interest.
Issued 9/23/07. Matures 8/22/08.
CD 22075026 Memorial Scholarship
$46,342.92 earning 3.07% interest
Issued 3/10/08. Matures 7/08/08.
CD 22078509 Boise proceeds plus WFIWC $2250 and Scholarship $110
$14,746.67 earning 2.92% interest
Issued 3/14/08. Matures 7/12/08.

**Issues in 2007:**

- Should we list Taxpayer Identification Number on general website?

**Issues in 2008:**

- New law requires filing tax return in 2008. Our "business period" (established when we received 501 (c) (3) status in May, 2000) is April 1, 2007 through March 31, 2008.

**Respectfully submitted, Karen Ripley, (karen.ripley@dnr.wa.gov)**

## Founders Award Committee Report
## April 2008

On behalf of the Founders Award Committee, I am pleased to announce that Dr. R. Ladd Livingston, long-time member of WFIWC and for many years Conference Treasurer, is the Founders Award Recipient for 2008. Ladd has been notified, and while he will not be in attendance this year, is looking forward to addressing the Conference in 2009.

Dr. Boyd Wickman, recipient for 2007, will present the Founders Award address following the banquet tomorrow evening. Boyd's plaque will be presented at that time. Invoice for the plaque was forwarded to Karen Ripley and she has made payment ($286.00) to Croft Trophy of Fort Collins.

The "traveling" Founders Award Plaque will be on display at this meeting. I will announce, at the final business meeting, that nominations for 2009 Founders Award will be accepted until 15 December 2008. I will also announce that the new Founders Award chair, beginning at the conclusion of this meeting, will be Dr. Barbara Bentz. Barbara has been a member of the committee for several years and has agreed to accept the position of chair.

During this meeting, we will strive to replace two committee members: one will serve in Barbara's former position; the other will replace Staffan Lindgren who has asked to be relieved of service on the committee. Staffan has served long and well – at one time as committee chair. His services will be missed. We accept his resignation both reluctantly and with much appreciation.

It has been my pleasure to serve as committee chair for the past few years. It is a very rewarding experience to see so many distinguished members of our organization recognized for their substantial contributions. I wish the committee, and conference, the greatest future success. We have benefited greatly from those who have been here before us, and so have a tremendous legacy to uphold.

Respectfully submitted, Ken Gibson, Outgoing Founders Award Committee Chair

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## WFIWC Memorial Scholarship Committee Report
## April 2008

Darrell Ross, Chair
Sandy Kegley
Steve Seybold
Terry Shore

Nine applications were received for the 2008 Memorial Scholarship. Five of the applications were from students pursuing M.S. degrees and four were from students pursuing Ph.D. degrees. The committee selected Greg Smith, an M.S. student at the University of Northern British Columbia working with Drs. Staffan Lindgren and Allan Carroll, as the recipient of the 2008 Memorial Scholarship. Greg's thesis research is focused on the life history of *Pseudips mexicanus*, and its interactions with the mountain pine beetle. Greg will be invited to give a presentation on his thesis research at the 2009 WFIWC meeting.

The committee encourages all qualified graduate students to apply for the 2009 Memorial Scholarship. The deadline to submit applications is January 15, 2009.

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## WFIWC History Committee Report
## April 2008

Boyd Wickman is researching a western pine beetle control project that occurred in northern California during 1914-1922. The so-called "Antelope Control Project" is significant because it was the first such project initiated by a private timber Company (the McCloud River Lumber Co.) and the Bureau of Entomology with no Forest Service involvement. It resulted in a long-term cooperative relationship between the company and the bureau.

Boyd, along with Russ Mitchell, also provided information to Les Joslin for the PNW Research Station publication, PNW-GTR-711, entitled "Ponderosa promise: A history of U.S. Forest Service Research in Central Oregon." It contains a chapter on forest entomology from the days of Paul Keen in the late 1920s to the present.

As reported last year, the Bancroft Library at U.C., Berkeley, has established a special collection on the history of forest entomology on the Pacific Slope featuring items deposited by Boyd. Indexing of the collection will be undertaken in 2008.

The manuscript by Mal Furniss entitled: Forest Entomology in Yosemite National Park: Creation of the Tenaya Ghost Forest and glimpses of forest renewal, 1903-1984 was published in the Heritage section of the American Entomologist 53(4). The account involves an old-growth stand of lodgepole pine killed by the mountain pine beetle early in the last century and includes sequential photos of scenes initially photographed by John Miller and John Patterson during 1912-1925, and re-photographed by Mal in 1953 and 1984.

Another manuscript, A History of Forest Insect Investigations in the Intermountain and Rocky Mountain Areas, 1901-1982, by Mal was published by the RM Research Station as General Technical Report RMS-GTR-195. Jose Negron provided historical photos from the Fort Collins files. Retirees John Schmid, Mel McKnight, Daniel Jennings, Steve Mata, and others provided recollections of their experiences at the Rocky Mountain and the Southwestern Stations.

Also during this period, Mal wrote about Bob Furniss' trip to Alaska in 1946, which brought entomology into prominence there. The article, Beginnings of forest entomology in Alaska: A spruce beetle outbreak on Kosciusko Island sets the stage, 1946 was in the Feb. 22 Forest Service employee newsletter and will appear in History Line next summer. Further in regard to Bob Furniss, his 1977 oral history interview was not edited by him and has remained as a rough transcript. M. Furniss edited the transcript, added references and photos, and deposited it with the Forest History Society. It may be downloaded at the web site: http://www.foresthistory.org/Research/FurnissRL.pdf

Aided by webmaster, Kathy Sheehan, Mal has posted many historical photos, accompanied by narratives, on the WFIWC website. Click on the link Photos/History. For presentation at this current meeting, two posters were prepared by committee members Sandy Kegley and Kathy Sheehan. Sandy's poster features the photos; Kathy's poster is a broader representation of the WFIWC website.

Professor Nathan Bender, Head of Special Collections and Archives, University of Idaho, has advised that he has finished the arrangement and description of the WFIWC materials in the archives and he will be changing the text on the library web page to reflect the updates. This is a giant step forward; little emphasis was given this collection prior to his presence there. An expression of appreciation from the membership would be appropriate.

Respectfully submitted,

M.M. Furniss and B.E. Wickman, Co-chairs

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## Common Names Committee Report
## March 2008

Committee Members – As of this writing, March 28, 2008, the Common Names Committee (CNC) has full (seven) membership with Bobbi Fitzgibbon, Lee Humble, Iral Ragenovich, Lee Pederson, John McLean, and co-Chairpersons Brytten Steed and Bill Ciesla.
This year the Committee has focused on preparing supporting materials for the Western Forest Insects (WFI) book revision. We developed a method for WFI section reviewers to consider common names for noted insects. To facilitate communication between the two 'projects', links have been created between the WFIWC-CNC website and the WFI book revision website.
The ESA rotates their CNC Chair annually. Thus, we again introduced ourselves to a new Chair person and clarified their preferred method of communication. In addition, the following proposals have been processed as follows:

<u>Approved by the WFIWC membership and sent to the Entomological Society of America (ESA) Common Names Committee (CNC) for their review.</u>

| | |
|---|---|
| *Disholcaspis quercusmamma* | oak rough bulletgall wasp |
| *Eriophyes calaceris* | purple erineum maple mite |
| *Hylurgus ligniperda* | redhaired pine bark beetle* |
| *Ips emarginatus* | emarginated ips |
| *Rhagium inquisitor* | ribbed pine borer |
| *Phaenops (Melanophila) gentiles* | green flathead pine borer |

<u>Approved by the Entomological Society of America CNC and ESA membership (officially approved in 2007/2008):</u>

| | |
|---|---|
| *Dendroctonus approximatus* | larger Mexican pine beetle |
| *Dendroctonus mexicanus* | smaller Mexican pine beetle |
| *Pseudohylesinus granulatus* | fir root bark beetle |
| *Pseudohylesinus sericeus* | silver fir beetle |
| | |
| *Disholcaspis quercusmamma* | oak rough bulletgall wasp |

| | |
|---|---|
| *Hylurgus ligniperda* | redhaired pine bark beetle* |
| *Ips emarginatus* | emarginated ips |
| *Rhagium inquisitor* | ribbed pine borer |

Not approved by the Entomological Society of America CNC:

| | |
|---|---|
| *Dasychira grisefacta* | grizzled tussock moth |
| *Eriophyes calaceris* | purple erineum maple mite |
| *Phaenops (Melanophila) gentiles* | green flathead pine borer |

Most submissions relate to the 200+ insects listed in Western Forest Insects (WFI) with common names not officially recognized by ESA. Names for new introduced species of importance (*) have also been submitted. In addition, species not found on the WFI list of 200+ names have been occasionally included to minimize confusion among species within a genus or associated group.

We strongly urge WFIWC members to consider common names for 'groups' (order, genus, etc.) to better identify 1) which insects have official names [may or may not match what is WFI], 2) evaluate which species warrant a common name [economically important or common], 3) record most common names used for an organism, and 4) compare names across the group to avoid additional confusion [one OK name may be more appropriate for another species; see 'Mexican pine beetle' example].

If you are interested in submitting a common name proposal or are considering common names as part of the WFI revision, please contact either Brytten Steed or Bill Ciesla.

Respectfully submitted,

Brytten E. Steed and Bill Ciesla, Co-chairs

## Final Business Meeting Minutes
## 10 April 2008

Chair **Peter Hall** called the meeting to order at 1:30 pm.

Bruce Hostetler, Acting Secretary, read the minutes of the initial business meeting. Bill Ciesla made a motion to accept the minutes as read. The motion was seconded by Bill Schaupp, and was approved unanimously.

Ingrid Aquayo reported that the 2008 WFIWC has brought in $31,990 and that will be enough to cover all expenses. She also reported that the Silent Auction brought in $1,115. Steve Cook was given a large thank you and round of applause for organizing and running the silent auction.

Peter Hall thanked the Local Arrangements and Program Committees for all the work they did in putting on the 2008 Work Conference. It was a well run and well organized meeting, and everyone showed their appreciation with a round of applause.

Treasurer Karen Ripley reported that she along with the counselors and the chair had checked the books and everything is in order.

The Chair asked for any additions or corrections to the Committee Reports which had been submitted earlier during the Conference. There were none.

The Chair opened discussions regarding locations of future meetings.

Karen Ripley invited everyone to Washington in 2009 for the 60$^{th}$ annual WFIWC.

Joel McMillin invited everyone to Arizona for the 2010 WFIWC and indicated that it would probably be held in Flagstaff. He also indicated that John Anhold would be in charge.

A motion to accept these invitations was made by Kathy Sheehan. The motion was seconded by Sheryl Costello and approved unanimously.

Counselor Nominating Committee members Bill Riel and Joel McMillin announced that the nominee for the vacant Counselor position is Jennifer Burleigh.

John McClean made a motion to accept the nominee. The motion was seconded by Brytten Steed and approved unanimously by conference members.

Chair Nominating Committee members Tom Eager and Darrell Ross announced that the nominee for Chair is Kathy Sheehan.

Ken Gibson made a motion to accept the nominee, and it was seconded by Joel McMillin. The motion was approved unanimously, and Peter Hall presented the WFIWC gavel to the new Chair Kathy Sheehan.

Kathy Sheehan thanked Peter Hall for his good work and dedication in serving as Chair for the last two years, and there was a hearty round of applause.

The Chair called for any new business. There was none.

Peter Hall made a motion to adjourn. The motion was seconded by Tom Eager. The meeting was adjourned at 2:15 pm.

Respectfully submitted,

Bruce B. Hostetler
Acting Secretary

## Memorial Scholarship Presentation

# Impacts of thinning ponderosa pine on pine bark beetles in northern Arizona

**Monica L. Gaylord, Richard W. Hofstetter and Michael R. Wagner**
**NAU School of Forestry, Flagstaff, Arizona**

Thinning of forest stands is often advocated as a mechanism to decrease tree and stand susceptibility to bark beetles. In ponderosa pine forests previous research has found that trees successfully attacked by bark beetles are often located in stands with lower radial growth and higher basal areas than unattacked trees, suggesting trees in stands of higher basal areas may have reduced defenses to bark beetles. Changes in microclimate that occur from stand thinning treatments, such as differences in wind movement and temperature between thinned and unthinned stands, have also been suggested as mechanism for reducing stand susceptibility to bark beetle attacks.

Currently, the ponderosa pine forests of northern Arizona are generally thought to be overstocked. Thinning treatments are proposed as management tools to restore forest structure to pre-European settlement conditions, as well as mitigate the possibility of crown fires and bark beetle outbreaks. Our objectives were to develop a regionally appropriate guideline for silvicultural treatments by assessing differences in bark beetle movement, bark beetle attraction to pheromone lures and tree defense across a range of basal area treatments. Our study was conducted at two sites, both located in ponderosa pine forests with 15 km of Flagstaff, Arizona. The first site is a long-term thinning study initially established in 1962. Thinning treatments range from 9.4 $m^2$/ha to 34.4 $m^2$/ha and an unthinned control ($\approx 37 m^2$/ha). Stands have been re-entered at 10 year intervals to maintain specified basal areas. The second site was thinned in fall of 2005 with basal areas ranging from 13.8 to 34.4 $m^2$/ha.

To measure differences in beetle movement, we used sticky traps affixed to trees and passive traps hung at different heights in the center of each thinning plot during the summer and early fall of 2005 and 2006. We collected only four bark beetles (*Dendroctonus valens*) over this time period. We collected at total of 96 predators (*Enoclerus* spp. and *Temnochila chlorodia*). We caught more predators on sticky traps in stands with lower basal areas than higher basal areas. For the passive traps we collected more bark beetles (*D. valens*, *D. frontalis, D.brevicomis* and *Ips pini*) and bark beetle predators in stands of lower densities than in stands of higher densities.

To assess differences in microclimate and differences in attraction to pheromone lures (possibly as a result of changes in microclimate), we measured wind speed in one plot of each thinning treatment at the new thinning site. Results indicated higher average wind speeds and gusts in stands of lower basal area than in stands of higher basal areas. Lindgren funnel traps baited with *I. pini* lures collected more *I. pini* bark beetles and predators in stands of higher basal than stands of lower densities. Trees in stands of higher basal area baited with lures known to attract *D.*

*brevicomis, D. frontalis* and *D. adjunctus* were attacked sooner than trees baited in stands of lower basal areas. Additionally, more trees were successfully attacked in stands of higher basal areas than in stands of lower basal areas. Funnel traps, affixed directly to baited trees collected the fewest beetles and predators in stands of lower basal areas. We found no consistent pattern between monoterpene profiles of attacked trees versus unattacked trees. Predawn water potentials indicated that water stress was higher in stands of higher basal areas than in stands of lower basal areas. We found no consistent pattern between tree resin flow volumes and stand basal area. Tree responses to fungal inoculations (i.e. lesion lengths) after fungal inoculations at the new site were minimal (1-2 cm) and showed no clear relationship with basal area treatments.

In summary our study showed that thinning treatments had the desired effect of decreasing water stress at both the old and new thinning sites. Thus, in southwestern ponderosa pine forests thinning should help increase tree vigor and defense against bark beetles. Additionally, when pheromone lures were present more beetles were collected in traps and more trees were successfully attacked in stands of higher basal areas than in stands with lower basal areas suggesting that microclimate changes could make pheromone plumes harder for bark beetles to locate in stands with lower basal areas.

## Lessons Learned by a Not-So-Old Forest Entomologist

**John H. Borden**
**Chief Scientific Officer, Contech Inc.**

Over a lifetime in forest entomology spanning 46 years, I have learned many things. These can be encapsulated in 21 Lifetime Lessons, as enumerated below.

1. Older does not necessarily mean wiser.
2. Go where your heart lies. Things will turn out just fine.
3. The insects always have the right answer.
4. Economically important insects are as interesting as non-economically important insects.
5. Applied research is no different from basic research, except that a use has been identified for the data from the outset.
6. There is nothing like the joy of discovery.
7. The buzz one gets by taking research to the operational phase comes close to the joy of discovery.
8. It's easier to get an insect to do what it wants to do than it is to stop it from doing what it wants to do.
9. Treasure your anomalies.
10. Adversity can be flipped over into success.
11. Keep a place in your heart for inventors. They really are special.
12. My ability to predict the future sucks.

13. Surround your self with the best and the brightest. They will enrich your life and make you look good.
14. Do not assume that other people are as smart as you are.
15. Expect the unexpected. View each unexpected occurrence as an opportunity.
16. Never underestimate the capacity for people to come up with "crackpot" solutions to a major problem.
17. Not all "crackpot" solutions are really crackpot.
18. Pick a good mentor. Honor and emulate him or her.
19. A career in research and teaching is excellent training for a job in business.
20. Pick a creed that fits you early in life and stick with it.
21. Work is a great retirement hobby.

Among the best and the brightest under Lesson No. 13 are 101 graduate students, three of whom (Jim Richerson, Ernie Lapis and Norm Alexander) have predeceased me. This presentation is dedicated to them.

## Founders' Award Address
## April 2008

## Images of the Past: The First 50 Years of Forest Entomology on the Pacific Slope

### Boyd Wickman


Boyd Wickman and Ken Gibson

Boyd Wickman and Ken Raffa

I want to thank my sponsor, Ken Raffa, the Founder's Award committee and members of the Work conference for honoring me with this award and giving me the opportunity to address you tonight.

My talk is dedicated to the memory of Bill MacCambridge. He was one of my early mentors on the 1951 spruce beetle project here in Colorado. He was also a close friend and super skiing buddy. He contributed a great deal to our profession and the Work Conference.

In 1950 the second Western Forest Insect Work Conference was held in nearby Fort Collins at the Armstrong Hotel. Room rates were $1.75 without bath, $2.75 with bath, Registration fee was $1.00 and dues were $1.00. Hec Richmond of the Victoria B.C. laboratory was chairman and there were 28 attendees. F.P. Keen, head of the Berkeley Forest Insect lab allowed entomologists wanting to attend from Berkeley, $58.00 for round trip Pullman coach fare, or $7.00 per day per diem if they drove a private vehicle with no mileage allowance. We have come a long way in 58 years, at least in terms of inflation.

By now you can probably guess the theme of my address. As many of you know, I have become enthralled with history. This seems to be an affliction that advances with age. But history is more than recounting the past; it is also how we all will be judged by future generations. So it behooves us to get things right to the best of our abilities.

I want to show you a series of images of the first 50 years of Forest Entomology in California, Oregon and Washington, or the "Pacific Slope", where many of our professional roots were established. I apologize for having so little history to offer about our profession in British Columbia. I hope some Canadian in the audience will rectify that gap.

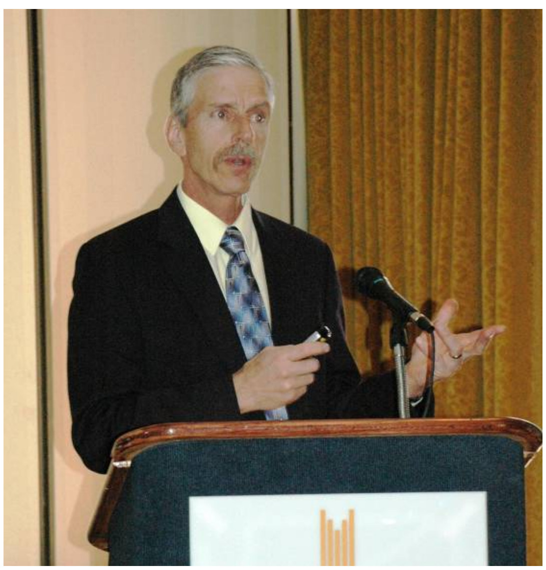
I will show you mostly pictures of our founders and their personal lives, and some highlights of their contributions. I will keep my comments brief in favor of showing numerous images. More detail can be found in my recently published biographies of pioneers H.E. Burke and J. Miller.

Slides were used to illustrate some pioneer entomologists and their lives. In addition, there were pictures of their modes of transportation, forest insect stations and control camps, examples of bark beetle outbreaks, survey methods, bark beetle control, defoliator problems and aerial spraying pesticides. Some closing comments were made about the rewarding profession called Forest Entomology.

## Opening and Banquet Addresses

**Bob Averill-Opening Address**
**United States Forest Service, Retired**

A Look Back:  Bob Averill presented an overview of the changes he has experienced during his career with USDA Forest Service, Forest Health. He also related his current perspectives with regards to the National Forest Service Retirees Organization.  Bob is presently serving as Chair of this group which lobbies the Forest Service and government for the benefit of current employees.



**Joe Duda-Opening Address**
**Colorado State Forest Service**

Forestry in Colorado: Joe Duda spoke to the group about how Colorado is facing the most devastating mountain pine beetle epidemic in written history and how federal, state, and local agencies have come together to address many issues concerning the affected communities and general public.  He also addressed the opportunities that have risen in recent years, such as innovative ways for wood utilization and the teachable moment for the general public to learn about forest dynamics and management.

**Dan Gibbs-Banquet Address**
**Colorado State Senator**

Senator Gibbs gave an address at the Tuesday, April 8, banquet.  He spoke to the group about current bark beetle related issues facing Colorado and legislation he is working on regarding bark beetle outbreaks and wildfire mitigation.

# Field Trip
# Rocky Mountain National Park

A field trip was taken into Rocky Mountain National Park, located approximately 30 miles northwest of Boulder, CO. Buses left the Millennium Harvest House around 10 AM and arrived at the Fall River Visitor Center for a short rest stop before heading on to the Alluvial Fan Picnic Area for lunch. Jeff Connor and Jeff Maugans of the Rocky Mountain National Park Staff discussed willow restoration, the use of elk exclosures, elk population management, and chronic wasting disease. The group was able to view an elk exclosure that is being utilized to keep the elk out of meadows. Buses were then loaded and driven to Many Parks Curve where the group unloaded and heard presentations from Bob Cain, USFS, Anna Schoettle, RMRS and Jeff Connor about the looming mountain pine beetle epidemic in lodgepole and limber pines and potential impact to ponderosa pine. From there the buses went to Moraine Park Museum parking lot and heard about Moraine Park history, fire, fuels, and wildland/urban interface in Rocky Mountain National Park from Jeff Connor and Jeff Maugans. The last stop of the day was made at Glacier Basin Campground where the group heard from Sheryl Costello, USFS, about the current problems with mountain pine beetles infesting trees in campgrounds. The park’s air curtain burner that is being used to dispose of mountain pine beetle infested trees was operating and the group was able to trudge through the mud and get a close up view. The group then bused back to the hotel in Boulder.

Lunch stop at the Alluvial Fan Picnic Area

Anna Schoettle, USDA Forest Service, RMRS, addressing the group and Bob Cain, USDA Forest Service, holding the microphone

Jeff Connor, Rocky Mountain National Park, addressing the group and Bob Cain holding the microphone

The Rocky Mountain National Park air curtain burner in action

Glacier Basin campground with mountain pine killed and felled trees in the foreground

## Plenary Session: Bark Beetles, Fuels, and Fire Behavior and Implications for Management

Elizabeth Hebertson, moderator (Forest Health Protection, Ogden Field Office)

In recent decades, bark beetles (*Dendroctonus* sp., *Ips* sp.) have caused extensive tree mortality throughout western North America. This mortality has long been assumed to increase fire hazard and potential fire behavior. In reality specific quantified data supporting this assertion for many forest systems are lacking.

During this session, Paul Langowski (Branch Chief-Fuels and Fire Ecology, Rocky Mountain Region) discussed concepts important for understanding the development of fuels complexes and how fuels complexes relate to fire behavior. He began by differentiating between 'fire risk' and 'hazard'. Fire risk applies to the probability of an ignition occurring as determined from historical fire record data. Probability is a number representing the chance that a given event will occur. The range is from 0% for an impossible event, to 100% for an inevitable event. The technical risk management definition integrates both probability and net value change. When used relative to wildland fires it refers to the probability of escape resulting in financial and ecological loss. Alternative management scenarios generate different degrees of risk and ultimately a different set of economic outcomes (Hesslin and Rideout, 1999). Land managers can change the probability of human-caused wildfire occurrence (in a limited fashion) through prevention and education programs. An influx of growing numbers of residents and visitors always increase the risk of human caused fire.

A fuel complex is defined by volume, type, condition, arrangement and location, that in turn determine the ease of ignition and the resistance to control. Hazard is a physical situation (fuels, weather, and topography) with potential for causing harm or damage as a result of wildland fire. Fire behavior depends on the fire environment, forest density, composition, amount of surface fuel, its arrangement, moisture content, and prevailing weather, and physical setting. Crown fire initiation depends on crown base height, foliar moisture content, and surface fire intensity. Crown fire spread depends on crown bulk density (weight per unit volume e.g. pounds per cubic foot), wind, and slope. In general as bulk density increases lower rates of spread are required to sustain the crown fire.

Stand attributes that affect fire's behavior include surface fuel condition, crown bulk density and crown base height. All three attributes can be altered by insect activity. Insect and disease damage alters standing fuels (needles, twigs, etc.), down woody fuels, duff, ladder fuels, herbaceous fuels.

The goal of hazardous fuels treatment is to achieve some combination of reducing flammability, reducing fire intensity, reduce the potential for creating firebrands and crown fires, and increase firefighter safety and effectiveness. Hazardous fuels treatment priorities reduce surface fuels, reduce ladder fuels, raise the bottom of the live canopy and reduce stand density. Hazardous fuels reduction treatments alter the characteristics that influence crown fire initiation and spread.

Dr. Michael Jenkins (Forestry and Fire Science, Utah State University) discussed bark beetle induced changes in forest fuels at the landscape level and techniques to predict the real impacts on fire hazard and potential behavior. With the predicted continuation of widespread drought in the West bark beetle outbreaks will intensify across large acreages of susceptible stands. The ability to predict the consequences of bark beetle altered fuels on fire hazard is vital to fire planners and land managers.

Bark beetle activity changes fuels over time such that the potential for high intensity and/or severe fires either increases or decreases. The amount of fine surface fuels increases two to three years following bark beetle outbreak as a result of litter deposition. However, higher rates of surface fire spread and fireline intensities in epidemic stands are more related to the decreased vegetative sheltering and its effect on mid-flame wind speed rather than changes in fine fuels. In post-epidemic stands (10 to 20 years following outbreak) large, dead, woody fuels and live fuels dominate. In these stands passive crown fires are more likely to occur than in endemic stands. Active crown fires are less likely due to decreased aerial continuity.

Using custom bark beetle fuel models, FARSITE model projections indicate that the probability of achieving larger fire sizes throughout the range of historic fire weather conditions in this lodgepole pine forest is greater during the current mountain pine beetle epidemics. The greatest change in fire size, however, occurs under the most extreme fire weather conditions (probability $< 5\%$). This result is probably due to the greater likelihood of fires transitioning from surface to crown fires under extreme fire weather conditions. Determining the significance of these differences is not possible due to inherent variably that exists between time steps and the limits of the models (both surface and crown) that make the FARSITE projections. However, even slight differences in fire size may have important implications for fire planning. FARSITE model projections of 20-year post outbreak landscapes suggests that the probability of larger fires increases most rapidly with extreme fire weather conditions.

## Plenary Session: Sudden Aspen Decline

Jim Worrall, Pathologist
Gunnison Service Center
USDA Forest Service
Rocky Mountain Region

A project was initiated in FY07 to determine the severity, site/stand factors and causal complex associated with sudden aspen decline (SAD) in southwest Colorado. First, we documented landscape factors (based on GIS-DEM analyses of aerial survey and cover-type data) and stand factors (based on stand exams in two areas of the San Juan NF) (Worrall *et al.*, in press). Generally there was a strong inverse relationship between elevation and damage, damage tended to occur on south and southwest aspects more than did healthy aspen, damage was most severe in open stands with large trees, and regeneration was poor in damaged stands. We observed five biotic agents most frequently associated with mortality: Cytospora canker, poplar borer, bronze poplar borer, and two aspen bark beetle species. We proposed a hypothesis on causal factors in a decline context:

*Predisposing factors*: low elevations, south to west aspects, low density, mature age distribution on the landscape;

*Inciting factors*: warm drought conditions;

*Contributing factors*: secondary, biotic agents mentioned above.

We began an intensive field survey in 2007. We completed 76 plots on four National Forests consisting of a randomly selected damage plot and a neighboring, paired healthy plot. Preliminary analyses indicate that:

a) Regeneration did not increase significantly with crown loss;

b) Root mortality was correlated with crown loss, and healthy plots had significantly higher volume of live roots and lower volume of dead roots than damaged plots;

c) In damaged plots but not in healthy plots, regeneration decreased significantly as root mortality increased. However, regeneration did not vary significantly with volume of live roots.

d) Depth of soil mollic layer did not vary significantly with crown loss.

e) Crown loss of plot does not vary significantly with average or oldest age of sampled codominant/dominant trees.

In general, there did not seem to be a significant regeneration response to crown loss, consistent with the limited stand exams reported earlier. Where there was any response, it was on plots with a large volume of healthy roots and/or mollic and especially pachic mollic soils.

Root mortality varied tremendously, from 0 to over 90% of root volume. Several analyses indicated a connection between crown loss and poor root condition (low volume/high mortality). Healthy plots mostly had low root mortality. However, under mostly dead overstories (>50% crown loss) root mortality ranged from <10% to >90%.

## Workshop I

## Assessing the economic, ecological and social costs of doing nothing with respect to bark beetle outbreaks

Moderator: Andris Eglitis, USDA Forest Service, Bend, OR

Concerns have been expressed by many people that there is not enough attention paid to the costs associated with "passive management" or no management of bark beetle outbreaks. The "effects of no action" is an issue that sounds fairly simple, but is actually quite complicated because of the interplay of hidden costs, ecological tradeoffs and social values tied to forest disturbances. In managing public lands, we are expected to identify the effects of the "no action alternative" but we often rely on general motherhood statements (e.g., increased fire hazard; loss of certain habitats) because the question is so difficult to answer. Our intent in this workshop is to offer some presentations on economic, ecological and social effects of bark beetles as a springboard for further discussion of this topic. We are separating the discussions out, but of course, the effects do not stand alone, nor are they exclusive. The examples that the speakers will present can be used as models for future work to evaluate the economic, ecological and social impacts of bark beetle disturbances that are not mitigated.

### They're Out of Control, We're Out of Control. Kaos Reigns. Time to Get Smart. Economics associated with the Southern Pine Beetle

Stephen Clarke
USDA Forest Service, Lufkin, TX

The southern pine beetle (SPB), *Dendroctonus frontalis,* causes extensive pine mortality throughout the southeastern United States. SPB suppression tactics, primarily cut-and-remove and cut-and-leave, are effective in controlling individual infestations and reducing tree loss. Economic analyses of SPB suppression programs to date have computed benefit/cost ratios ranging between 2.5 and 6.2:1, depending on the discount rate used. These analyses only incorporated timber values, and economic effects on wildfire, recreation, hydrology, wildfire, etc. were not calculated. In addition, the models utilized in the analyses greatly underestimated the impacts of SPB without suppression, as on average they predicted that timber volume losses doubled without active SPB suppression. In the past 30 years, areas with suppression programs have lost <3% of the susceptible host type during outbreaks, compared to >40% of the host type killed in areas without SPB suppression. It is evident that SPB suppression is cost-effective, and that SPB integrated pest management is an important factor in both SPB population dynamics and the current forest management practices in the southeastern U.S.

## Predicting the ecological costs of bark beetle outbreaks

Helen Maffei and Mike Simpson
USDA Forest Service, Bend, OR

(presented by Helen Maffei)

Comparing the expected response of ecological systems to unmanaged bark beetle outbreaks with proposed management actions is a key component of credible project analysis and informed decision making. Yet this direct comparison is often not made. As a result, it is difficult for managers to gauge the relative amount of expected ecological benefit derived from preventative management scenarios and to decide if intervention is desirable, or even possible. Landscape modeling techniques can be utilized to predict and display and these comparisons. In order to have the most utility, these procedures must provide: 1) Context; impacts are represented at the appropriate spatial and temporal scale; 2) A repeatable process 3) Ability to prioritize treatment opportunities 4) Credibility.

A number of approaches are being used to successfully represent, and model the ecological impact of unmanaged bark beetle outbreaks. Some examples include modeling ecological impacts of bark beetles as changes in: 1) Amount and/or distribution of seral states across the landscape as compared to a reference condition. 2) Habitat of keystone species; 3) Amplitude, frequency and location of other disturbance processes; 4) Site productivity or nutrient capital. Credibility (both internal and external) is required for modeling results to be useful. Utilizing the best science, representing key interactions between key predictive variables, explicit documented assumptions, good input data, and repeatable analysis procedures are important features of a credible analysis. An accurate spatial vegetation layer of the existing condition is equally important. Assembling this information is usually many times more consuming and frustrating more than actually running the models and thinking about and discussing the results. While there are a number of methodologies for mapping spatial data at the landscape level, very little work has been done to evaluate and compare them with each other. Validation and refinement of predictive models can also increase credibility. We presented an approach which compared bark beetle risk rating on a retrospective spatial vegetation layer (1996) with actual bark outbreaks mapped with digitized aerial sketch maps (1996-2007)

**Community perspectives on pine beetle impacts and management in Colorado**

Courtney Flint
University of Illinois, Urbana-Champaign, IL

Nine communities in five northern Colorado counties were studied to determine the social implications of an extensive mountain pine beetle epidemic and their expectations for management response to that disturbance. The systematic survey was conducted in two phases: 1) 165 key informant interviews in nine communities with multiple criteria and snowball sampling [Summer 2006] and 2) Household mail surveys to 4100 residents in the communities [Spring-Summer 2007]. The community members were asked to consider an array of impacts including aesthetics, personal feelings, tourism, community identity, ecological relationships, land use conflicts, and economic issues based on their values. Respondents also commented on individual actions that they have taken in response to the bark beetle outbreak, and identified community-based actions that they would support.

The following conclusions can be drawn from the community study:

Local residents feel the impacts of the mountain pine beetle outbreak in north central Colorado.

Local residents are concerned about forest risks – for their own safety and property and communities, but also for the integrity of forest ecosystems.

In general, local residents are not satisfied with forest management, though some are sympathetic to bureaucratic limitations.

Local residents are doing what they can to take action.

The mountain pine beetle outbreak in Colorado is NOT value-neutral in the minds of local community residents.

There is considerable community variation – one size will not fit all.

"Managing for the next forest" in Colorado may mean managing this forest in order to meet expectations by community residents.

However, research from Alaska suggests that reaction to beetles may subside over time.

# Invasive Forest Insects

Bob Rabaglia, moderator
USDA Forest Service, Arlington, VA

Invasive insects have had a significant impact on forests across North America, but probably nowhere has the impact been greater than in the northeast. There are several species in the northeast and southeast which have the potential to significantly affect the forests in the West. The emerald ash borer has killed millions of ash trees in seven states and Ontario, Canada and could significantly change the urban and rural forests of the West. *Sirex noctilio* has been recently found in four states and Ontario, and although its impacts have been minimal, it is unclear how it will impact the pine forests of the west. In the south, a new disease, laurel wilt, vectored by an ambrosia beetle is killing redbay trees and other Lauraceae.

Speakers at the session included:

**Update on *Sirex noctilio***
Peter DeGroot
Canadian Forest Service, Natural Resources
Canada, Sault Ste. Marie ON, Pdegroot@NRCan.gc.ca

**Emerald ash borer in the East**
Roeland Eliston
USDA APHIS PPQ, Western Region Program Manager, Ft Collins CO,
Roeland.J.Elliston@aphis.usda.gov

**Emerald ash borer and the Great Plains Initiative**
Bob Cain
USDA Forest Service, Rocky Mt Region, Ft Collins, CO, rjcain@fs.fed.us

**Early detection and rapid response project and laurel wilt**
Bob Rabaglia
USDA Forest Service, Forest Health Protection, Arlington, VA, brabaglia@fs.fed.us

**Non-native bark beetles in the west**
Andy Graves
USDA Forest Service, Pacific Southwest Research Station, Davis, CA.

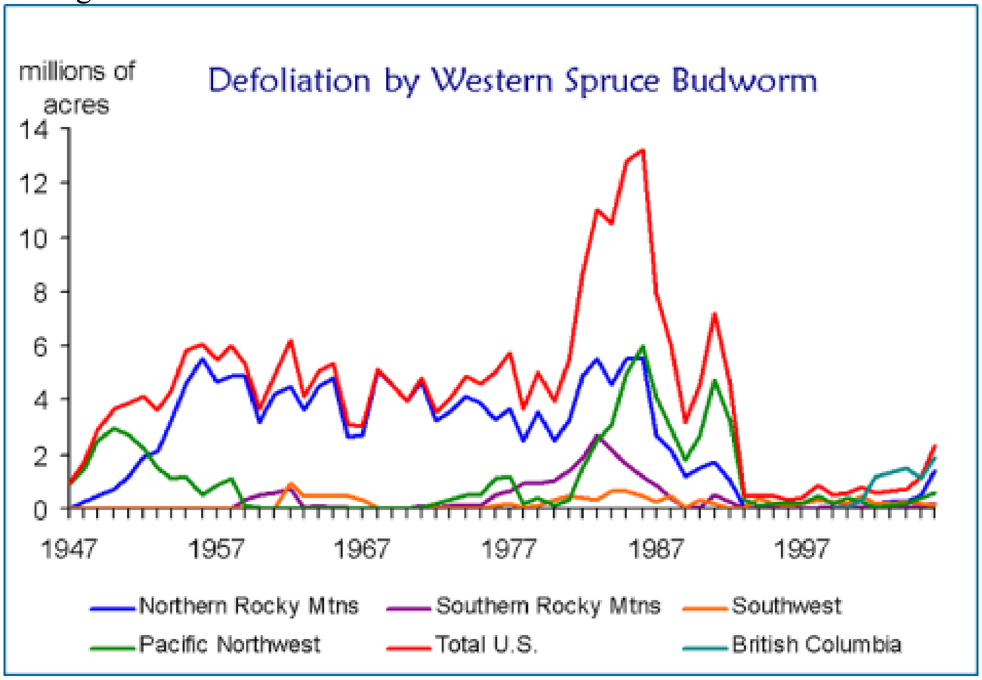
# Western Forest Defoliators

Moderator: Darren Blackford
USDA Forest Service, Forest Health Protection, Ogden, UT

## Western Spruce Budworm, *Choristoneura occidentalis*

Kathy Sheehan
USDA Forest Service, Portland, OR

After approximately 15 years at relatively low levels, western spruce budworm populations are on the rise throughout the west.




The increasing budworm-caused defoliation has sparked interest in past suppression and silvicultural treatments. Project reports and other documents associated with ~100 suppression projects conducted against budworm since 1970 has been posted on a website: http://www.fs.fed.us/r6/nr/fid/budworm/info.shtml. Additional information (particularly for Canadian projects) is welcome! We are also starting to gather documents associated with silvicultural treatments aimed at reducing budworm impacts on trees.

One analysis of suppression projects aimed at western spruce budworm in Oregon and Washington during the previous outbreak found that treatments early in the outbreak (primarily using carbaryl) generally reduced defoliation in the year following treatment. However, after treatments later in the outbreak (primarily using *B.t.k.*), defoliation patterns (including both extent and severity) were generally similar in treated and adjacent untreated areas. (Sheehan 1996 - http://www.fs.fed.us/pnw/pubs/gtr367.pdf - a 2.6 MB pdf file)

### Balsam Woolly Adelgid, *Adelges piceae*

Laura Moffitt
USDA Forest Service, Boise, ID

While this forest pest has been around parts of the west for over a few decades, its presence is now becoming so extensive and severe, that in some areas the continued existence of subalpine for trees is in question. The brief history and biology of this insect and answers to questions of why it's of concern in western forests, how land managers are dealing with it, and what still needs to be done, were discussed during this session.

### Willow Scale, *Diaspidious gigas*

Bob Hammon
Tri River Area Extension of Colorado, Grand Junction, CO

Aspen mortality and dieback caused by the willow scale is becoming more and more prevalent in various aspen stands of the west, including areas of Colorado's Western Slope. The biology and distribution of the willow scale on the Western Slope of Colorado and mitigation measures being planned for this situation were discussed during this session.

## The Interface of Atmospheric Processes and Forest Health

Moderators: Steve Seybold and Iral Ragenovich

Discussion Contributors: Alex Guenther (NCAR-Boulder), Andy Graves (UCD-Plant Pathology), Harold Thistle (FHTET-Morgantown), and Allan Carroll (Natural Resources Canada, CFS-Victoria)
Participants: Brian Aukema, Gary Blomquist, Sheryl Costello, Robert Cruz, Scott Diguistini, Leanne Egeland, Bobbe Fitzgibbon, Monica Gaylord, Peter Harley (NCAR-Boulder), Don Heppner, Jeff Hicke, Teri Howlett, Thomas Karl (NCAR-Boulder), Colleen Keyes, Christopher Keeling, Jennifer Klutsch, Fraser McKee, Joel McMillin, John Moser, Don Owen, John Popp, John Schmid, Kjerstin Skov, David Wakarchuk, Christine Wiedinmyer (NCAR-Boulder). Total number of attendees was 34 (some participants were not recorded).

This workshop explored and discussed the interactions of atmospheric science and various physical processes with forest health. Physical aspects of the forest environment range from microclimatic effects such as air flow, environmental chemistry, and aerosol formation below and above the canopy to regional impacts such as drought and global impacts such as climate change. In this workshop we covered the role that a new multidisciplinary project (BEACHON) is playing in research on forest environments and forest health; emerging research on the mechanism behind the impact of drought on tree susceptibility to bark beetles; the physical processes behind the dispersion of insect pheromones and other semiochemicals in forests; and the impact of climate change on forest insect population biology and range shifts. Boulder, Colorado is the home of the National Center for Atmospheric Research, so this workshop was a good opportunity for the western forest health community to make new contacts with world class atmospheric research scientists at this institute.

**Introduction by Seybold**: On behalf of my co-moderator Iral Ragenovich, welcome to this workshop session that will explore the interaction between the atmospheric and physical sciences with forest health. For many of us, our professional activities are being influenced by the growing awareness that we are living in a time when climate is changing. We thought that it would be interesting to try something unusual, risky, and new by stepping back and taking a look at some of the underlying physical processes at work in forest ecosystems and to consider their relevance and impact on forest health.
In today's discussion we'll touch on several topics of biosphere-atmosphere interactions such as environmental chemistry, aerosol formation, drought, air flow, and temperature. We'll think about how they affect forest insect biology and population dynamics, either directly or indirectly through the physiology of their host trees.

Our first discussion contributor will be Alex Guenther, who is a senior scientist and group and section leader of the Biosphere-Atmosphere Interactions Group at the National Center for Atmospheric Research here in Boulder. Alex has published some seminal papers on natural levels of emission rates of terpenes and other volatile organic compounds in U.S. forests. Alex will lead off our discussion by introducing the BEACHON project and its relationship to forest environments.

**Guenther**: Project BEACHON (Biosphere-Energy-Atmosphere-Carbon-Hydrogen-Oxygen-Nitrogen) is a multidisciplinary and regional-scale program of study and research that will integrate field measurements into regional-scale models. The motivation for the project is the acknowledgement by the scientific community that the earth system is changing and that we will need to predict changes and their impacts on time scales of months to years. The rationale behind the project is to ask how energy, water, carbon, and biogeochemical cycles are coupled with a changing earth system. Key symmetrical questions are: 1) How does the biosphere respond to changes in the atmosphere and 2) How does the atmosphere respond to changes in the biosphere? Are there significant interactions and feedbacks? The sensitivity of water-limited landscapes such as western U.S. pine forests is another key motivating force for the development of BEACHON.

Scientific themes behind BEACHON are 1) bioaerosol and cloud processes; 2) precipitation variability and magnitude, 3) bio-atmosphere exchanges of energy, aerosols, carbon, water, organics, and nitrogen; and 4) disturbances (e.g., drought, fire, and insects). BEACHON is a regional scale program, but it will have local-scale impacts, i.e., it is multiscale. The project will incorporate new biogeochemical and hydrological data from leaf and plant scale to canopy and boundary layer scales into previously derived regional-scale models for weather, biology, emission and deposition, and chemistry. The ultimate goal is to integrate the multiscale information to a global scale product.

Examples of NCAR's involvement in BEACHON include a helicopter-based system for measuring $CO_2$, $H_2O$, and energy while hovering or moving. The project has been developed in collaboration with Duke University scientists and will be expanded with NCAR's assistance to include sampling of volatile organic compounds (VOC's), ozone, nitrogen, and particulates. It could collect chemical data from small areas such as forested landscapes undergoing bark beetle outbreaks. Another example was a ground-based flux system that used sonic anemometers and chemical detection systems (PTR-MS) in a walnut orchard in California. This system detected canopy-scale emissions of an airborne signal (methyl salicylate) that is known to attract predaceous insects. It may also be a dominant source of secondary aerosol formation. Methyl salicylate appeared to be released in greater quantities from the trees under drier conditions when the irrigation system was turned off. In other words, its emission was responding to water and temperature stress. This system could also be utilized in forests. A final example is the planned installation of a 30 m flux tower at the Manitou Experimental Forest in Colorado (summer 2008). Measurements will be made of precursors and biogenic aerosols with the goal of gauging their impacts on aerosol formation. The overall goal is to get data such as this into the regional-scale models.

A discussion ensued about topics such as a planned study to make flux measurements from a human-elicted bark beetle infestation in a pinyon pine/juniper woodland in Arizona and New Mexico. Questions were raised about the ability to scale up the planned pinyon pine/juniper study to a regional level. Peter Harley asked about what flux measurements mean on a regional level? He also posed a question to the bark beetle scientists in the audience wondering about the impact of 2-methyl-3-buten-2-ol released by pines in the West on bark beetle behavior.

**Thistle**: Discussion contributor Thistle presented information on the atmospheric transport of pheromone plumes in forest canopies. The objectives of this project are to 1) Develop a tool to aid operational pest managers and researchers in the placement of pheromone sources and 2) Increase awareness of influences on atmospheric dispersion in the canopy by entomologists using passive dispersers of pheromone gas. The key question in this work is: What is the concentration of pheromone gas in the air around a pheromone source? Secondary questions include: 1) How much pheromone is being eluted (emitted)? 2) What is the concentration of pheromone in the air around the source? and 3) What level of concentration causes the desired bioactivity (behavioral influence)?

Although the physics are known for describing the transport of pheromone plumes in forest canopies, the equations are extremely complex. The variables in the equation are 1) velocity of air in 3-D, 2) concentration of the scalar (pheromone) being transported, 3) pressure, 4) density (typically assumed constant), 5) viscosity (typically assumed constant), 6) molecular diffusivity (typically assumed constant and negligible), and 7) buoyancy (temperature change with height). Another factor in the equation is the drag that is represented by the forest canopy. However, even in the most sophisticated modeling, it is almost impossible to exactly describe the canopy. A description might include the canopy surface area, the distribution in space, flexibility (rigidity), surface characteristics, and temporal changes. Various assumptions in the description include the uniformity, horizontal uniformity and vertical variation, and randomization. Thistle then described a series of surrogate pheromone transport studies that have been conducted in various forest types (loblolly pine, lodgepole pine, ponderosa pine). The purpose of the work is to empirically provide the data that might be used to test equations derived in theory to describe pheromone plume structure in forests. The study conducted in a loblolly pine stand in Louisiana compared measurements taken under thinned and unthinned scenarios. The basic design of the study is to release a tracer gas (sulfur hexafluoride) and then measure the ambient concentration of the gas using syringe samplers or fast response analyzers located at 5, 10, and 30 m concentric rings, and at various heights. Simultaneously with these measurements, a wide range of meterological data are recorded (temperature, windspeed, humidity, etc.) in the research plots. The concentration of the $SF_6$ declined more precipitously with distance from the release point in the unthinned stand than in the thinned stand. The pheromone plume model demonstrates how the plume dispersion changes and the air movement increases as the stand is opened. In a dense, closed stand there is very little movement of the plume and is stays within the stand. As the spacing increases, more of the plume escapes to the upper atmosphere and out of the stand.

In some studies, the tracer gas was released as a series of puffs (every second). The behavior of the tracer gas in the forest was modeled based on a Gaussian model, and Thistle showed a series of concentration surfaces developed by using this model.
Thistle ended with a brief discussion of the papers published on this research, his thoughts about its impact, and plans for technology transfer.

**Graves**: The USDA-NRI-funded project, "Defining a mechanistic link in Jeffrey pine among stand thinning, drought, and risk of mortality from Jeffrey pine beetle, *Dendroctonus jeffreyi*," is a multidisciplinary program of research whose aim is to explore the mechanism that links drought stress of a pine tree to the success of a tree-killing bark beetle. Graves briefly reviewed the evidence for the correlation of drought stress of Jeffrey and related pines to the levels of bark beetle-caused tree mortality in California and Nevada. He introduced a proposed biochemical mechanism that connects drought stress of pines to resin defenses and carbohydrate levels that influence the colonization behavior and development of bark beetles. Methyl jasmonate and zeazanthin are two of the plant metabolites that are thought to be critical components of the drought-response mechanism.

The following key hypotheses were presented: 1) Increased stand density exacerbates drought stress and increases carbohydrate content (plant allocation) and free amino acids (drought stress) in bole subcortical tissue; 2) Moderate drought stress stimulates zeaxanthin and jasmonate production (leading to increased resin production) and with severe drought jasmonate production is highly stimulated, but resin exudation pressure is reduced; 3) Trees in thinned stands will have lower volatile organic compound (VOC) emissions (alkanes and monoterpenes); and 4) Trees in dense stands will have lower tissue palatability than trees in thinned stands, but will have higher beetle colonization density due to high VOC emissions and low resin exudation pressure.
The following four objectives were also presented: 1) Demonstrate how stand thinning influences tree drought stress and bole subcortical tissue quality; 2) Demonstrate how drought stress influences level of jasmonates, and both quantity and quality (monoterpenes, alkanes) of resins; 3) Demonstrate how drought stress influences foliar and bole VOC emissions; and 4) Demonstrate how VOC emissions, resins, and palatability influence colonization success of *D. jeffreyi*.

Graves described six experimental sites in California Jeffrey pine stands, in which groups of trees were classified as "thinned" or "unthinned" depending on the stand densities and competition experienced by the trees on the sites. He also described the entomological and physiological data that is being collected at these sites. Drought stress in individual trees is being assessed with sap-flow monitoring techniques, leaf water potential, and leaf turgor potential at solar noon. Foliar and bole emissions of VOC's are being collected from a subsample of trees within plots for chemical analyses (GC-MS). The production and chemical composition of resin are also being measured with similar techniques. The foliar and pigment content are being assessed with an emphasis on zeaxanthin and jasmonate levels in leaf and bole subcortical tissue, respectively. The tissue palatability of Jeffrey pine phloem is being determined by laboratory feeding assays with the Jeffrey pine beetle. Finally, the colonization density of Jeffrey pine beetle is being recorded and this is correlated in each plot on an index of drought stress.

A slide that solicited questions from the group prompted a discussion that focused on the specific hypotheses of this project. One participant (Thomas Karl, NCAR) was skeptical that thinned stands would have lower VOC emissions and this point was discussed. Graves responded that it was possible that although trees in lower density stands may have increased availability to water and nutrients and a higher temperature on the bole surface, in extreme drought situations, this may actually lead to a reduction in overall VOC emissions, particularly at the stand level. Another discussion topic involved the proposed differences in tissue quality in stressed versus highly stressed trees and how this might relate to bark beetle preference and palatability. Graves responded that it was likely that there was a threshold in tissue quality that was optimal for beetle development, but this may not represent the ideal habitat for the beetle because of other defense parameters in the tree. He proposed a scenario whereby a tree may have highly nutritious and abundant phloem that could be considered optimal for insect development, but that the quantity and quality of defensive resin might make it unlikely that the beetle could develop successfully. A follow-up question dealt with whether a healthy tree would be likely to have the best tissue for insect development. Graves responded that he thought that might be the case, but due to other conditions in the tree, a tree like this may not be considered optimal for colonization.

**Carroll**: Using the mountain pine beetle as a model, Carroll described how climate change and a historically large outbreak are interacting in lodgepole pines in British Columbia. Specifically, he posed the question about how mountain pine beetle is interacting with the carbon cycle and whether there might be some feedback between the outbreak and climate change. This scale of thought in this presentation was reminiscent of the BEACHON project described earlier in the session by Guenther.

Carroll presented a series of maps showing the course of the outbreak of mountain pine beetle since 1999, with the summary cumulative impact of 14 million ha (35.6 million acres) infested in B.C. as of 2007. This is the largest bark beetle outbreak in recorded history in the world. It encompasses much of central B.C. and his spread into eastern B.C. and western Alberta. From a December 2005 regional mountain pine beetle task force report, Carroll reported that at that time, 710 million $m^3$ in timber volume was infested. This is equivalent to about 12 yrs of harvest from the BC interior; over 5.5 times Canada's annual softwood lumber production (128 million

$m^3$/yr); the wood necessary to build 11.1 million homes (2500 $ft^2$); and 5.6 yrs of U.S. housing starts (based on 1.9 million homes built in 2003).

Carroll raised the question about whether this unprecedented outbreak arose from forest management issues or from climate change (or both). For the outbreak to occur, mountain pine beetle requires abundant susceptible hosts and a climate favoring its survival. At the beginning of the outbreak (perhaps because of fire suppression), the vast majority of the pine hosts in B.C. and Alberta were classified as “at risk” to mountain pine beetle, and this degree of susceptibility of the tree population was considered outside the range of natural variability. The susceptible trees were in the 80 to 160 yr age classes and the number of these trees at the beginning of the outbreak was three-times greater than it was in a historically reconstructed age distribution from 1910. The forest management strategies most responsible for this high degree of susceptible host type were fire suppression (less than 1% of the area burns currently compared to historical data) and selective logging (prior to 1970, lodgepole pine was considered a weedy species and was not harvested widely).

Carroll then reviewed the role of climate in the current mountain pine beetle outbreak. Temperature and precipitation data in B.C. since 1950 suggest that temperature has increased throughout the province by up to 2.5°C, but that precipitation has also increased on a percentage basis in most areas except the eastern and southeastern regions of the province. In an analysis of climatic suitability for mountain pine beetle between 1931 and 2000, the percentage of area in the extremely suitable class increased between 1971 and 2000 and this area was roughly contiguous with the outbreak region in south-central B.C. These effects were correlated with the regional range expansion of mountain pine beetle.

The presentation ended with a discussion of the impact of the mountain pine beetle outbreak on the carbon cycle (a preview of an upcoming paper published by Kurz et al. 2008, *Nature* 452:987–990) and a presentation of the hypothetical range expansion of mountain pine beetle into the boreal jack pine forest of the central Canadian provinces. A stand- and landscape-level model of forest carbon dynamics in B.C. derived by Kurz and colleagues (CBM·CFS3) accounts for carbon tied up in aboveground and belowground biomass, dead wood, litter, and soil carbon. This model accounts for all carbon stocks required under the Kyoto Protocol and IPCC Reporting Guidelines. Carroll showed a flow chart that illustrated how the three major sub-pools of carbon interacted with the atmosphere (biomass—i.e., living forest plant tissues; and variable and stable sub-pools of dead organic matter). A south-central B.C. study area of 374,000 $km^2$ of productive pine (and spruce) forest land was used to evaluate the impact of the outbreak on the carbon cycle. A Monte Carlo projection technique and past trends were used to predict the course of the outbreak through 2020. The conclusion was that the forests in question were net carbon sinks until 2002, but from 2003 to 2020 became a source of environmental carbon (mean estimated production of 17.6 megatons/yr). For comparison, the total emissions from fire between 1959 and 1999 for all of Canada was 27 megatons/yr. By 2020 the carbon cycle and carbon holding capacity of these mountain-pine-beetle-impacted forests were not projected to recover to pre-outbreak levels. This type of analysis suggests that if net insect disturbance increases due to climate change, then a positive feedback loop via the effect to the carbon cycle may pertain.

The invasion of the mountain pine beetle into western Alberta has placed the species in new contact with the hybrid zone for lodgepole and jack pines. This raises the potential for the movement of the insect along an invasion corridor through central Canada to eastern North America along the continuous jack pine distribution. Carroll explained that with the predicted levels of $CO_2$ to be released in this century, this corridor will have also increased climatic suitability for the mountain pine beetle.

Carroll concluded that the mountain pine beetle outbreak has been affected by climate change (i.e., there has been a net increase in disturbance); there have been large carbon emissions to the atmosphere (with peak impacts from the mountain pine beetle outbreak showing similar magnitude to fire for all of Canada from 1959-1999); there is a probably going to be feedback of outbreaks to future climate change; and there is likely going to be future eastern range expansion (and increased disturbance) of mountain pine beetle into forests and tree species that have not been exposed to this beetle in recent geologic time (if ever).

**Ragenovich** briefly summarized the session and thanked all contributors and discussion participants.

## Workshop II

## Media and Education

Dave Steinke and Shawna Crocker, moderators

**Dealing With the Media and Environmental Education**

**Dave Steinke** Public Affairs Specialist
USDA Forest Service, Rocky Mountain Region, Denver, CO

Some guidelines for effectively communicating to the public through the media are: focus on a few key issues rather than trying to deal with all aspects of a complicated subject. These key issues should be 2 or 3 “talking points”. Timing of information is an important issue. Old news isn’t really “news”, utilize “teachable moments" to get your message across. For complex or controversial topics consider using a communication plan. A communication plan will allow you to plan out who will be releasing information, what information will be released, and when that information will be released. Other considerations are who your target audience is, and anticipating what the public’s reaction will be. In general, some considerations of the conveyance of information to the public should be done as soon as possible and as freely as possible. If there is a sense that important information is being held back, it will create a negative attitude among the public and may induce the media to “go after” the source. Finally, use your Public Affairs professionals early and often. They are professionals who are there to make your job easier and can provide much help.

**Shawna Crocker** – Program Director, Project Learning Tree, Colorado State Forest Service, Fort Collins, CO

Project Learning Tree (PLT) is an environmental education program that is intended to reach K-12 educators in many states nationwide. Project Learning Tree was begun in Colorado in 1973, and this program has been coordinated by the Colorado State Forest Service since 1984. The program is delivered to an average of 500 teachers annually, which translates into approximately 15,000 students reached annually. PLT annually presents a series of training workshops that are between 3 and 16 hours long. Workshops are interactive and incorporate reading, technology and the input of topic specialists. Workshop participants may receive college credit for their involvement in Project learning Tree. PLT materials are continually revised to reflect changing trends in natural resource education.

## Wood borers: Trapping studies and identification aids

Moderator: Andris Eglitis, USDA Forest Service, Bend, OR

This session focused on a nationwide study of attractants for pine sawyers and on novel approaches to beetle taxonomy. The presentations, including a description of a screening aid for identifying buprestids, served as a springboard for additional discussions on the broad topic of wood borers.

### Smells of Pines and Engraver Beetles Attract Pine Sawyers and Many Close Friends

Dan Miller [1], Chris Asaro [2], Chris Crowe [1], Jim Meeker [3] and many others.
[1] USDA Forest Service, Southern Research Station, Athens GA
[2] Virginia Dept. Forestry, Charlottesville VA
[3] USDA Forest Service, Forest Health Protection - R8, Pineville LA

(presented by Dan Miller)

In southern pine forests, we found that southern pine sawyers, *Monochamus titillator*, were attracted to funnel traps baited with the host volatiles, ethanol and (–)-α-pinene, or the pine engraver pheromones, ipsenol and ipsdienol. We used wet cups containing RV antifreeze (ai. propylene glycol) with all traps as we had found that traps with dry cups containing dichlorvos kill strips caught 76% less *M. titillator* than traps with wet cups. In 2006, we found that combining all four compounds were more attractive than either of the two binary blends for *M. titillator*. In addition, the quaternary blend was attractive to many other species of bark and wood boring beetles. In 2007, we tested the quaternary blend against two binary blends (ethanol + (–)-α-pinene and ipsenol + ipsdienol) and found similar effects of the quaternary blend on attraction of 7 of the 8 North American species of *Monochamus* at ten locations in Canada and the United States. At all locations, traps baited the quaternary blend were attractive to many species of bark and wood boring beetles as well as their predators. Further trials in twelve more locations are planned for 2008. This study has been possible only because of the efforts of numerous collaborators which include representatives from all research stations, regions and many National Forests of USDA Forest Service; four research stations of the Canadian Forest Service; B.C. Ministry of Forests and Range; state agencies in five states; six universities in Canada and the United States.

## Uncorking the taxonomic "bottleneck" with digital imagery

James R. LaBonte
Oregon Department of Agriculture

There has been a drastic decline in the availability of taxonomic expertise for many groups of insects over the past few decades despite an unchanged or often increased need for that same expertise. For example, the national Early Detection/Rapid Response Program for Exotic Scolytinae, designed to detect newly introduced exotic wood boring insects (mainly ambrosia and bark beetles), produces large volumes of insects that need to be sorted and identified. The ED/RR Program uses non-specific lures (a necessity for dealing with broad taxa of potentially destructive invasive and transportable species) and many native or non-significant exotic insects are trapped that need to be screened efficiently and separated from the potential target species. The first several years of ED/RR survey revealed that more than 90% of the scolytines collected were common natives or non-significant exotics comprised of 10 species. This pattern held true throughout several regions of the U. S. although the particular species involved might change. As such, with proper diagnostic tools, these commonly trapped species could be presorted from the collection by non-taxonomists, leaving the questionable or less common individuals for identification by the specialist. While not addressing the ultimate problem of a deficient taxonomic infrastructure in the U. S., this is a much more efficient use of the existing taxonomic resources available for scolytine identification in the USA.

Development of such diagnostic aids by the Oregon Department of Agriculture is made possible through the use of extended depth of field images. These images are acquired with a highly sophisticated Leica camera system in conjunction with a high quality stereomicroscope. A series of images are acquired at all points throughout the depth of field of a specimen. These individual images are then collated via software to form a single composite image. The resulting image has extremely high resolution and can display critical diagnostic characters of the common species that are the targets of the screening aid. The images are used to illustrate all morphological characters of a dichotomous key to the target species. Strategically placed “action buttons” enable users to efficiently move throughout the key, particularly among non-sequential couplets and to return to originating couplets. A detailed explanation of one such screening aid for western Buprestidae follows in the next presentation.

The current screening aids are focused largely on the bark and ambrosia beetles from North America commonly trapped in the ED/RR survey including aids for the Eastern U. S., Pacific Northwest (including Alaska) and the Western USA. As discussed below, a similar aid has been developed for the western Buprestidae. A screening aid is under development for western

Cerambycidae. All these screening aids are designed to distinguish those species commonly trapped in ED/RR or other wood boring insect surveys from either exotic target species or uncommonly trapped species. More refinements and additional aids will be developed in the future, providing funding is available. CDs of current versions of all completed screening aids are available by request from the author.

## A Screening Aid for Identifying Western Buprestids

James R. LaBonte
Oregon Department of Agriculture

Using the hardware and software described above, a screening aid has been developed by the Oregon Department of Agriculture for western Buprestidae (commonly known as flat-headed or metallic wood boring beetles) that were abundant in traps used in ED/RR or other exotic wood boring insect surveys. The screening aid distinguishes buprestids from similar families and then provides a dichotomous key to target species that has all characters illustrated with extended depth of field images.

As with the screening aids mentioned above, this screening aid is not a comprehensive treatment of western U. S. buprestids. Instead, it is designed to enable efficient sorting and identification of the most abundant species found in wood boring insect trap samples from surveys conducted by the ODA and the USDA Forest Service in the Pacific Northwest and the West over the past ten years. This screening aid will be most reliable in the conifer forest regions west of the Rocky Mountains. It may not function well with species found in the desert West or east of the Rockies. Sixteen native species of buprestids are addressed by this screening aid. Several exotic pest species including the emerald ash borer (*Agrilus planipennis*) and the oak splendour beetle (*A. biguttatus*) are also included. This aid is designed so that any species other than the screening targets will end at a couplet with "NST", which equals "Not a Screening Target". NST specimens are NOT unimportant or to be discarded - quite the opposite! Any specimen that does not appear to be a screening target should be forwarded to a cooperating taxonomist for further identification. This aid is not intended to be used without taxonomic support.

If all goes according to schedule, a version of this screening aid will be available on a website sponsored by the Forest Health Enterprise Team (FHTET) by July 2008.

# Verbenone Discussion Group
# Breakout Session II

Ken Gibson
USDA Forest Service, FHP, Missoula, MT

Discussion group objective

Discuss what we do and don't know about verbenone; where it seems to work and where it doesn't; provide input to Tom Eager useful in finalizing his verbenone "white paper."

Introduction

Verbenone is a pheromone that is important in the chemical communication system of several economically important bark beetle species. It plays a role in the natural colonization of host trees, specifically in the mediation of mass attack so that optimum attack densities are achieved by the beetles. It has been categorized as an *anti-aggregant* because in the process of mass attack it causes attacking beetles to spread out to take advantage of the entire surface of the prospective host tree. Later in the attack sequence, the release of larger amounts of verbenone by the beetles results in newly arriving beetles being repelled from the host and being forced to attack other hosts. Thus, in these latter stages of host colonization, verbenone serves to send the message that the host is fully occupied and is no longer suitable for further occupation.

Recognition of the function of verbenone as an anti-aggregant in the latter stages of host tree colonization has been the basis of much work to deter bark beetles from attacking host trees. In many cases, field trials have been successful at preventing attack of potentially susceptible host trees. However, in many other cases verbenone failed to protect the target hosts. In a number of instances, the successes and failures occurred in the same locations, in the same time frame, and under highly comparable conditions. In some situations, a slight alteration in the conditions of the study has resulted in great differences in the results. In other situations the source of variations in results are unknown, and analysis has had to rely on speculation. **The lack of consistency in the results of many verbenone trials has been a source of great frustration to individuals undertaking these trials as well as to the bark beetle research community as a whole.** (Eager, Tom. 2006. "History and Prospects for Using Verbenone to Manage Bark Beetles")

History of verbenone testing in the West

Early tests of 0.5-gram bubble capsules (up to 68 per acre), in 1988 and 1989 in both LPP and PP stands, showed promising, but mixed, results in protecting trees from mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (MPB) attack. For the next several years, up to and including 1993, we conducted one kind of verbenone test or another: we tested it in both PP and LPP stands, we used hand applications of bubble capsules at several rates, and ever tested aerial applications of verbenone-impregnated beads. By about 1994, we had pretty much decided results were variable enough we couldn't justify its continued use! During the mid-1990s, MPB populations were relatively low—and there wasn't much interest in verbenone and MPB (at least in the Northern Region). In the meantime, Ron Billings and others were finding some success using much higher doses of verbenone against SPB.

In 2000, Rob Progar instituted a test against building MPB populations in central ID, using the relatively new 5-gram verbenone pouch that Pherotech was then manufacturing. Noting some success in Rob's project, we (Northern Region, FHP) initiated an "area" test in LPP in building MPB populations in western MT and WBP stands in northern ID. Since then, we have had a yearly verbenone test of one-kind or another in LPP, PP, and WBP stands in our Region—and others have been conducted throughout western US and Canada. We've looked at a couple of different verbenone pouches, singly and coupled with varying combinations of GLVs. I think it safe to say, after 7-8 years of fairly rigorous testing—and not a minor amount of operational use; if someone were to ask any of us if verbenone protects host trees from MPB attack, we would have to honestly reply, "Sometimes!" A "silver bullet" verbenone is not!

Questions pertaining to verbenone's use

1. Does verbenone work well enough, consistently enough, that we should be recommending its use to protect MPB hosts from attack?

2. If so, when and how much? Individual-tree protection: 2 or more pouches per tree? Area protection: 20, 30, 40 pouches per acre? Does it depend on beetle population? Do we need to replace pouches at mid-season?

3. Are there certain population levels—infestation thresholds—where we shouldn't be recommending the use of verbenone?

4. Can we significantly increase the effectiveness of verbenone by removing currently infested trees in conjunction with its use?

5. If we can't remove infested trees, are we wasting our time (and money) using verbenone?

6. Can we enhance verbenone's effectiveness by using GLVs in conjunction with it? What GLVs are most effective? Do they work well enough that we should make that part of a standard recommendation? If so, what are NEPA requirements for using GLVs? Do we know?

7. What about "push-pull" strategies? Does verbenone work better at "pushing" beetles if we are "pulling" them somewhere with tree baits or traps?

8. Tom, and others, have on occasion suggested we need more oversight in the testing and operational use of verbenone. Do we? How would something like that be administered? Is it too late—is the "genie" already out of the bottle?

9. We've concentrated on protecting MPB hosts with verbenone. Are there other bark beetles for which it either works or bears testing? We know it seems to work relatively

well against SPB, we've tested it against *Ips* spp—with very inconsistent results; others have looked at it against WPB. Others? Optimism?

Discussion

Perception remains that verbenone is not consistently reliable. In some places, at some times, and under proper circumstances, it works relatively well. At other times results are disappointing. Following points were brought out as discussion ensued.

1. Does verbenone protect MPB hosts from infestation? Most agree where there are no alternatives (carbaryl treatments, silvicultural manipulations), using verbenone is better than doing nothing.

   Most of the time, individual-tree protection is good—typically 80% or greater. "Area" protection seems to be less so. However, Nancy Gillette has had promising results in area tests with verbenone impregnated flakes; and it is her belief, the larger the area, the greater the likelihood of success.

2. "Area" protection was evaluated in the Northern Region, in 2001, using 5-gram pouches. Based on Ian Wilson's work in Canada, we used 40 pouches per acre (about 10-meter grid). Results were quite satisfactory, so in 2002 we compared 20 (about a 15-meter grid) to 40 pouches per acre. Results were equally good, so we began recommending 20 pouches per acre for area treatments. In other parts of western US, recommendations have been for higher application rates. John Borden suggested 20-40, 5-gram pouches per acre should work well, most of the time. And they did until subjected to unusually warm summers. In those conditions, 5-gram pouches were depleted before beetle flight was over. The newer 7.0- and 7.5-gram pouches have performed much better. Warmer summers and milder winters may also be producing variability in MPB life cycle—early emergence, late flights, etc. Even with larger pouches, may need more than one application per season—depending on seasonal weather.

   The question is not so much how many pouches per acre to use, but what is the source of verbenone's inconsistency. It may be a function of both the behavior of beetles and verbenone under varying conditions.

   Tom suggested verbenone can be considered a "tool" on a continuum of short-term effective protection using cabaryl, compared to long-term, stand-altering treatments using silvicultural techniques. Verbenone may be thought of as somewhere in between those two extremes—and may be more effectively used as a part of integrated, long-term strategy to reduce beetle-caused mortality. Because of the inherent variability entailed in using verbenone under vastly different conditions, some suggest that its use may always require as much "art" as "science."

   One of the things we don't do well enough is follow up on verbenone use. We should not only make sure it is used under proper circumstances, we should also evaluate where and when it is used, to make sure its use has met management objectives.

Economic considerations are also important in using verbenone. It is much more expensive (than MCH, e.g.), and we need to make sure we are getting appropriate returns on our investments. Verbenone demand is high now, but may decline as MPB hosts are depleted. Verbenone will always be fairly expensive to produce and use—mostly because of much higher quantities required. Economics also suggest verbenone's indefinite use in a particular area may be inappropriate.

3. Are there situations where we should not be using verbenone at all? Rob's data suggest using verbenone year after year in the same area—where beetle populations are high—will likely result in disappointments. His studies showed favorable results initially, poorer results in succeeding years. Was that a function of stand conditions, beetle populations, weather? Not sure… If verbenone is not going to protect trees thru an outbreak, should its use be initiated at all?

4. Using verbenone as part of an IPM program. John's work over the past few years suggests if we can't remove infested trees in conjunction with verbenone use, chances of success are greatly diminished. If more than 15% of the stand to be protected is currently infested, and most to all infested trees cannot be removed before beetle flight, treatment results may be disappointing. (Note: Rob is initiating a multi-Region [US] test to measure the effect of removing infested trees in conjunction with verbenone use. Data collected should provide support for John's proposals regarding the benefit of removing infested trees as a means of increasing verbenone's effectiveness.)

   We should consider verbenone a stop-gap measure, not a long-term fix. In AZ, FHP requires those receiving funds to use verbenone have a long-term management plan in place. Perhaps we should not be supporting verbenone projects unless managers are committed to long-term stand management. That could imply there will be places where we should not be recommending use of verbenone.

   Some "unconventional" uses of verbenone: Lorraine used verbenone to protect young stands (20 years old) of LPP regeneration. Use was mostly satisfactory. We are also using verbenone, mostly successfully, to protect high-elevation WBP "plus" trees that are becoming valuable in restoring WBP stands devastated by both MPB and blister rust. In 2007, verbenone was used to protect individual second-growth PP with some success.

   A question arose about verbenone attracting MPB at low levels. Both John and Dave (Wakarchuk) agreed that most data suggest that is a non-issue. It appears not to be enough of a concern that removal of pouches towards the end of beetle flight, for example, would be necessary.

5. Can we enhance verb by using GLVs? Results to date have not been conclusive, but promising. Tests conducted this year MT showed good success using a combination of verbenone and GLV (50:50 blend of hexenol and hexanol). GLV much less expensive than verbenone, and because of their benign properties shouldn't be many roadblocks to

getting them registered. Those hoops will have to be jumped thru, but testing of GLVs should be continued.

6. Merit of push-pull strategy? This seems to be a very attractive alternative—pulling beetles (with attractant pheromones in traps or as tree baits) out of an area we are trying to protect (with verbenone). Such projects can make for extremely difficult-to-design experiments; but in theory, they should work fairly well. John's operational uses, recommendations, and studies are promising.

7. Do we need more "administrative oversight" in the operational use of verbenone? We have been using verbenone operationally now for several years and we haven't always evaluated the effectiveness of those uses as well as we should have. In the Southeast, monitoring and oversight procedures have been relatively well developed by keeping track of where and when verbenone was used and evaluating its performance. Is there a place for manual instructions on oversight? Would that reflect how verbenone uses might change with changing levels of MPB populations?

## Conclusions

- Verbenone is not, and never will be a "silver bullet," but we can recommend its use with appropriate reservations and caveats.
- There are places where we can reasonably use verbenone, and others where it may not be appropriate.
- We should use our expertise to provide more oversight to verbenone's use.
- There seems to be the possibility of enhancing verbenone's effectiveness thru the use of GLVs.
- Economics should be more of an issue in verbenone's use than it appears to be.
- Is verbenone effective against other bark beetles? Some evidence that may be the case; but much more testing needs to be done.
- We concluded a "User's Guide" for verbenone may be some time in developing. Perhaps a good topic for Western Bark Beetle Working Group to undertake.

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## Symbiosis: A key driver of cross-scale interactions

Moderators: Kenneth Raffa and Diana Six

All organisms are involved in symbioses. Symbioses are now recognized as major drivers in evolution and in determining the structure and composition biological communities. Symbioses are of critical importance in forest ecosystems. Indeed, some of the most important forest insects have attained pest status because of their partnering with mutualistic microbes which has allowed them to excel in what otherwise would be marginal habitats, to exploit new niches, to avoid competition, and to buffer environmental variability. In this workshop, we explore how symbiotic interactions affect and influence insect hosts, other symbionts, host trees, and host natural enemies in forest ecosystems.

## Bacterial associates of bark beetles: The little dictators of insect-fungal interactions that drive landscape-level processes

Aaron S. Adams and Kenneth F. Raffa
University of Wisconsin, Madison, WI

Bark beetles are major disturbance agents in forest ecosystems, and provide an ideal system for studying cross-scale interactions. They are ecosystem engineers at landscape levels, yet their populations are largely driven by microscale processes. In particular, their abilities to overcome tree defenses and colonize the relatively nutrient poor subcortical environment of the host tree rely upon mutualism with fungi. As parent beetles tunnel egg galleries in the tree phloem, they vector fungus propagules that germinate and penetrate the host. Brood feed on fungus-colonized phloem. This symbiosis relies on brood contact with fungus propagules after pupation for transport by emerging adults. Other, opportunistic fungi such as *Trichoderma* and *Aspergillus* are highly antagonistic to the beetles. We found that the bacterial assemblage associated with both bark beetles and the host tree impact the growth of these symbiotic and opportunistic fungi. Volatiles from bacteria isolated from the bark beetles *Dendroctonus valens* and *Ips grandicollis* stimulated the growth or spore production of their symbionts, *Leptographium terebrantis* and *Ophiostoma montium*. Several of beetle-associated bacteria inhibited the antagonistic fungi. Host trees play an important role in bacterial-fungal-bark beetle interactions by two mechanisms. First, their allelochemicals affect the strength and direction of the above relationships. Second, endophytic bacteria isolated from defensively induced tree tissues inhibited *L. terebrantis* and three opportunistic fungi. We hypothesize that bacteria associated with bark beetles provide a mechanism which improves the reliability of the beetle-fungus association. Conversely, endophytic bacteria may serve as an additional defensive mechanism against the beetle-fungus complex.

## Interactions of *O. clavigerum,* a tree pathogen associated with MPB, with lodgepole pine defense metabolites

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*Ophiostoma clavigerum* (Robinson-Jeffrey & Davidson) Harrington, is a lodgepole pine pathogen and staining fungus that is specifically associated with the bark beetle *Dendroctonus ponderosae* (Mountain Pine Beetle, MPB). Lodgepole pine defenses include the biosynthesis of terpenoids and phenolics, some of which may be toxic to MPBs and MPB-associated fungi. The wide diversity of host tree defense compounds may be due to host-vector-pathogen co-adaptation. Therefore understanding the mechanisms by which such defenses affect microorganisms is important for understanding the complex network of interactions between *O. clavigerum*, its MPB vector and the lodgepole pine host. Little is known about such mechanisms. To address this, we identified *O. clavigerum* genes that were differentially regulated during the earliest stages of host colonization, when fungi encounter the significant constitutive oleoresin response, by transcriptional profiling of *O. clavigerum* mycelia that were exposed to selected oleoresin terpenoids. In this presentation I will discuss this transcriptional profiling in the context of the current draft genome assembly of the fungal pathogen, and insights we have generated into the relationship between host and pathogen.

## Psyllids, it's what's inside that counts

Allison Hansen and Timothy Paine
Department of Entomology, University of California, Riverside, CA

The diversity, occurrence, and effects of bacterial endosymbionts harbored within insects are largely unknown. Despite the prevalence of endosymbionts throughout many insect orders, little is known about the role and maintenance of endosymbionts within insect hosts. Two psyllid-bacterial endosymbiont symbioses that are important pests in urban forestry and agriculture have been genetically characterized. For one of these psyllid species, research was conducted on a landscape level in California. Field data reveal that secondary (i.e. the endosymbiont is facultative to the insect host) endosymbiont infection frequencies among psyllid populations varied dramatically from 0-75%, and were significantly related to parasitism pressure by a solitary endoparasitoid of the psyllid. Potential implications of these results show that the psyllid harbored secondary endosymbiont may confer resistance to the introduced parasitoid biocontrol agent for the psyllid. In regard to the second psyllid-bacterial endosymbiont symbiosis, a novel bacterial endosymbiont was discovered that could mediate important interactions with a wide array of host plants.

## Have phoretic mites influenced the evolution of insect-microbial symbiosis in bark beetle systems?

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Although mites are often believed to be passive inhabitants of bark beetle communities, we now know that they can have strong interactions with non-mite species, are major components of biological diversity, and can impact bark beetle population dynamics and fungal interactions. We have identified over 110 species of phoretic mites on bark beetles in the western U.S. Of which, approximately 35% are likely predaceous on beetle eggs or larvae or other mites and nematodes, 15% are believed to feed on fungi and other microbes while the remaining 50% have unknown feeding preferences and behaviors. Here, we discuss the ecological and evolutionary role of mycophaous mite species in shaping beetle-fungal relations. The relative strength and importance of most mutalisms vary temporally and spatially with respect to the extent that they confer reciprocal benefit. The mutualism(s) between tree killing-bark beetles and fungi allow beetles to utilize resources within a habitat that would be inaccessible without each other. However such associations may have evolved indirectly via continual introduction by mite-fungal mutualisms. Phoretic species and mutualists competing for access to beetles is likely a very dynamic process and have changed over both ecological and evolutionary time and at multiple spatial scales. Ecological strategies of mites and fungi and their relationships will be discussed in the context of their association with bark beetles.

### Geographic variation in the fungal symbiont community of the southern pine beetle

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Many bark beetles are associated with communities of fungi. The southern pine beetle, *Dendroctonus frontalis*, is known to be associated with two mutualistic mycangial fungi and one antagonistic phoretic fungus. All descriptions of fungi from this beetle have been made from beetles in the southeastern US. However, this beetle also occurs in two other regions, the southwestern US and central southern Mexico/northern Central America. The three populations of the beetle exist in areas with distinctly different host trees and climates and likely little to no gene flow likely occurs among them. We speculated that long term separation of the three populations as well as different physical and biological environments may have acted to alter symbiont community compositions. To address this question, we isolated fungi from beetles from each population. The fungi were grouped by morphology and then subsamples from each morpho-group were sequenced to confirm identifications. We found striking differences in phoretic fungi among populations. *Ophiostoma minus*, which is a common antagonist in the southeast was lacking in Mexico. The phoretic associate of the beetle in Mexico, *O. pulvinisporum*, was likewise lacking in the southeast. In Arizona, *O. pulvinisporum, O. minus* and *O. ips* were common phoretic associates. *O. ips* was also common in the southeast. Closely related *Ceratocystiopsis* were present in beetle mycangia in all three populations. *Entomocorticum*, another mycangial associate, may be lacking in Mexico. Given that these associates have strong influences on their hosts, the varied nature of the fungal communities with this beetle may have major implications for beetle population dynamics in the three regions.

## Workshop III

## Remote Sensing

Jim Ellenwood, moderator
USDA Forest Service Forest Health Technology Enterprise Team, Fort Collins, CO

### Latest Developments in Automated Mortality Sampling from High Resolution Imagery

Arpad Lazar, ITX, Inc.,
USDA Forest Service Forest Health Technology Enterprise Team, Fort Collins, CO

A widespread Mountain Pine Beetle infestation in the Rocky Mountain region has resulted in extensive tree mortality. Accurate estimates of tree mortality can help with assessments of a variety of ecosystem related parameters. This study is a collaborative effort between the USDA Forest Service's Rocky Mountain Research Station (RMRS) and the Forest Health Technology Enterprise Team (FHTET) and is focused on developing methods for extracting tree mortality estimates from aerial remote sensing of the Fraser Experimental Forest.

## Western Spruce Budworm and Northern Spotted Owl - Long-Term Change Detection Study

Vern Thomas, ITX, Inc.,
USDA Forest Service Forest Health Technology Enterprise Team, Fort Collins, CO

A 19-year period of western spruce budworm (Choristoneura occidentalis) defoliation of coniferous forests on the eastern slopes of the Cascade Mountains in southcentral Washington is being analyzed for effects on northern spotted owl (Strix occidentalis caurina) populations and their habitat. Analysis includes the use of Region 6 annual insect and disease aerial survey data, owl demographic data, forest inventory plot data (USDA Forest Service R6 Current Vegetation Survey (CVS) and USDA Forest Service Forest Inventory Analysis (FIA), and satellite image-based change detection analysis. Landsat 5 Thematic Mapper images of pre-defoliation (1985) and ongoing/post-defoliation (2003) vegetation conditions are being characterized and analyzed for similarities and differences. Relationships among vegetation conditions, disturbance history, and owl demography are being examined for trends and associations that characterize the effects and interrelationships of western spruce budworm defoliation, vegetation conditions, spotted owl populations, and other associated disturbances.

## Development of the Next Generation Risk Map for 2010

Frank Krist and Jim Ellenwood
USDA Forest Service Forest Health Technology Enterprise Team, Fort Collins, CO

The USFS has begun work on a next generation national risk map at a 30-meter resolution to facilitate local and regional planning efforts. In support of this project, forest parameter datasets of basal area and trees per acre are being developed for more than 175 tree species using ground inventory data and 52 national data layers ranging from three-season Landsat 7 imagery to local soil information. To develop models of forest parameters by tree species, USFS Forest Inventory and Analysis (FIA) data are linked to each national data layer and analyzed within Cubist data mining software (Rulequest 2007). Model outputs are converted to a 30-meter spatial dataset using ERDAS Imagine software. Using a multi-criteria modeling approach, susceptibility and vulnerability models can be developed for a wide range of forest pest species. With more detailed data, models can be refined to better represent field conditions.

## Native Plant and Invasive Plant Biological Control

Moderator Carol Randall, USFS FHP Coeur d'Alene, Idaho

### Presenters and Abstracts:

Dan Bean, Colorado Department of Agriculture, Palisade Insectary Director

Established in 1945 the Palisade Insectary is focused on biological pest control. The work of the Insectary involves the importing, rearing, establishing, and colonizing of new beneficial organisms for control of specific plant and insect pests that are detrimental to agricultural industries and urban areas. The results of successful biological pest control are reduced production costs, decreased amounts of chemicals entering the environment, and established colonies of beneficial insects offering a natural permanent pest control solution. This program offers the citizens of Colorado a useful alternative to the use of chemicals for control of specific pests. In this presentation current insectary programs were presented and opportunities for collaboration discussed.

Bob Hammon, Colorado Tri River Area Extension Agent

Mr. Hammon is an extension agent who deals with a variety of topics including biological control of field bindweed and the identification of insects affecting seed production of native plants. In his talk Bob discussed some of the work he has been doing with commercial producers of native seed and the challenges he has encountered when these plants are grown in a production system. Insects which normally do not impact the plants significantly when grown naturally suddenly become significant pests and require new and innovative approaches to insure a profitable seed crop can be produced. The implications of Bob's work from a biological control perspective were discussed.

Joe Milan, Bureau of Land Management / Idaho State Department of Agriculture Biological Control Coordinator for the State of Idaho-

Idaho is beginning to develop a sophisticated biological control of invasive plants program and recently Joe Milan became the first statewide biological control of noxious weed program manager. In this talk Joe discussed Idaho's new statewide monitoring program for biological control of weeds.

## Molecular Techniques and Forest Insects

Moderator: Chris I. Keeling
Michael Smith Laboratories, University of British Columbia, Vancouver, BC, Canada

The available genomic resources and molecular tools for exploring forest insects are expanding rapidly and are increasingly being used to place our extensive biological understanding of forest insects into context at the molecular level. Several insect genomes have been, and are being, sequenced. However, a genome for a forest insect pest has yet to be sequenced. Fortunately, transcriptome sequencing projects are filling this gap with a few forest insects. Significant genomic resources do exist for tree species, such as the Poplar genome and the large transcriptome resources in pine and spruce. In addition, the genomes of fungal associates are becoming available. Both of these non-insect resources provide complementary information to the insect resources for studying plant-insect and insect-microbe interactions at the molecular level. The speakers in this session discussed some of their recent progress in applying molecular tools and genomic resources to the study of forest insects, their associated fungi, and their host trees. In particular, the speakers discussed progress in understanding the population genetics, the functional genomics of pheromone biosynthesis, the detoxification of host defense chemicals, and the genomics of plant-insect and insect-microbe interactions of conifer insect pests.

## Large-scale genomics projects of the white pine weevil-spruce tree and the mountain pine beetle-pine tree-blue stain fungus systems

Chris I. Keeling
Michael Smith Laboratories, University of British Columbia, Vancouver, BC, Canada

An overview will be given of two large-scale genome projects currently in progress in Canada that are investigating conifer-insect interactions.

(1) *Treenomix II: Conifer forest health* (www.treenomix.ca) is a large-scale Genome BC-funded project to develop and apply new knowledge and tools from conifer genomics to spruce breeding programs. The areas of research include comparative genomics, functional genomics of conifer defence, conifer adaptation to climate, and the issues of genomics and society. In this presentation I will briefly describe the progress in the functional characterization of the large gene family of spruce terpene synthases, including the 3-carene synthases in Sitka spruce, for which the enzyme products appear to be correlated with the white pine weevil resistance rating of specific spruce genotypes in BC.

(2) *Mountain pine beetle epidemic: Phase I* is a large-scale Genome BC and Genome AB-funded project to use genomics of the interacting bark beetles, fungal pathogens and host pine trees to improve forest ecological risk models. This two-year interdisciplinary project, which started in Jan. 2008, will deliver valuable genomic resources including a complete genome sequence for the fungal associate, *Ophiostoma clavigerum*, and sequences of expressed genes in the beetle and in lodgepole and jack pine. The sequence information will be used to identify genes involved in control and timing of fungal spore germination, detoxification of the host tree's secondary defense metabolites by the fungi and beetle, beetle pheromone biosynthesis and olfaction, insect cold tolerance physiology, and in the chemical and physical defence responses of the pines. The new sequence data will also aid development of genetic population markers to support detailed tracking of specific traits important to the spread of the epidemic. The information from Phase I will be used to support Phase II research on specific aspects of the physiology and population genetics of the interacting organisms, and will be used to support better predictive models for understanding the spread of the epidemic.

**The use of molecular techniques to inform our understanding of insect-fungal associations**

Diana L. Six
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Many forest and woodland insects are mutualistically associated with fungi. These include bark beetles, ambrosia beetles, *Sirex* wood wasps, attine ants, and *Macrotermes* termites. Mutualisms with fungi allow these insects to succeed in what would otherwise be marginal habitats. Indeed, mutualisms with fungi have allowed many of these insects to become so successful that many are considered serious pests. While many of the insect partners have been intensively studied, the fungal partners have often been ignored or treated only superficially. In part, this has been due to the difficult nature of reliably determining the identity of the fungal associates. However, with the advent of advanced molecular techniques we now have a multitude of tools to not only identify the fungi with confidence, but also to look at population structure, gene flow, and evolutionary patterns with the host. Here I present examples of the value of using molecular techniques in studying insect-fungal symbioses using the following systems:

1. Characterization of fungi (and detection of cryptic species) associated with bark beetles (southern pine beetle, lodgepole pine beetle)
2. Development of phylogenies of fungal associates to inform our understanding of the origins and evolution of insect-fungus symbioses (*Sirex* wood wasps, bark and ambrosia beetles)
3. Population genetics and movement of fungal genotypes (mountain pine beetle in the context of range expansion due to climate change, red turpentine beetle introductions into China, ambrosia beetle introductions into North America)

**Pre- and post-genomic studies on pheromone production in the pine engraver beetle and an update on genomic studies in the mountain pine beetle**

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Midgut tissue of pine bark beetles produce many of the pheromone components that direct the mass attacks that are necessary to successfully colonize trees. In *Ips pini*, a modest expressed sequence tag (EST) project yielded 574 tentative unique genes (TUGs). Microarray studies showed that both feeding and application of juvenile hormone up-regulated the mevalonate pathway genes and other genes potentially involved in ipsdienol pheromone production, and the regulation of many of these genes was confirmed with qRT-PCR. Further characterization of these genes allowed the description of the first geranyl diphosphate synthase from an animal, and showed that this unique gene had both geranyl diphosphate and myrcene synthase activity. A highly up-regulated cytochrome P450 (CYP9T2) was functionally expressed and shown to hydroxylate myrcene to ipsdienol. However, the product of this gene was an 81:19 (–/+) mixture of ipsdienol, and not the expected 95:5 (–/+) mixture. An examination of the oxidoreductases showed one that was up-regulated similar to genes involved in pheromone production, and expression and characterization of this gene showed that it oxidized ipsdienol to ipsdienone. The use of genomics allowed the rapid isolation and characterization of nearly all the genes involved in pheromone production in *I. pini*. A similar, more extensive study is underway in the mountain pine beetle, *Dendroctonus ponderosae*. From 12,073 ESTs, 4,034 TUGS have been isolated, and microarrays are being developed to examine the genes involved in pheromone production. Major pheromone components in the mountain pine beetle include verbenone, *exo*-brevicomin and frontalin. To date, a cytochrome P450 that hydroxylates $\alpha$-pinene to verbenol has been isolated and expressed. Based on our experience with *I. pini* pheromone production, we expect rapid progress in describing and characterizing the genes involved in pheromone production in the mountain pine beetle. Preliminary RNAi studies in both *I. pini* and *D. ponderosae* suggest that this technique has great potential for silencing selective genes to study pheromone production, and may have potential in insect control.

## Challenges in assembling a genome sequence for *Ophiostoma clavigerum* using new sequencing technologies

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*Ophiostoma clavigerum* (Robinson-Jeffrey & Davidson) Harington is the primary pathogen of lodgepole pine, and is vectored by the Mountain Pine Beetle (MPB, *Dendroctonus Ponderosae*). The MPB is a polyphagous, scolytid bark beetle currently infesting lodgepole pine forests in British Columbia and Alberta, Canada, over an area the size of England. A prerequisite for fully characterizing the relationships of *O. clavigerum* with its vector MPB and lodgepole pine host is generating a reference genomic sequence for the fungus. Recent technological advances in DNA sequencing have made it possible to generate genomic sequence data rapidly and cost-effectively. We used a hybrid approach that combined the strengths of Sanger sequencing and second generation sequencing technologies from Illumina and Roche (454 Life Sciences) to generate a draft genome sequence for *O. clavigerum*. While the new sequencing technologies produce large amounts of sequence data in each run, their short read lengths complicate genome assembly. In this presentation I will discuss some of the challenges faced by researchers who seek to take advantage of the large amounts of data generated by the current second generation sequencing technologies.

## Bark Beetle Research Updates
## Breakout Session III

Moderators: Dan Miller, USDA Forest Service, Southern Research Station, Athens GA and Brytten Steed, USDA Forest Service, FHP Northern Region, Missoula MT.

Attendance was strong with 50-60 participants and 40-50% participation in a round-table format. Both management and research interests were raised, with comments offered by a diverse group of participant. Attendees hailed from both the Canadian and United States Forest Service research and management branches, as well as state/provincial agencies, universities and commercial companies with new university students and retired professionals in the audience. Comments offered by participants at the conclusion of the session, suggest that the informal round-table format for a concurrent workshop is a welcomed alternative to presentation-based workshops.

Specific topics identified by participants included pine engravers, mountain pine beetle (MPB), Jeffrey pine beetle, western pine beetle, spruce beetle, Douglas-fir beetle, southern pine beetle, roundheaded pine beetle, work covering multiple species, and exotic species. Past, present, and future studies were described, covering a broad range of issues such as:

- Semiochemicals and silvicultural treatments (verbenone was covered in previous session);
- Efficacy of systemic insecticide injections;
- Bark beetle species interactions, especially as they might relate to beetle outbreaks;
- Expansion of bark beetle activity into new host trees (MPB reproduction in spruce) or new ranges (spruce beetle expanding across the boreal forest);
- Role and identification of mite and fungal symbionts;
- Genetics of bark beetles and their symbionts; and
- Exotic species (particularly in California).

One particular topic that received much discussion was the importance of monitoring and continued research related to current bark beetle activity and the effectiveness of suppression and prevention techniques. Assumptions based on data from previous outbreaks (esp. MPB) should be re-evaluated due to the differences in current environmental conditions (stand structures, weather/climate patterns) and socioeconomic factors (management constraints, urban encroachment, need for water, etc.). Everything old is new again!

## Graduate Student Presentations

Moderator: Steve Seybold
Location: Millennium Room

Discussion Contributors: Seth Davis (NAU-Flagstaff), Amanda Garcia (NAU-Flagstaff), Honey-Marie Giroday (UNBC-Prince George), Fraser R. McKee (UNBC-Prince George), and Ryan Bracewell (Utah State University)

Participants: Gary Blomquist, John Borden, Don Bright, Allan Carroll, Steve Clarke, Danny Cluck, Tom Coleman, Valerie DeBlander, Peter DeGroot, Scott Diguistini, Tim Ebata, Tom

Eckberg, Armando Equihua-Martinez, Monica Gaylord, Don Grosman, Andy Graves, Liz Hebertson, Don Heppner, Bruce Hostetler, Terri Howlett, Chris Keeling, Colleen Keyes, Glenn Kohler, Dan Miller, John Moser, Don Owen, Iral Ragenovich, David Quiroz-Reygadas, Jim Rineholt, Terry Shore, Bruce Thomson, Mike Wagner, Dave Wood. Total number of attendees was 40 (some participants were not recorded).

### 1. Interspecific interactions among two primary bark beetles

Seth Davis, Rich W. Hofstetter, Kier D. Klepzig
Northern Arizona University, School of Forestry

Davis presented his research on the co-occurrence of western pine beetle, *Dendroctonus brevicomis*, and southern pine beetle, *Dendroctonus frontalis*, in ponderosa pine, *Pinus ponderosa*, in Arizona. A survey of naturally infested trees revealed that both species are found in the same host tree. The fitness impacts of the two species co-colonizing a single host were minimal as fecundity was more affected by the presence of conspecifics than heterospecifics. In experimental studies, the impacts of adult gallery density and parent species ratio affected each beetle species differently. In Arizona, these two species apparently synergize during host finding and attack, but their populations remain endemic via density dependant interspecific interactions. Future research may explore how co-colonization may act as a mechanism for long term population stability or coexistence.

### 2. Effects of burn season and fire injury on the quantity and quality of ponderosa pine resin

A.M. Garcia[1], R. Hofstetter[1], and S.L. Smith[2]
[1] Northern AZ University, School of Forestry, Flagstaff, AZ 86001
[2] USDA Forest Service, Region 5 Forest Health Protection, Susanville, CA 96130

The structure and function of ponderosa pine forests have been highly modified from their presettlement condition by past management practices including fire exclusion, logging, and heavy grazing. Thinning and prescribed burn treatments are being implemented to reduce the likelihood of stand replacing wildfires and to reduce the threat of unacceptable levels of bark beetle caused tree mortality. Little information is available on how bark beetles will respond to the increased use of fire; in particular, how fire seasonality and severity may alter host resistance to bark beetles (Coleoptera: Scolytinae). We investigated the response in tree resin quantity and quality for two years following spring and fall burns in eastside pine stands on three National Forests in northern California. Monoterpene composition of xylem resin was analyzed in all treatments. In a trapping study, we also investigated western pine beetle attraction to resin collected from trees with no fire injury and those with high or low crown injury from fire. These studies will provide information on attack behavior and bark beetle caused tree mortality following prescribed fires.

**3. Effect of terrain on insect deposition and population establishment in northeastern British Columbia**

Honey-Marie Giroday, Brian H. Aukema
University of Northern British Columbia

This presentation focused on the mechanism for dispersal and establishment of the mountain pine beetle, *Dendroctonus ponderosae*, in an area of British Columbia to the east of its native range. Dispersal of the beetle is affected by wind speed, wind direction, and turbulence; establishment of the beetle is affected by land formations, susceptible hosts, and climate. Two questions that guided the research are: 1) Are the distributions of infestations uniform relative to susceptible habitat? and 2) Are the infestations associated with specific landforms? Using GIS data on infestation inventory, landforms, and stand susceptibility classes (0-5), Giroday analyzed the effects of habitat susceptibility and landform on the likelihood of infestation. She found that establishment patterns were influenced by habitat susceptibility. For example, less area was infested when the stands were of very low susceptibility (Class 0), but there was a variable trend in infestation of stands with low to high susceptibility (Class 1-5). However, stand susceptibility was not an absolute driving factor in determining establishment. She also found that the pattern of establishment was significantly different from uniform relative to landforms. For example, there was more establishment in U-shaped valleys and canyons, and less infestation on open slopes and plains. Ongoing research will model establishment patterns by using data on landform and susceptibility classes, microclimate, west-east gradients, and distance from infestations of the previous year. She is also investigating the contribution of long distance and short distance dispersal to spread of epidemic infestations of the mountain pine beetle.

**4. Effects of present and natal host on female colonization and male joining behavior in mountain pine beetle colonizing lodgepole pine vs. interior hybrid spruce**

Fraser R. McKee
University of Northern British Columbia

McKee reviewed the literature and history of the association of mountain pine beetle, *Dendroctonus ponderosae*, with spruce, *Picea* spp. These instances of colonization occur when *D. ponderosae* populations are high. Spruce is generally thought to be a poor host for this beetle. The unprecedented outbreak of *D. ponderosae* in the central interior of B.C. has led to more frequent observations of this beetle colonizing spruce. McKee's research focuses on two objectives: 1) to study the effect of natal host species on host acceptance behavior of female *D. ponderosae* and 2) to study the effect of natal host species on male selection of females. Both female host acceptance behavior and male joining behavior were affected by the natal host. Females that emerged from spruce had higher rates of host acceptance than those that emerged from pine. Interestingly, spruce was a more highly accepted host than pine by females reared from either species. Males did not preferentially join females that had entered the same host species from which they emerged. Finally, males preferentially joined females that shared developmental host histories. Future research will focus on the effect of this two-host system on reproductive potential of *D. ponderosae* and on the natural enemy complex. Also, the outbreak status of *D. ponderosae* will be considered in future evaluations of colonization of the nonhost (spruce).

### 5. Evidence of reproductive isolation in *Dendroctonus ponderosae*

Ryan Bracewell[1], Karen Mock[1], Barbara Bentz[1,2], Michael Pfrender[3]
[1]Wildland Resources Department, Utah State University, Logan, UT
[2]USDA Forest Service, Rocky Mountain Research Station, Logan, UT
[3]Biology Department, Utah State University, Logan, UT

We present evidence that not all *Dendroctonus ponderosae* populations are reproductively compatible. Seven populations were collected and crossed in a common garden experiment, and analyzed for any possible inviability and hybrid sterility. All population crosses produce ample quantities of offspring with both males and females represented. However, the hybrids males from distant crosses (S. California x Idaho and S. California x Utah) were nearly completely incapable of producing offspring when backcrossed to parental lines. Hybrid male sterility is considered the first postzygotic barrier to evolve between divergent taxa (Haldane's rule) and its occurrence suggests this is an incipient speciation event within *D. ponderosae*. Recent rangewide genetic analyses did not uncover any signal of reproductive isolation within this species which also suggests that this event is very recent. Interestingly, by combining published record of crossing experiments and this current analysis, evidence suggests two *D. ponderosae* groupings, an East and West group, with a reproductive barrier somewhere between present day Malheur N.F., in Oregon, and the Sawtooth N.F., in Idaho.

Moderator: Ken Raffa
Location: Century Room

Discussion Contributors: Eric Pfeifer (U. of Idaho), Danielle Reboletti (NAU-Flagstaff), David Jack (UNBC), Joel Egan (Colorado State University), Kathy Bleiker (U. of Montana)

### 6. Thinning and bark beetle-caused mortality in mixed conifer forests of northeastern California

Egan, J. M.[123], Jacobi, W. J.[1], Negron, J. F.[2], Smith, S. L.[3], and Cluck, D. R.[3]
[1]Colorado State University, [2]Rocky Mountain Research Station and [3]Forest Health Protection, USDA Forest Service

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The Warner Mountains on the Modoc National Forest of Northeastern California experienced below average precipitation from 1998-2005. Interactions between drought, bark beetles, and stand conditions resulted in a high occurrence of tree mortality from 2001-2007. Various silvicultural prescriptions were implemented over the last several decades throughout the Warner Mountains to reduce stand density. Our study tested whether a population of forested areas treated from 1985-1998 had significantly less bark beetle-caused mortality relative to a population of non-treated areas. We sampled ponderosa pine (*Pinus ponderosa* var ponderosa P. and C. Lawson) and white fir (*Abies concolor* var lowiana Gordon) in commercial thinned, salvage-thinned, and non-thinned areas. A total of 20 commercial thinned, 20 salvage-thinned and 20 mixed conifer non-thinned plots were sampled to estimate forest, site and mortality characteristics. The fir engraver (*Scolytus ventralis* LeConte) caused greater density of mortality (trees $ha^{-1}$) in non-thinned compared to both the commercial thinned and salvage-thinned plots. Percent mortality (trees $ha^{-1}$ killed / trees $ha^{-1}$ host available) did not differ in any of the mixed conifer treatments. Thus, the fir engraver-caused mortality was reduced in direct proportion to the intensity of fir removal. We modeled the density of mortality with site and stand characteristics. Fir engraver-caused mortality was associated with white fir density, elevation, and $elevation^2$.

## 7. Associations between the mountain beetle, mites, and fungi: Can mites influence mountain pine beetle population dynamics?

Danielle Reboletti, Richard Hofstetter, Diana Six, and John Moser

The role of mites living on the exoskeleton of mountain pine beetles (*Dendroctonus ponderosae Hopk. Coleoptera: Curculionidae: Scolytinae*) is unknown. The objectives of this study are to determine (1) which mites are present, (2) the three most prevalent species of mites, (3) which fungi are present on these mites and beetles, and (4) which fungi promote reproductive success of mites. Beetles were collected in the Black Hills National Forest of western South Dakota. Fungi were isolated from the exoskeleton of beetles and mites; additional isolations were attained from the University of Montana. Later, mites were reared upon different isolated fungi to determine the relative growth rates of each mite species on a particular fungus and whether the mite species are mycetophagous. *Tarsonemus ips* and *Proctolaelaps subcorticalis* are the two most prevalent mite species. Each species are regularly found in different places on the beetle exoskeleton. Comparisons of fungal species and mite species location on the beetle exoskeleton illustrate mite-fungal associations among phoretic mites. Bioassays and behavioral studies will ascertain the specificity of feeding behavior for each mite species, which is currently unknown for mites associated with the mountain pine beetle. Mites may have effects on beetle population dynamics by playing important roles in the transport of certain fungi that are either beneficial or detrimental to beetle larvae survival and brood production.

# Poster Abstracts

## 1. A landscape-level spread model for mountain pine beetle: Impacts of spatiotemporal pattern and climate

Brian H. Aukema, Research Scientist,
Canadian Forest Service University of Northern British Columbia
ADM 2019, 3333 University Way
Prince George, BC V2N 4Z9

The increasing number, spatial extent and frequency of insect outbreaks throughout North America has placed renewed emphasis on quantifying relative contributions of exogenous and endogenous factors that contribute to their pattern and spread. We use mountain pine beetle as a model system to construct a spatiotemporal regression model that incorporates the spatial and temporal arrangements of outbreaking insect populations, as well as various climatic factors that influence insect development. As a proof-of-concept, we examine an outbreak of mountain pine beetle covering an 800 thousand ha area on the Chilcotin Plateau of British Columbia, Canada, during the 1970s and early 1980s, from build-up to collapse phases. The model not only detects significant climate signatures contributing to outbreak propagation, but can correctly predict outbreak locations one year in advance with almost 80% accuracy.

## 2. Formation of the Western Bark Beetle Research Group-USDA Forest Service Research and Development

Barbara J. Bentz, Christopher J. Fettig, Nancy Gillette, Matt Hansen, Jane L. Hayes, Rick G. Kelsey, John E. Lundquist, Ann M. Lynch, Jose F. Negrón, Chris Niwa, Robert A. Progar, and Steven J. Seybold
USDA Forest Service, Rocky Mountain Research Station, Logan, UT 84321
USDA Forest Service, Pacific Southwest Research Station, Davis, CA 95616
USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO 80526
USDA Forest Service, Rocky Mountain Research Station, Tucson, AZ 85721-0058
USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR
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USDA Forest Service, Pacific Northwest Research Station, Anchorage, AK 99503

During the last decade elevated levels of bark beetle-caused tree mortality have occurred in spruce forests of Alaska and the Rocky Mountains, lodgepole pine forests of the Rocky Mountains, pinyon-juniper woodlands of the southwestern U.S., and ponderosa pine forests of Arizona, California and South Dakota. Given the high regional significance of these impacts on all values derived from forest ecosystems, the executive leadership of the three western USDA Forest Service research stations (Pacific Northwest, Pacific Southwest, and Rocky Mountain) proposed a west-wide initiative to strengthen cooperative working relationships among researchers and their many partners. To meet this mandate, the Western Bark Beetle Research Group (WBBRG) was created in January 2007 during a meeting in Stevenson, Washington.

WBBRG is composed of scientists from the three research stations with expertise in bark beetle research, development, and application in the West. The mission of the WBBRG is to serve as an ad hoc umbrella organization aimed at fostering communication, and enriching scientific interactions among Forest Service bark beetle researchers in the western U.S. Specifically, the organization will lead in the identification of western bark beetle research priorities; pursue priority research; promote relevance of the research; and work to increase the overall quality, productivity, timeliness, and delivery of research. WBBRG emphasizes basic and application-motivated research that will enhance our scientific understanding of bark beetles and ultimately solve problems faced by our diverse stakeholders, especially USDA FS Forest Health Protection, the National Forest System, state, county, and private land managers, and extension and academic cooperators.

### 3. Evidence of Reproductive Isolation in *Dendroctonus ponderosae*

Ryan Bracewell[1], Karen Mock[1], Barbara Bentz[1,2], Michael Pfrender[3]
[1]Wildland Resources Department, Utah State University, Logan, UT
[2]USDA Forest Service, Rocky Mountain Research Station, Logan, UT
[3]Biology Department, Utah State University, Logan, UT

We present evidence that not all *Dendroctonus ponderosae* populations are reproductively compatible. Seven populations were collected and crossed in a common garden experiment, and analyzed for any possible inviability and hybrid sterility. All population crosses produce ample quantities of offspring with both males and females represented. However, the hybrids males from distant crosses (S. California x Idaho and S. California x Utah) were nearly completely incapable of producing offspring when backcrossed to parental lines. Hybrid male sterility is considered the first postzygotic barrier to evolve between divergent taxa (Haldane's rule) and its occurrence suggests this is an incipient speciation event within *D. ponderosae*. Recent rangewide genetic analyses did not uncover any signal of reproductive isolation within this species which also suggests that this event is very recent. Interestingly, by combining published record of crossing experiments and this current analysis, evidence suggests two *D. ponderosae* groupings, an East and West group, with a reproductive barrier somewhere between present day Malheur N.F., in Oregon, and the Sawtooth N.F., in Idaho.

### 4. Another outbreak of Douglas-fir tussock moth, *Orgyia pseudotsugata* (Lepidoptera: Noctuidae: Lymantriinae), in Colorado – 2007 to ?

William M. Ciesla[1], Sheryl Costello[2], Ingrid Aguayo[3], Brian Howell[2], and Patricia M. Ciesla[1]
[1] Forest Health Management International, Fort Collins, CO
[2] USDA Forest Service, R-2, Lakewood Service Center, Lakewood, CO
[3] Colorado State Forest Service, Fort Collins, CO

Moderate to heavy defoliation of Douglas-fir by the Douglas-fir tussock moth, *Orgyia pseudotsugata*, was detected in western Douglas County, CO during August 2007. Total area of defoliation was 1920 acres. Data on levels of parasitism are given for two collection sites within this outbreak area.

### 5. Western Tent Caterpillar in the Sangre de Cristo and Culebra Ranges, Colorado

William M. Ciesla[1] and Ingrid Aguayo[2]
[1] Forest Health Management International, Fort Collins, CO
[2]Colorado State Forest Service, Fort Collins, CO

An outbreak of western tent caterpillar, *Malacosoma californicum*, has been underway in aspen forests in the Sangre de Cristo and Culebra Ranges of southern Colorado for several years. In 2006, aerial surveys indicated 4,800 acres of aspen forests were defoliated. The outbreak expanded in 2007 with 20,500 acres of aerially visible defoliation.

### 6. A retrospective study on thinning and bark beetle-caused mortality in northeastern California

Egan, J. M.[1,2,3], Jacobi, W. J.[1], Negron, J. F.[2], Smith, S. L.[3], and Cluck, D. R.[3]
[1]Colorado State University, [2]Rocky Mountain Research Station and [3]Forest Health Protection, USDA Forest Service

The Warner Mountains on the Modoc National Forest of Northeastern California experienced below average precipitation from 1998-2005. Interactions between drought, bark beetles, and stand conditions resulted in a high occurrence of tree mortality from 2001-2007. Various silvicultural prescriptions were implemented over the last several decades throughout the Warner Mountains to reduce stand density. Our study tested whether a population of forested areas treated from 1985-1998 had significantly less bark beetle-caused mortality relative to a population of non-treated areas. We sampled ponderosa pine (*Pinus ponderosa* var ponderosa P. and C. Lawson) and Jeffrey pine (*Pinus jeffreyi* Grev. and Balf.) trees in pre-commercial thinned and non-thinned plantations and in mixed conifer forests of ponderosa pine and white fir (*Abies concolor* var lowiana Gordon) in commercial thinned, salvage-thinned, and non-thinned areas. A total of 20 pre-commercial thinned, 13 plantation non-thinned, 20 commercial thinned, 20 salvage-thinned and 20 mixed conifer non-thinned plots were sampled to estimate forest, site and mortality characteristics. Plantation and mixed conifer data were analyzed separately. In plantations, the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) caused greatest density of mortality (trees $ha^{-1}$ killed) which was 10 times greater in the non-thinned compared to the pre-commercial thinned plots. In mixed-conifer areas, the fir engraver (*Scolytus ventralis* LeConte) caused greater density of mortality in non-thinned compared to both the commercial thinned and salvage-thinned plots. Percent mortality (trees $ha^{-1}$ killed / trees $ha^{-1}$ host available) was reduced in the pre-commercially thinned compared to the non-thinned plantations but no difference was found between the mixed conifer treatments. Thus, the fir engraver-caused mortality was reduced in direct proportion to the intensity of fir removal. We modeled the density of mortality with site and stand characteristics for each study area. In the plantation plots, we found that the mountain pine beetle-caused mortality was associated with the treatment and density (trees $ha^{-1}$) of all species ($R^2$ = .49). In the mixed-conifer plots, we found fir engraver-caused mortality was associated with white fir density, elevation, and $elevation^2$.

## 7. Efficacy of systemic injections at reducing defoliation of western spruce budworm, *Choristoneura occidentalis*

Jeffrey Fidgen[1], Carol Randall[2], Neal Kittelson[1], Tom Eckberg[1], and Jim Rineholt[3]
[1]Idaho Department of Lands, Coeur d'Alene, ID; [2]USDA Forest Service, Forest Health Protection, Coeur d'Alene Field Office, Coeur d'Alene, ID; [3]Sawtooth National Recreation Area, USDA Forest Service, Ketchum, ID

Western spruce budworm is a periodic and severe pest of true fir and Douglas-fir across most of its range. In Idaho, populations of this pest are high on approximately 450,000 acres, much of which borders the wildland-urban interface. Landowners would prefer a selective, low exposure risk treatment tactic for individual high value trees in yards and other areas treatment options are limited. Stem injections are low risk and selective, but few compounds have been tested for efficacy against forest pests, such as budworm. We evaluated the efficacy of three tree injected compounds known to affect Lepidoptera like spruce budworm (emamectin benzoate, acetamaprid, abamectin).

Defoliation (%) of grand fir trees injected with emamectin benzoate (5%) was significantly lower than on untreated trees (25%). In a different trial, defoliation of Douglas-fir trees injected with abamectin (10%) was significantly lower than on untreated trees (50%). Abamectin injected into subalpine fir did not significantly reduce defoliation compared to untreated trees. For acetamaprid injected into Douglas-fir and subalpine fir, defoliation levels did not differ significantly from untreated trees.

We suspect inconsistent results are due to the interaction of tree species physiology and compound mobility rather than compound efficacy. This is a reminder that applicators must consider tree species as well as target insect when considering stem injections.

## 8. High elevation emerging geometrid insect pests in the southwestern United States

Bobbe Fitzgibbon [1], Ann Lynch [2], and Terry Rogers [3]
[1] USDA Forest Service, Region 3 Forest Health, Arizona Zone, Flagstaff, Arizona;
[2] USDA Forest Service, Rocky Mountain Research Station, University of Arizona, Tucson, Arizona; [3] USDA Forest Service, Region 3 Forest Health, New Mexico Zone, Albuquerque, New Mexico

### Introduction

Since 1996, native geometrids have been responsible for 3 separate outbreaks at high elevations in the southwestern United States. Historically these insects were not known to cause damage. Speculation that climate change may be a factor in these outbreaks has led to the current study.

Specimens taken at two of the outbreaks have both been identified as *Nepytia janetae;* the third geometrid has been identified as *Enypia griseata.* Adults of *N. janetae* were described in 1967 from collections made in Arizona and New Mexico. The larvae of the two insects identified as *Nepytia janetae* have been observed to have different feeding patterns, different elevational ranges and different host ranges in addition to physical differences. The third outbreak by a geometrid was found in a 2007 in Arizona. Significant tree mortality has been associated with heavy defoliation by the geometrids alone or in conjunction with secondary agents such as bark beetles and other defoliators.

Methods

Permanent plots have been set up at the sites of the first two outbreaks. Temperatures at the locations of outbreaks are being monitored and compared with historical data. Genetic testing will be necessary to determine if the insects identified as *N janetae* are indeed the same species.

Preliminary results

Mortality from the geometrid outbreak 1996-1999 varied by mountain range from 18 to 85%. Mortality due to the New Mexico *Nepytia janetae* outbreak 2005-2007 was already at 15% in the spring. Site factors do not appear to influence host susceptibility.

## 9. Defining a biochemical and mechanistic link among Jeffrey pine stand density, drought, and risk of mortality from Jeffrey pine beetle, *Dendroctonus jeffreyi*

Andrew D. Graves[1,2], Nancy E. Grulke[2], David M. Rizzo[1], Barbara Demmig-Adams[3], William W. Adams[3], and Steven J. Seybold[2]
[1]Department of Plant Pathology, UC Davis, [2]USDA Forest Service, PSW, [3]Department of Ecology and Evolutionary Biology, UC at Boulder

Jeffrey pine forests in California and Nevada experience chronic bark beetle outbreaks and tree mortality caused by the Jeffrey pine beetle, *Dendroctonus jeffreyi* Hopkins (JPB), during extended droughts. Reducing stand density may improve stand health by increasing individual tree access to water, carbon, and nutrient resources. The availability of these resources may determine tissue palatability to bark beetles as well as resin production, but the biochemical mechanisms behind these correlations are poorly understood. Oleoresin provides both a physical barrier and chemical impedance to bark beetle attack. Ironically, the volatile organic compounds (VOCs) emitted from defensive resins also attract bark beetles. In this project we examine this complete drought-response mechanism in Jeffrey pine over a three-year, field-oriented study across its geographic distribution. The objectives of this project are to: demonstrate how stand density influences tree drought stress and bole subcortical tissue quality, demonstrate how drought stress influences level of zeaxanthin and jasmonates, and both quantity and quality of resins (monoterpenes, alkanes), demonstrate how drought stress influences foliar and bole VOC emissions, and demonstrate how VOC emissions, resins, and phloem palatability influence colonization success of JPB.

Observations revealed that bark beetles were present at all sites, though in low number, despite considerable drought stress on trees. The percentage needle elongation (i.e., needle length) generally reflected the amount of precipitation at study sites and may serve as a proxy for drought stress. Additionally, resin quantity was highly variable across all sites and was not well correlated with other measures of tree health. VOC emissions from Jeffrey pine foliage and bark were extremely different in both quantity and composition of alkanes and terpenoids. Those compounds considered crucial to bark beetle attraction such as *n*-heptane, and α- and β-pinene, were shown to volatilize primarily from the bark surface of the stem.

## 10. Challenges of mapping insect-caused tree mortality in mountainous terrain with satellite imagery

Jeff Hicke
University of Idaho

High-elevation ecosystems such as whitebark pine forests are currently subjected to multiple threats, including white pine blister rust and fire suppression. An additional threat in recent years has been extensive outbreaks of mountain pine beetle. These infestations have killed substantial numbers of trees in the Central and Northern Rocky Mountains, including in the Greater Yellowstone Ecosystem and in Idaho. Monitoring outbreaks in these rugged, mountainous regions at sufficient spatial resolution for ecological studies requires high-resolution remotely sensed imagery. Here we report on a study that used QuickBird satellite imagery (2.4-m spatial resolution) to map whitebark pine mortality following an infestation of mountain pine beetle in central Idaho. A maximum likelihood classification was developed to partition the landscape into clouds/water, non-vegetated, grass, live tree, and dead tree classes. We identified class members by visually inspecting the imagery, then divided the members into training and evaluation data sets. We used the ratio of red to green reflectance (the "red-green index", RGI) and the green reflectance (Rg) as variables in the classification. Because class means of these variables varied with illumination (a function of sun position and topography), we stratified the class members and the image to be classified by the solar incidence angle, then performed five classifications. High accuracies of the resulting classification compared with image-derived class members and field observations were achieved (86 and 91%, respectively). Our study illustrates the capability of very high-resolution satellite imagery for monitoring this significant threat to whitebark pine ecosystems.

## 11. Physiologic effects of thinning/soil moisture ratio on tree vigor and resistance to bark beetle pressure – Proposed research

Teri Howlett[1], Ingrid Aguayo[2], Bill Bauerle[1], Jose Negron[3]
[1]Department of Horticulture and Landscape Architecture, Colorado State University, Fort Collins, CO 80523, [2]Colorado State Forest Service, Fort Collins, CO 80523;
[3]USDA Forest Service, Fort Collins, CO 80526

In North America, mountain pine beetle (MPB) *Dendroctonus ponderosae* Hopkins outbreaks are killing a large number of mature and over mature trees. Thinning of forest stands has been used in hopes to reduce beetle susceptibility by increasing physiological resistance which is shown to decline with increased stand density (Kolb 1998). What often is not considered with thinning are site characteristics like soil moisture and climate that also influence beetle invasion success. *In situ* water relations of bark beetle resistant trees are not known. Dense unmanaged stands experience many stresses, yet moisture stress appears to be the decisive stressor for beetle attack (Haack 1997). Karasev (1976) and Lorio et al. (1977) found volatile oil composition and amount were related to pest resistance with water stressed trees more susceptible to attack. Thinned stands (at the appropriate density to precipitation ratio) have less drought stress that overlaps with beetle flight. The objectives of this research are: 1. Compare identified thinned and non-thinned pure lodgepole pine (*Pinus contorta* Dougl.) (LP) stands using physiologic, oleoresin constituents, and standard growth measurements (to show the release response) in relation to soil volumetric water content before, during, and after a bark beetle invasion. 2. Identify attributes of susceptible and resistant trees. 3. Analyze the density to soil moisture ratios and compare them to area precipitation to identify an ideal density-precipitation ratio for forest management. It is hypothesized that thinned LP are more resistant to bark beetle invasion due to lower tree level water stress.

This project will be conducted within the Colorado State Forest Service (CSFS) State Forest, Jackson County, CO. Stands of pure LP of similar characteristics will be identified that have been left untreated and previously thinned with high beetle pressure. At each plot the following information will be collected: species, condition class, crown class, DBH, total height, percentage defect, age, seedling/saplings on fixed plot (1/100 ac), slope/aspect. Stem density plots will be randomly assigned and consist of a total of 20 randomly selected trees each. Increment cores will be taken on the selected trees and repeated sampling of: gas exchange, light absorption, height, predawn and solar noon water potential, stem diameter, projected leaf area, leaf stomatal conductance, dark respiration, net photosynthesis, dry weights for needles and canopy width will be taken. Bi-weekly soil bulk volumetric water content will be measured throughout the season in five locations per plot. Results of mortality and vigor will be compared between thinned and un-thinned plots before, during, and post beetle attack. Tree volatiles will be collected from fresh collected foliage and air samples and analyzed using headspace SPME and GC/MS. The research will be conducted during summers of 2008-2010.

Gas exchange data will be normalized by log transformation. Treatment effects on growth, gas exchange, and water potential will be evaluated by ANOVA. Plot density variation in gas exchange and water relations variables will be assessed by Fisher's LSD. Soil volumetric water content and water potential data will be analyzed by two-way ANOVA and a preplanned SNK post-hoc test for multiple pairwise comparisons.

## 12. Evaluation of a mature lodgepole pine stand's resistance to the current MPB epidemic after nitrogen fertilization

David Jack[1], John McLean[1], and Gordon Weetman[1]
[1]University of British Columbia, Faculty of Forest Sciences

Research is currently under way in the interior of British Columbia, Canada to determine whether nitrogen fertilization can be used to increase mature lodgepole pine trees' natural defences against the mountain pine beetle and thereby reduce the impact of the mountain pine beetle infestation in pine stands.

The research area is a mixture of lodgepole pine, spruce, and true fir that regenerated 140 years ago after fire. Thirty 40 x 40 m plots were established in the summer of 2006. In fall 2006, three nitrogen fertilizer treatments were applied randomly on 10 plots each: control (no fertilizer), 200 kg N/ha, and 400 kg N/ha. In summer 2007, fungal inoculations were performed to evaluate the effect of fertilizer treatments on the response of trees against two isolates of the blue stain fungus *Grosmannia clavigera* and on local beetle microflora.

The treatments resulted in a significant increase in foliage nitrogen with increasing nitrogen treatments. By late August 2007, only the 400 kg N/ha treatment significantly increased nitrogen levels in pine phloem. The resulting lesion lengths between the three fungi isolates were significantly different; however, differences between nitrogen treatments were not significant within each isolate. Some level of current mountain pine beetle activity is evident on 36% of the lodgepole pine as a result of the 2007 flight. This current mountain pine beetle infestation will be monitored in 2008 to see if there is a treatment effect.

## 13. Protecting whitebark and ponderosa pines from mountain pine beetle attack using verbenone and green-leaf volatiles

Sandy Kegley[1] and Ken Gibson[2]
USDA Forest Service. Forest Health Protection
[1]Couer d'Alene Field Office; [2]Missoula Field Office

In 2007, we tested verbenone and green-leaf volatiles (GLV) in their ability to protect individual whitebark and ponderosa pines from mountain pine beetle (*Dendroctonus ponderosae* Hopkins) attack. In late May, we selected 160 whitebark pines and 200 ponderosa pines on the Lewis & Clark National Forest in west-central Montana, in which beetle populations were active.

In June, we treated each individual whitebark pine with one of 4 treatments: 2, 7.0-gram verbenone pouches (Pherotech International); 2, 7.5-gram verbenone pouches (Synergy Semiochemical); 1, 7.5-gram verbenone pouch and 1, 10-gram GLV (50:50 blend of hexanol and hexenol, Synergy Semiochemical); and no pouches at all (control). In close proximity to each treated tree (no closer than 5 feet, but no further than 10 feet), we placed a standard mountain pine beetle tree bait (Synergy Semiochemical).

Also in June, we treated each individual ponderosa pine tree with one of 5 treatments: the same 4 as in the whitebark pine test, and the addition of a fifth treatment: 2, 10-gram GLV pouches. Tree baits were placed in a similar manner.

In late September, following beetle flight, we evaluated each treated tree in both treatment areas. For these analyses, "mass-attacked" and "strip-attacked" trees were combined, as were "pitchouts" and "non-attacked" trees. Results were as follows:

| | --------Whitebark Pine----------- | | ---------Ponderosa Pine----------- | |
|---|---|---|---|---|
| | **% Attacked** | **% Not Attacked** | **% Attacked** | **% Not Attacked** |
| **Verb (Syn)** | 12.5 | 87.5 | 10 | 90 |
| **Verb (PT)** | 17.5 | 82.5 | 7.5 | 92.5 |
| **Verb + GLV** | 25 | 75 | 12.5 | 87.5 |
| **GLV alone** | -- | -- | 37.5 | 62.5 |
| **Control** | 87.5 | 12.5 | 55 | 45 |

In summary, we obtained very good results with all treatments except GLV alone and control. Synergy verbenone pouches protected 87.5% of treated whitebark pines and 90% of ponderosa pines. Pherotech verbenone pouches protected 82.5% of whitebark pines and 92.5% of ponderosa pines. Verbenone plus GLV protected 87.5% of ponderosa pines and 75% of whitebark pines from mountain pine beetle attack.

## 14. Mountain pine beetle in lodgepole pine: fuels and stand characteristics

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Aerial and ground surveys of lodgepole pine (*Pinus contorta*) in Colorado's Arapaho-Roosevelt National Forest, Sulphur Ranger District indicate a current sustained mountain pine beetle (*Dendroctonous ponderosae*) (MPB) epidemic. Because it is unknown how this epidemic will affect fuel loads and potential fire behavior, 221 randomly placed plots were established during the summers of 2006-2007 in areas with MPB-induced mortality and in uninfested areas in the outbreak affected area. Downed woody debris amounts in all size classes were not significantly greater in plots with MPB-induced mortality (range of total fuel load=0.05 – 156.4 Mg/ha). To assess fuel amounts 6 and 12 years after plot measurement in plots with MPB-induced mortality, 10% and 80%, respectively, of the killed lodgepole pine were converted to downed woody fuel loads. The total fuel load for plots projected to 6 years after plot measurement was not different compared to uninfested and current year infested plots. However, when 80% of the killed trees were calculated to downed woody fuel loads – projecting the plots 12 years after plot measurement – the fuel load was significantly greater than uninfested, current year, and 6 year projected fuel loads by approximately 120%. This project will help predict future conditions for fire management objectives by providing a baseline to model potential fire behavior, fire-related tree mortality, and crown fire potential in lodgepole pine forests of Colorado.

## 15. Synchrony and host preference of *Leucopis* spp. (Diptera: Chamaemyiidae), predators of hemlock woolly adelgid in the Pacific Northwest

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In a survey of predators associated with hemlock woolly adelgid (HWA) at 16 sites in western Oregon and Washington, two fly species, *Leucopis argenticollis* Zetterstedt (Diptera: Chamaemyiidae) and *Leucopis atrifacies* (Aldrich) (Chamaemyiidae), were among the most abundant predators collected; second only to the adelgid specialist *Laricobius nigrinus* Fender (Coleoptera: Derodontidae). Both *Leucopis* spp. are recorded as adelgid specialists in the literature. Furthermore, other chamaemyiid species have been used successfully in adelgid biological control programs in Chile and Hawaii. Collectively, this information suggests that *L. argenticollis* and *L. atrifacies* are good candidates for biological control of HWA in eastern North America.

Preliminary studies were conducted to determine the feasibility of using either *Leucopis* spp. for biological control of HWA in eastern North America. In the field, *Leucopis* spp. larvae were most abundant when progrediens and sistens eggs were present in the spring and early summer. *Laricobius nigrinus* larvae were also collected in the spring; however, they are not present in the early summer to compete with *Leucopis* spp. First instar *Leucopis* spp. larvae appear to aestivate over the summer and resume development in the fall. This suggests synchrony with the HWA life cycle. In laboratory assays, *Leucopis* spp. larvae lived longer and were found in association with their prey more often when provided with HWA compared to two alternative adelgid prey species. Further studies will be needed to determine whether either *Leucopis* spp. should be released for biological control of HWA in eastern North America.

## 16. Trend of two invasives: the banded and European elm bark beetles

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The banded elm bark beetle (BEBB), *Scolytus schevyrewi* is an invasive beetle from Asia that attacks elm (*Ulmus* sp.) trees, and may vector the fungal pathogen causing Dutch elm disease, *Ophiostoma ulmi*.  BEBB shares a similar biology to an established invasive, the European elm bark beetle (EEBB), *Scolytus multistriatus*. However, BEBB seems to attack standing trees more aggressively and appears now more abundant than EEBB in the Rocky Mountain region,

suggesting that it may have displaced EEBB and/or is better able to colonize regions beyond EEBB's range. Our objectives were to determine the relative abundance of BEBB and EEBB in seven states, and compare how each species locates host elms for attack.
To monitor abundance, a trap Siberian elm log, baited funnel trap, and passive plexiglass trap were set up at four sites in each state and checked from April/May to September. BEBB was less common than EEBB in California (13%), BEBB increased in abundance in Nevada (68%) and Utah (65%), and was highest in Colorado (89%) and Wyoming (83%). BEBB populations were minor moving east to Kansas (3.3%), and Missouri (2.7%). This survey suggests that BEBB may be displacing EEBB since EEBB is no longer commonly found in Colorado where it was often found in the past.

Flight towards uninfested and variously infested elm logs was monitored for BEBB in Colorado and Wyoming, and for EEBB in California. BEBB responded strongly to elm odors and showed no preference for elm infested with females or males. EEBB responded somewhat to elm odors but more so to pheromones from an elm that was infested by EEBB females for 48-96 hr. Colonizing female EEBB required a few days to produce an attractive pheromone. In Nevada, BEBB responded indiscriminately to all elm logs regardless whether it was infested with BEBB, EEBB, or both. Thus, when a new elm is available, BEBB may have a competitive advantage attacking first. Whereas, EEBB may attack in greater numbers later, following pheromone production from the initial attacks of EEBB females.

## 17. The forest insect and pathogen hazard rating system database

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The Forest Health Technology Enterprise Team's *Forest Insect and Pathogen Hazard Rating Systems Database* is a collection of detailed summaries of insect and disease hazard and risk models and citations organized in a Microsoft Access relational database. It has been constructed to serve three primary users: (1) Field practitioners can use it to locate published literature for evaluating field conditions and making treatment prescriptions. (2) Researchers and other investigators will find it helpful when reviewing previous study methods and findings. (3) Groups doing strategic planning, such as that done for the National Insect and Disease Risk Map efforts, can use it as the basis for integrative modeling.

The core of this database consists of tables linking detailed information about hazard rating systems (models) and their associated published literature (citations). Each rating system, or model, estimates some measure of risk or hazard to forest stands or trees from one or more insect or pathogen agent.

Details provided about the models include information such as:
- its spatial scope (e.g. whether it estimates hazard to trees, plots, stands or broad regions);

- its type (such as whether the model is an empirical regression equation, simulation model, or simple look-up table based on expert opinion) as well as a classification as to whether the model estimates the susceptibility or vulnerability of its scope;
- what host tree species the model is applicable to;
- its applicable spatial geography (where the model was developed and/or where the model is applicable);
- the independent variables used by the model to estimate hazard;
- and the model's dependent variables (output type), such as a quantitative mortality estimate, or qualitative hazard class).

Descriptive notes for both citations and models are provided. Relationships between models and citations are thoroughly cataloged, as well as relationships among models and among citations. Electronic copies of publicly distributable documents are provided. Internet URLs (hyperlinks) to on-line copies of citation documents are provided, where available. Hyperlinks to the online USDA PLANTS database and the Forestpests.org database are provided for individual host tree species and individual pest agents. The Forest Health Technology Enterprise Team's 2006 National Insect and Disease Risk Map (NIDRM) Models are included in this database. (http://www.fs.fed.us/foresthealth/technology/nidrm.shtml). The geographic scope of the models included is limited to the continental United States and Canada. Hazard agents included in this database include forest insects and pathogens. Models predicting windthrow, fire, or other abiotic hazards are generally not included (though such factors may occur as a model's independent driving variable.) A built-in "Report Generator" allows the user to easily query the database and generate reports. Currently, the database contains 543 citations, 191 of which are seminal for 512 models, 200 of which are NIDRM models. The application, available free of charge from FHTET, includes over 200 publicly-distributable documents and contains links to over 200 documents online.

## 18. Contribution of landscape level bark beetle outbreaks to fuel loading and fire behavior in pine forests of the Southwest

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[1]USFS Region 3 Forest Health, [2]Uni. of Idaho, [3]USFS RMRS, [4]Northern Arizona University

Landscape-level bark beetle outbreaks occurred throughout southwestern ponderosa pine forests during 2001-2003 in response to severe drought and forest stand conditions. Pine mortality was primarily caused by *Ips* species (*I. lecontei* and *I. pini*) and secondarily by *Dendroctonus* species (*D. brevicomis, D. adjunctus, D. frontalis*). Previous studies suggest that bark beetle outbreaks can cause increases in fuel loads, influence fire behavior, and perhaps increase the severity of the fires (Jenkins et al. 2008); however, these relationships have not been examined in pine forests of the Southwest. Romme et al. (2006) hypothesized that bark beetles' effects on fire behavior follow a fuel succession: 1) Increased risk of crown fire initiation immediately following outbreak, 2) Reduced crown fire spread and initiation after needle drop, 3) Increased crown fire initiation and spread after snags fall. This study examined the second and third stage (4-5 years post-outbreak) of the hypothesized succession in changing fuels.

## Methods

Forest Health Monitoring (FHM) funding was used to establish a network of plots in 2003 – 2004 to document overstory impacts caused by outbreaks in Arizona. Plots encompassed a range of beetle-caused tree mortality levels, stand conditions and site characteristics. Using additional FHM funding in 2007, we revisited plots to measure fuel loading and potential fire behavior on ponderosa pine forests. Plots containing pine mortality were paired with plots having no mortality with respect to site characteristics (Forest, elevation, topography). Data on downed fuel loads and stand characteristics were collected from 40 pairs of plots on the Prescott, Kaibab, Coconino, Apache-Sitgreaves and Tonto National Forests. Canopy fuels were calculated using allometric equations developed by Brown (1978) and adjusted by crown class as suggested by Reinhardt et al. (2007). Canopy fuel profiles were developed for each stand and canopy bulk density was estimated as the maximum one foot layer running mean bulk density (Carlton 2005). Fire hazard was estimated by calculating the torching index and crowning index (Scott and Reinhardt 2001) using the fire behavior modeling system NEXUS (Scott 1999). Three separate fire behavior modeling runs were made on each plot. First, all variables were held constant except stand characteristics (crown bulk density, available canopy fuel loading and canopy base height). This run was made to investigate the influence of bark beetle-caused tree mortality on the stand structure and potential fire behavior. The second set of model runs was identical to the first scenario except that the fuel model was changed from 9 (Anderson 1982) to 10 (Anderson 1982) for all plots which had surface fuel loadings over 10 tons per acre (22.4 mg/ha). This model scenario was used to account for changes in surface fuels between the sampled plots. The third scenario adjusted the wind reduction factor (influences effective mid flame wind speed) from 0.2 to 0.3 for all stands that had a basal area of less than 50 $ft^2$/ac. This model scenario was used to account for decreased drag within the stand due to a decrease in canopy fuels.

## Results

### Post-outbreaks stand conditions

Bark beetle outbreaks caused significant reductions in ponderosa pine tree density, basal area, and stand density index; however, mean tree height and quadratic mean diameter were not significantly different between stands with tree mortality and stands without tree mortality.

### Surface and canopy fuels

Bark beetle-caused tree mortality resulted in significant increases in surface fuels for all categories except 1000-hr rotten fuels. Total surface fuel loading and fuel bed depth were 58 and 57 percent higher, respectively, in stands with bark beetle-caused tree mortality than stands without tree mortality.

Canopy fuels were significantly higher in stands without tree mortality compared with stands containing tree mortality; however, canopy base height was significantly lower in non-mortality stands. Canopy bulk density estimates were not significantly different between non-mortality and mortality stands. This was primarily a function in a change in the length of the canopy since available canopy fuels were significantly different.

Crown fire hazard

Crowning index was significantly lower in stands containing bark beetle-caused tree mortality compared with stands without tree mortality. Critical fire-line intensity was significantly higher in mortality stands, suggesting that more surface intensity is needed in these stands to promote a surface fire into the canopy. Torching index estimates confirmed that the ability of surface fire to transition in mortality stands was lower assuming the only differences were in stand structure. However, after potential fire behavior predictions were adjusted for increases in surface fuels and increased wind speeds due to lower resistance in the canopy, the torching index was not significantly different between non-mortality and mortality stands.

## Conclusions

Bark beetle outbreaks by primarily *Ips* reduced stand densities and increased surface fuels and crown base heights due to high mortality of mostly small diameter trees. Potential fire behavior modeling suggests that higher wind speeds are required to promote torching 4 to 5 years post-outbreak. However, after accounting for increases in surface fuels and lower drag coefficients in more open stands, the wind speeds required for torching are not significantly different than stands with no tree mortality. Thus, at this point along the fuel succession time line, the apparent trade-off between lower crown base heights and fire intensity in the non-mortality stands and higher crown base heights and intensity in stands with bark beetle-caused tree mortality stands, resulted in little difference in fire hazard.

## 19. Phoretic arthropods of the red imported fire ant (*Solenopsis invicta*, Hymenoptera: Formicidae) in central Louisiana

John Moser
USDA Forest Service, Pineville, LA

A total of 4665 phoretic arthropods were taken from red imported fire ant alates that were preparing to fly from nests in Pineville, LA. A wide variety of taxonomic groups were represented, including two insect- and 14 mite families. At least 23 of the 29 species found may be new; five of the common species are currently being described. At least three mite species may be predators, but many other species may be associated with fungi or are general feeders.

## 20. Assessing dendroecological methods to reconstruct defoliator outbreaks on *Nothofagus pumilio* in northwestern Patagonia, Argentina

Juan Paritsis and Thomas T. Veblen
Department of Geography, University of Colorado at Boulder

### Introduction

The history of insect outbreaks is crucial in understanding and managing forested landscapes. However, there is little quantitative information about past insect outbreaks for the temperate forests of the southern hemisphere. In the Patagonian Andes in Argentina, the southern beech *Nothofagus pumilio* experiences extensive defoliations caused by *Ormiscodes* (Saturniidae) species.

Dendrochronology offers a method to reconstruct the history of past insect defoliations over broad time scales in forested landscapes. To reconstruct past defoliator insect outbreaks it is necessary to control for climatic effects on tree-ring growth. This is commonly done using a species that is not attacked by the insect defoliator (i.e. a non-host species) and that has a similar ring growth response to climate variation as the host species.

We evaluated the effectiveness of a native conifer, *Austrocedrus chilensis,* as a non-host species in reconstructing past *Ormiscodes amphinome* outbreaks on *N. pumilio* and we assessed the effectiveness of alternative and supplemental procedures to reconstruct these defoliations.

### Methods

We selected five sites for dendrochronological sampling (paired *N. pumilio* host stand and *A. chilensis* non-host stand. Site selection was based on the occurrence of the extensive 1986 *Ormiscodes amphinome* outbreak to calibrate the methods with a known event. We used three *N. pumilio* tree-ring width series from the International Tree Ring Database to generate an independent regional host chronology to use as a climatic control.
Correlation functions between monthly climate data and tree-ring chronologies of *N. pumilio* and *A. chilensis* were used to test for similar responses in tree ring growth to climatic variability. Two different climate periods were selected (1920-1976: below avg. temp. and 1977-2003 above avg. temp.).

Methods used to reconstruct the outbreaks

1. Host vs. non-host correction (NH): *A. chilensis* used as non-host to correct for climate variation by applying equation (1).
2. Host vs. host regional correction (HR): *N. pumilio* regional chronology used to correct for climate variation by applying equation (1).
3. Detection of extreme tree-ring growth reductions using a kernel (K): Identification of narrow rings by applying equation (2).

4. Morphological variations in annual ring formation (S): Identification of a typical morphological anomaly caused by the defoliation.

(1) $Ict = Iht - (Int - \bar{I}n) (SDh / SDn)$

where Ict is the corrected *N. pumilio* index at year t, Iht is the uncorrected *N. pumilio* index at year t, Int is the *A. chilensis* index for year t, $\bar{I}n$ is the mean of the *A. chilensis* chronology for the common period between host and non-host chronologies, and SD are the standard deviations for the period common to both chronologies for the host and non-host respectively.

(2) $st = yt \quad (yt-3 + yt-2 + yt-1 + yt+1 + yt+2 + yt+3)-1 \quad 100$

where st is the percentage reduction for the tree-ring at the year t and yt is the tree-ring width for the year t.

## Results

Growth response to climatic variability was more similar between *N. pumilio* and *A. chilensis* during the 1920-1976 compared to the other two periods analyzed. *N. pumilio* and *A. chilensis* chronologies were significantly correlated only at the most xeric sites (i.e. 1000-1200mm). In addition to the 1986 defoliation, on two sites, 1878 appears to be an outbreak year as three methods indicate defoliations on that year.

## Conclusions

*A. chilensis* appears to be more effective as a non-host species towards the more xeric sites compared to the more mesic sites (i.e. 1500-2500 mm) due to the similarities in its growth response to climatic variability compared to *N. pumilio*.
To reconstruct insect defoliations on *N. pumilio*, we recommend application of all four of the reconstruction methods tested here. An outbreak event can be inferred when three or more methods indicate the same defoliation year.
This study illustrates the importance of explicitly testing the assumption of a similar growth response between host and non-host species in the area in which the outbreaks will be reconstructed.

## 21. Biological control vs. herbicide to suppress leafy spurge over an eight-year period

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The effectiveness of *Aphthona* flea beetles (87 percent *A. lacertosa* and *A. czwalinae* and 13 percent *A. nigriscutis*) as biological control agents of leafy spurge was compared with a single application of herbicide (picloram) and untreated plots for a period of 8 years. Percentage of cover of leafy spurge, grasses, forbs, shrubs, and bare ground; spurge height; and flea beetle numbers were measured each year from 2000 through 2007. Cover of leafy spurge on *Aphthona* biological control plots exhibited annual declines until 2005. In 2006, these plots showed a rebound in leafy spurge coverage followed by a decline in 2007. Spurge cover increased on the herbicide-treated plots and remained unchanged on the untreated check plots from 2000 through 2003. In 2003, the flea beetles began to emigrate from the release point within the biological control plots and dispersed throughout much of the surrounding leafy spurge infested area including the herbicide treated and check plots. This dispersal and colonization caused a subsequent decline in spurge cover on the herbicide-treated and control plots from 2004 through 2007

**22. Inundative release of flea beetles as a biological “herbicide” on riparian leafy spurge**

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Leafy spurge is an exotic, deep-rooted, invasive perennial weed native to Eurasia. It replaces native grasses and forbs favorable to livestock, and can reduce cattle carrying capacity on forest and range lands by 50 to 75%. Leafy spurge invades aggressively by means of high seed production and underground shoots. It is estimated that leafy spurge infests over one million hectares (2.5 million acres) in North America. Current methods to manage leafy spurge are chemical herbicides, grazing with goats and sheep, and biological control insects that are specific to leafy spurge to kill, reduce plant vigor, or reduce seed production of leafy spurge. This weed is especially difficult to control in riparian areas because of restrictions on herbicide use and the inability of biological control insects to survive the occasional flooding that occurs in the late winter and spring. The purpose of this study was to assess the impact of increasing the density of beetles per flowering stem over two consecutive years on the biomass, stem, crown, and seedling density of riparian leafy spurge. We released treatments of zero (untreated check), 10 and 50 beetles per flowering stem on three 24 square meter plots in each of three riparian study sites distributed across central-south Idaho. The biomass, number of stems, crowns and seedlings of leafy spurge were significantly reduced after the first treatment year at all three sites. Repeated releases the following year showed no evidence that the effect of beetle addition differed among sites. There was very strong evidence that the percent of spurge stems remaining in 2006 was related to the number of beetles applied in 2005. It was estimated that for every 10-fold increase in the number of beetles applied per plot, there was a 18.5% decrease in the percent of spurge stem counts remaining in 2006 (95% confidence interval 7.4 to 28.4% decrease).

## 23. WFIWC Website

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US Forest Service, Pacific Northwest Region, Portland, OR

The WFIWC website presents a range of information for members. All past proceedings are available online, as is a listing of current members. Founders Award recipients – and many of their speeches – are posted, as well as recipients of Memorial Scholarships. The Common Names Committee has been active in recent years – view their work on common names likely to be used in the current revision of *Western Forest Insects*. Mal Furniss has recently enhanced the website through the addition of historic photos from the WFIWC archives and his personal collection. A few bits of website trivia: among website visitors, Internet Explorer is the most popular browser (87% of visitors), and Google is the search engine most commonly used to find the website (93% of visitors).

## 24. Managing western spruce budworm

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As western spruce budworm populations have increased in recent years – after generally remaining low since the early 1990's – there has been renewed interest in options for managing budworm. A team representing USFS, tribes, and state agencies is currently gathering reports and other documentation regarding past suppression projects and silvicultural treatments aimed at budworm. This team will review the effectiveness of various tactics and strategies used to manage budworm, and summarize their findings in a "state of knowledge" publication. A workshop to review the draft findings and identify research needs will be held in late 2009. Information for ~100 suppression projects conducted since 1970 (gleaned from ~95 reports) is available at: www.fs.fed.us/r6/nr/fid/budworm/

## 25. Mountain pine beetle outbreak tree mortality and subsequent fire occurrence in Colorado

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A need for understanding the interaction between the condition of post-epidemic bark beetle stands and subsequent fire occurrence has escalated due to recent unprecedented mountain pine beetle outbreaks in Colorado's lodgepole pine dominated forests. Historic mountain pine beetle *(Dendroctonus ponderosae* Hopkins) outbreaks resulted in widespread tree mortality across Colorado in a multitude of forest types. Previous mountain pine beetle-caused mortality has generally been thought to increase subsequent fire occurrence but there is limited research on this question. Our objectives are to determine if correlations exist between mountain pine beetle outbreaks and subsequent fire occurrence in Colorado, match the associated weather and fire occurrence in mountain pine beetle outbreak locations of Colorado, and determine temporal occurrence of those fires since the mountain pine beetle outbreak. We used historic aerial detection survey records dating back to 1980 in conjunction with available digital fire records as a guide to locate our study areas. These data delineate spatial areas containing lodgepole pine dominated forest type and subsequent historic fire points. Fire locations occurring within previously mapped mountain pine beetle-caused mortality will be visited in 2008. Sampling will be conducted to verify the presence of mountain pine beetle-caused mortality prior to the fire event as well as confirm the location of the recorded fires. Weather attributes will be analyzed in relation to post-outbreak fire years. In addition, the temporal scale of fires post-outbreak will be analyzed.

## Group Photographs

Back row:  Bernard Benton, Jim Ellenwood, Keith Sprengel, Bruce Hostetler, Don Bright, Andy Eglitis

Front row:  Bob Averill, Jessica Halverson, Karen Ripley, Diane Hildebrand, Barbara Barr, Joel Egan

Back row: Don Grosman, Dan Miller, Jennifer Burleigh, Terry Shore, Roger Burnside, Peter de Groot

Front row: Bobbe Fitzgibbon, Art Stock, Helen Maffei, Ann Lynch, Lorraine MacLauchlan, Diana Six

Back row: Mike Wagner, Iral Ragenovich, Dan Miller

Front row: John Withrow, Tim Ebata, Laura Moffitt, Nancy Gillette, Sunil Ranasinghe

Back row: John Popp, Matt Jedra, Ken Gibson, Chris Keeling, Peter Hall, Gary Blomquist

Front row: John McLean, Brytten Steed, Teri Howlett, LK Hart, John Borden, Dave Wood

Back row: Tom Eager, Kurt Allen, Bob Cain, Boyd Wickman, Tom Eckberg, Harry Quicke

Front row: Amy Gannon, Rob Flowers, Carl Jorgensen, Sheryl Costello, Kathy Sheehan, Darren Blackford

Back row: Joel McMillin, Larry Yarger, Danny Cluck, John Moser, Jennifer Klutsch, David Wakarchuk, Bob Rabaglia

Front row: James LaBonte, Armando Equihua-Martinez, David Quiroz-Reygadas, Carlos Magallon, Eric Smith, Andy Graves

Back row: Bill Riel, Don Owen, Steve Seybold, Bruce Thomson

Front row: Dan West, Rob Cruz, Liz Hebertson, Robert Hodgkinson, Brian Aukema, Honey Giroday

Back row: Jeff Hicke, Jim Rineholt, Jim Vandygriff, Darrell Ross

Front row: Tom Coleman, Ron Billings, Carroll Williams, Darci Carlson, Bill Schaupp, Ken Raffa

Back row: Nancy Sturdevant, Glenn Kohler, Ingrid Aguayo

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