

**65<sup>th</sup> Western Forest Insect Work Conference**  
**Sacramento, California**  
**31 March – 3 April, 2014**

*The New Normal – Changes in Disturbance Regimes and Ecosystem Consequences*

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# 65<sup>TH</sup> WESTERN FOREST INSECT WORK CONFERENCE

31 March – 3 April, 2014

Sheraton Grand Sacramento, Sacramento, CA

**Program:** Chris Fettig, Cynthia Snyder, and Don Owen

**Local Arrangements:** Beverly Bulaon and Martin MacKenzie

**Registration and Souvenirs:** Cynthia Snyder and Meghan Woods

**Field Trips:** Beverly Bulaon and Martin MacKenzie

**Silent Auction:** Don Owen

**Technical Equipment:** Zack Heath, Jeff Moore, and Meghan Woods

**Poster Session:** Martin MacKenzie

**Banquet:** Beverly Bulaon and Cynthia Snyder

**Photographs:** Bill Ciesla

**Student Session:** Dan Ott

**Local Transportation:** Beverly Bulaon

**Proceedings:** Chris Fettig

**WFIWC website:** Kathy Sheehan and Meghan Woods

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## WESTERN FOREST INSECT WORK CONFERENCE OFFICERS

### Current Executive Committee:

Chair	Steve Cook
Immediate Past Chair	Rich Hofstetter
Secretary	Laura Lazarus
Treasurer	Karen Ripley
Councilor	Kathy Bleiker
Councilor	David Jack
Councilor	Glenn Kohler

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

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

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

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

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

**Adhoc Technology Committee:** Joel Egan (Chair)





**WESTERN FOREST INSECT WORK CONFERENCE 2014**  
**SHERATON GRAND SACRAMENTO HOTEL**  
**MARCH 31 – APRIL 3, 2014**  
**SACRAMENTO, CALIFORNIA**

*The New Normal – Changes in Disturbance Regimes and Ecosystem Consequences*

**OFFICIAL AGENDA** (All times PDT)

**MONDAY, 31 MARCH**

- 1300-1800    Registration Open
- 1600-1700    Executive Meeting
- 1800-2000    REGISTRATION CON'T/POSTER SETUP/DISCUSSION

**TUESDAY, 1 APRIL**

- 0700-1000    Registration Open
- 0800-0815    WELCOME TO SACRAMENTO/HOTEL DETAILS/HOUSEKEEPING  
*Beverly Bulaon, Forest Health Protection*
- 0815-0845    DISTINGUISHED SPEAKER
- “Bright lights and big challenges on California’s forests today”  
*Russ Henly, California Natural Resources Agency*
- 0845-0945    PLENARY SESSION 1
- 0845-0915    “Pattern and the unprecedented: Examining forest-insect interactions through the  
lens of history”  
*Connie Millar, Pacific Southwest Research Station*
- 0915-0945    “Rear-view mirrors and crystal balls: Informing guesses about forest insects under  
climate change”  
*Vince Nealis, Pacific Forestry Centre*
- 0945-1015    BREAK
- 1015-1115    PLENARY SESSION 2
- 1015-1045    “Recent and projected changes in western US forest wildfire activity”  
*Anthony Westerling, University of California, Merced*

- 1045-1115 “Past, present, and future in the forests of California’s Sierra Nevada: Variability in forest response to environmental change, and the role of management in promoting ecosystem resilience”  
*Hugh Safford*, Pacific Southwest Region
- 1115-1145 MEMORIAL SCHOLARSHIP PRESENTATION
- “Assessing host colonization of the walnut twig beetle (*Pityophthorus juglandis*), vector of thousand cankers disease: Pre- and post-landing behavior”  
*Stacy Hishinuma*, University of California, Davis
- 1145-1200 INITIAL BUSINESS MEETING
- 1200-1300 LUNCH (on your own)
- 1300-1330 PREPARATION FOR AFTERNOON SESSIONS
- 1330-1500 GRADUATE STUDENT SESSION
- “Clustering of pine mortality attributed to the European woodwasp, *Sirex noctilio*”  
*Christopher Foelker*, Dylan Parry, Christopher Whipps and Melissa Fierke, SUNY-College of Environmental Science and Forestry
- “Emerald ash borer, from East to West”  
*Stephen Burr* and Rich Hofstetter (Northern Arizona University) and Deb McCullough
- "Limber pine stand conditions after white pine blister rust and mountain pine beetle outbreaks in the central and southern Rocky Mountains"  
*Christy Cleaver* and Bill Jacobi (Colorado State University), Kelly Burns, Jim Blodgett and Bob Means
- “Cone and seed insects of southwestern white pine (*Pinus strobiformis*)”  
*Gennaro Falco*, Kristen Waring, Rich Hofstetter and Nicholas Aflitto (Northern Arizona University), Joel McMillin and John Anhold
- "Structural relationships to defoliation by the pine butterfly (*Neophasia menapia*) on the Malheur National Forest, Oregon"  
*Ari DeMarco* (Oregon State University), Dave Shaw, Rob Flowers and Lia Spiegel
- “Evaluating high release rate MCH (3-methylcyclohex-2-en-1-one) treatments for preventing *Dendroctonus pseudotsugae* (Coleoptera: Curculionidae) infestations”

*Harrison Brookes* and Darrell Ross (Oregon State University), Tara Strand, Harold Thistle, Iral Ragenovich and Laura Lazarus

1500-1530 BREAK

1530-1700 CONCURRENT SESSION 1

1) ISLAND FORESTS UNDER ASSAULT: NATIVE AND INVASIVE PEST ISSUES OF THE PACIFIC ISLANDS (*Sheri Smith*, Chair)

“Recent insect introductions and outbreaks in the Hawaiian Archipelago”  
*Robert Hauff*, Division of Forestry and Wildlife, Hawaii

“Biological invasion of forests on Guam and other islands in Micronesia”  
*Aubrey Moore*, University of Guam

2) EAST MEETS WEST 1: EASTERN INVASIVE INSECT SPECIES THAT THREATEN WESTERN FOREST ECOSYSTEMS (*Tom Coleman* and *Steve Seybold*, Chairs)

“Emerald ash borer”  
*Damon Crook*, University of Massachusetts

“Redbay ambrosia beetle”  
*Bud Mayfield*, Southern Research Station

“*Sirex* woodwasp”  
*Christopher Foelker*, SUNY-College of Environmental Science and Forestry

3) INSECT AND DISEASE COMPLEX INTERACTIONS (*Martin MacKenzie*, Chair)

“You cannot separate the insects from the fungi they facilitate, or vice versa; or why I decided studying insects would make me a better pathologist”  
*Martin MacKenzie*, Forest Health Protection

“Symbiotic fungi of the red turpentine beetle – an evolving story”  
*Don Owen*, California Department of Forestry and Fire Protection

“Polyphagous shot hole borer/*Fusarium* dieback, an invasive beetle/disease complex threatening agricultural and natural landscape trees in California”  
*Akif Eskalen*, University of California, Riverside

1730-1830 SHERYL COSTELLO MEMORIAL FUN RUN



1900-2100 POSTER SESSION/SILENT AUCTION FOR MEMORIAL SCHOLARSHIP

2000-2045 SPECIAL PRESENTATION

“Forestry and forest health in South Africa”  
*Bill Ciesla, Forest Health Management International*

### **WEDNESDAY, 2 APRIL**

0700-0900 Registration Open

0800-0900 BUSINESS MEETING AND FIELD TRIP PREPARATION

0900-1700 FIELD TRIP (see pages 9–10)  
Stop 1: *Jenkins Lake, Eldorado National Forest: “Managing for forest health and resilience in the Sierra Nevada”*  
Stop 2: *Negro Bar, California State Park, Folsom: “Gray pine, the overlooked unique endemic”*

1800-2200 2013 FOUNDER’S AWARD

“Global climate change implications for forest entomology: Contributions of Northern Arizona University students”  
*Mike Wagner, Northern Arizona University*

### **THURSDAY, 3 APRIL**

0800-0830 FINAL BUSINESS MEETING

0830-1000 CONCURRENT SESSION 2

4) EAST MEETS WEST 2: HOW SHOULD WESTERN FOREST PEST SPECIALISTS PREPARE FOR THE NEXT WAVE OF EASTERN INVASIVE INSECT SPECIES? (*Steve Seybold and Tom Coleman, Chairs*)

Open discussion

5) CLIMATE AND FOREST INSECTS (*Jeff Hicke, Chair*)

“*Choristoneura* and weather: Inferences from the dendrochronological record”

*Ann Lynch and Tom Swetnam, University of Arizona*

“Climate and spruce beetle (*Dendroctonus rufipennis*) effects across latitudinal and forest productivity gradients in southwest Alaska”

*Rosemary Sherriff*, Humboldt State University

“Whitebark pine and mountain pine beetle outbreaks in the western United States: Quantifying the influence of climate”

*Jeff Hicke* and Polly Buotte (University of Idaho), Haiganous Preisler and Ken Raffa

6) DEFOLIATING INSECTS IN THE WESTERN UNITED STATES (*Rob Progar*, Chair)

“That other budworm: Western blackheaded budworm in Washington”

*Glenn Kohler*, Washington Department of Natural Resources

“Westside Story: The western oak looper in Oregon and Washington”

*Beth Willhite*, Forest Health Protection

“No need to panic: A review of the largest recorded outbreak of pine butterfly in Oregon's history”

*Robbie Flowers* (Oregon Department of Forestry), Ari DeMarco, Dave Shaw and Don Scott

“Balsam wooly adelgid, a guide to rating severity in western North America”

*Kathryn Hrinkevich* (Oregon State University) and Rob Progar

1000-1030 BREAK

1030-1200 CONCURRENT SESSION 3

7) SOMETHING NEW UNDER THE SUN? APPLICATIONS OF I&D GRAY LITERATURE AND CURRENT STATUS (*Beth Willhite*, Chair)

“Using gray literature to put forest pest conditions into historical perspective: Region 5 examples”

*Danny Cluck*, Forest Health Protection

“Gray literature: The process and the payoff”

*Amanda Grady*, Forest Health Protection

“Using historic forest health information to enhance management decisions”

*Joel Egan*, Forest Health Protection

“U.S. Forest Service Digital Collections”

*Sally Dunphy*, USDA Forest Service Library

8) TOOLS FOR TREE PROTECTION (*Don Grosman*, Chair)

“A review of different chemical application systems”  
*Don Grosman*, Arborjet Inc.

“Recent advances in insecticide tools and tactics for protecting conifers from bark beetle attack in the western United States”  
*Chris Fettig*, *Don Grosman*, *Steve Munson*, *Darren Blackford* (Forest Health Protection), and *Laura Lowrey*

“Injecting systemics into IPM of an exotic woodborer: EAB SLOWing Ash Mortality project (SLAM)”  
*Nathan Siegert* (Forest Health Protection), *Deb McCullough* and *Rodrigo Mercader*

"Beyond verbenone and MCH....What's new in tree protection"  
*Dave Wakarchuk*, Synergy Semiochemical Corp.

9) BIOLOGICAL CONTROL OF FOREST INSECTS AND WEEDS (*Justin Runyon*, Chair)

“Fungal bioinsecticides: Developing new tools for bark beetle management”  
*Cliff Bradley*, *Janina Bradley* and *Egan Jankowski* (Montana BioAgriculture), *Chris Fettig*, *Rob Progar* and *Brytten Steed*

“Predators of hemlock woolly adelgid in the Pacific Northwest: Potential for biocontrol in the East”  
*Darrell Ross* (Oregon State University), *Glenn Kohler*, *Sarah Grubin*, *Kimberly Wallin* and *Nathan Havill*

“Moving beyond the lottery method: Can we predict effectiveness of weed biocontrol agents?”  
*Justin Runyon*, Rocky Mountain Research Station

“Biological control of weeds in California”  
*Mike Pitcairn*, California Department of Food and Agriculture

1200-1300 LUNCH (on your own)

1300-1330 PREPARATION FOR AFTERNOON SESSIONS

1330-1500 CONCURRENT SESSION 4

10) (ALL NEW!) REGIONAL REPORTS: AN OPEN DISCUSSION FORUM  
ON THE STATE OF FOREST INSECTS IN THE WEST (*Beverly Bulaon*,  
Chair)

Open discussion

11) IMPACTS OF BARK BEETLES ON GOODS AND SERVICES OF  
WESTERN FOREST ECOSYSTEMS (*John Lundquist*, Chair)

“Bark beetles, trees, and people: An economic perspective”

*Eric Smith* (Forest Health Technology Enterprise Team) and Dan McCollum

“Impacts of the western pine beetle outbreak in southern California on  
ecological goods and services”

*Chris Fettig*, Pacific Southwest Research Station

“Mountain pine beetle in Colorado: The good, the bad, and the ugly”

*Bob Cain* (Forest Health Protection) and Jose Negrón

“Spruce beetle and western balsam bark beetle response to defoliator and sap-  
sucking damage”

*Ann Lynch*, University of Arizona

“Douglas fir beetle outbreak in the Rocky Mountains after fire”

*Rob Progar*, Pacific Northwest Research Station

“Status and impact of walnut twig beetle in forests and orchards”

*Steve Seybold*, Pacific Southwest Research Station

“Impacts of the 1990s spruce beetle outbreak on the ecosystems and  
communities of the Kenai Peninsula”

*John Lundquist*, Forest Health Protection and Pacific Northwest Research  
Station

Open discussion

12) PEST EXCLUSION EFFORTS FOR INVASIVE INSECTS IN  
CALIFORNIA (*Cynthia Snyder*, Chair)

“Collaborative outreach”

*Dave Pegos*, California Department of Food and Agriculture

“Port monitoring and safeguarding against invasive species”

*Mark Hitchcox*, Animal and Plant Health Inspection Service

“Detector dogs at California ports” (demonstration)

*Jennifer Berger* and her canine *Dozer*, California Department of Food and Agriculture

Firewood Task Force

*Don Owen*, California Department of Forestry and Fire Protection

1500-1530 BREAK

1530-1700 TOUR OF CALIFORNIA STATE CAPITOL GROUNDS  
Urban trees and their coordinated management

## INITIAL BUSINESS MEETING

April 1, 2014  
Sacramento, California

### Opening Comments

Steve Cook welcomed everyone to the 2014 meeting. A moment of Silence was observed for the passing of former members Red McComb and Dave Bridgewater. Steve announced that the high elevation field trip portions would be cancelled on Wednesday due to accessibility issues.

### Old Business

No old business. Please see the WFIWC website for last year's meeting notes.

### New Business

1. 2014 Committee Reports
  - a. Steve Cook read the History Committee Report for Sandy Kegley.
  - b. Joel Egan read the Ad Hoc Technical Advisory Committee Report.
  - c. Steve Cook read the Student Scholarship Fund Raising Committee Report. The silent auction made \$800 in 2013. Don Owen is requesting items quickly for this year's auction.
  - d. Bill Riel read the Founder's Committee Report.
  - e. Bill Ciesla read the Common Names Committee Report.
  - f. Glenn Kohler read the Treasurer's Report for Karen Ripley.
  - g. Darrell Ross read the Memorial Scholarship's Report.
2. *New motions:*
  1. Make the Ad Hoc Technical Advisory Committee permanent. Bill Ciesla made a motion to accept and Glenn Kohler seconded.
  2. Cap the student registration fees at 30 percent of the year's total registration fee every year. Darrell Ross made a motion and Bill Ciesla seconded the motion.
3. A new Secretary is needed to replace Laura Lowrey for 2015.
4. A new counselor is needed to replace Glenn Kohler.
5. Recent snowfall presents safety and access issues for Wednesday's field trip. Steve decided to cancel the high elevation portion of Wednesday's field trip.
6. Sandy Kegley requested we ask for volunteers for the History Committee during the Initial Business Meeting.
7. Bill Riel motioned to end the meeting, Kathy seconded the motion.



## HISTORY COMMITTEE REPORT

The photos/History link to the WFIWC website has received 4,000 visitors since its inception in 2008. Most visitors remain anonymous; however, some people request permission to publish particular photos. Such use is encouraged and negotiated on an individual basis. Dieter Steiner, a human ecologist living in Zurich, Switzerland, is working on a biography of Rachel Carson ("Silent Spring" 1962) in German. To illustrate the spraying campaigns undertaken in the immediate postwar period, he asked to use the picture of a DC-3 spraying DDT to control the Douglas-fir tussock moth in Idaho in 1947. The book will be published by oekom in Munich, a publisher in environmental literature. Fernando E. Vega, USDA, Beltsville, and Rich Hofstetter are co-editing a book on bark beetles and requested permission to include a photograph of A.D. Hopkins and Stephen L. Wood that appear under Personnel.

An extensive biographical and historical article by Mal Furniss on the Douglas-fir beetle in western forests has been accepted by the American Entomologist. It was to appear in the spring 2014 issue but due to its length has been moved to the summer issue.

Boyd Wickman advises that he is writing a well-illustrated story dealing with forest insects in Yosemite N.P. during the period 1906-1960s. He was personally involved there from 1953 to 1962 with controlling the lodgepole needleminer with DDT and the mountain pine beetle with ethylene dibromide. He has a rough draft completed but needs biographical information on park officials. He had scheduled a meeting with the park archivist when the Rim Fire occurred and has rescheduled a meeting for this summer.

Submitted by Mal Furniss, Boyd Wickman, and Sandy Kegley

## TREASURER'S REPORT

<b>Account balances:</b>	<b>Checking:</b>	<b>Savings:</b>	<b>CD's:</b>	<b>NAFIWC</b>	<b>Total:</b>
Jan 1, 2011	\$ 4,147.36	\$12,926.73	\$80,847.03		\$ 97,921.12
Jan 1, 2012	\$ 8,062.62	\$95,216.35	\$11,992.03		\$ 115,271.00
Jan 1, 2013	\$ 6,716.45	\$94,007.83	\$12,055.69	(\$14,480.00)	\$ 112,778.97
Jan 1, 2014	\$10,804.40	\$107,417.54		(\$14,855.33)	\$ 118,221.94

The Western Forest Insect Work Conference has sound financial status. Although interest rates are very low, we have solid account balances.

1. In 2013, WFIWC balances increased by \$5442.97.
2. 2013 WFIWC Coeur d'Alene earned \$3466.51. Many thanks to the planning committee for an excellent meeting and high awareness to contain meeting costs.
3. 2013 earnings for the Memorial Scholarship Fund included payments from two vendors (ArborJet and Contech) which each contributed \$200 to the Scholarship fund for their booths in Coeur d'Alene. The 2013 Silent Auction earned \$800. \$750 was paid to Stacy Hishinuma the 2013 Memorial Scholarship winner.
4. The recent banking records, check register and US Tax Returns are available and will be reviewed by the Councilors during this meeting. The 2010 and 2011 Tax Returns are also available at: <http://www.fsl.orst.edu/wfiwc/admin/treasurer.htm#taxes>. The 2012 Tax Return is complete and a hard copy is available. It has not yet been posted. The 2013 Tax Return is due May 15, 2014.

Recent changes in account balances.

1. In March 2014, \$14,855.33 was sent to Virginia Tech to support the next North American Forest Insect Work Conference. These are the funds that were generated by the last NAFIWC in Portland, Oregon and, although WFIWC held the money, it wasn't ours. WFIWC currently has a CD in that amount, but paid NAFIWC in full from the checking account.
2. As of 3/20/2014 the expenses for the Sacramento meeting were \$32,120.19. Revenue will be received April 2 from the Eventbrite Meeting Planning website. There will be a final bill for the hotel, but all other significant meeting expenses have been paid already.

Memorial Scholarship

1. In 2014, two donations have been made to the Memorial Scholarship fund: \$100 in memory of David Bridgewater and \$75 for use of a historic WFIWC photo in a publication.
2. A \$750 Scholarship will be awarded in 2014.
3. Ripley has not yet thoroughly reviewed recent years' earnings in order to combine all the explicit Memorial Scholarship Fund donations and interest into a separate account or CD. This is a goal for 2014.

If anyone has questions about these documents or wants to review them at any time, please contact Treasurer Karen Ripley ([karen.ripley@dnr.wa.gov](mailto:karen.ripley@dnr.wa.gov)).

## FOUNDER'S AWARD COMMITTEE REPORT

Representing the Founder's Award Committee, it is my pleasure to announce the selection of Dr. Terry Shore (posthumously) as the 2014 WFIWC Founder's Award recipient. Lorraine MacLauchlan nominated Terry, and she has been notified of his selection. We invited Lorraine to collaborate with Terry's colleagues to compile an address and decide how to best present it in Terry's honor at the 2015 WFIWC meeting.

At the meeting this year (Sacramento, CA), Dr. Mike Wagner will be giving his Founder's Award address during the banquet. Craft Trophy in Ft. Collins, Colorado, did a wonderful job once again on the plaque that will be presented to Mike. In my absence, Founder's Award Committee member Joel McMillin will say a few words about the Award and Brytten Steed, Mike's nominator, will present the plaque to him.

Last year the Founder's Award Committee put together a poster that will be on display again this year in the poster room. The poster shows the amazing legacy of the WFIWC Founder's Award and includes pictures of all past recipients. Also on display are the 2 'traveling' plaques with all the recipients' names. As a reminder, information about all the Founder's Award recipients is on the WFIWC website, including a write-up of each address. Thanks to Joel Egan for taking video of Founder's Award presentations and making these available on the WFIWC website.

We encourage WFIWC members to consider nominating one of the many people who have been important in western forest entomology, and to WFIWC, for this prestigious award. Nomination information is available on the WFIWC website.

I have been the Chair of the Founder's Award Committee since 2009, and was on the Committee for several years prior to that. It is time for me step down as Chair, and give other WFIWC members the opportunity to serve the conference by being on the Founder's Award Committee. Joel McMillin, a current Founder's Committee member, has agreed to be the new Founder's Award Committee Chair. The Committee will work together to appoint a new member to the committee.

Respectfully,  
Barbara Bentz  
Founder's Award Committee Chair

Committee members:  
Joel McMillin  
Ken Raffa  
Bill Riel  
Steve Seybold

## AD HOC TECHNICAL ADVISORY COMMITTEE REPORT

Consideration of future WFIWC website design and responsibilities

Joel M Egan, Adhoc Technology Committee Chair, [jegan@fs.fed.us](mailto:jegan@fs.fed.us), 406-329-3278

Kathy Sheehan is the current webmaster for the WFIWC and has supported this conference with years of dedicated service and technological support. Kathy has recently taken a new position and will not be able to continue updating and administering the WFIWC website. Meghan Woods has updated the website for the 2014 annual meeting. Kathy and the Adhoc Technology Committee have discussed updating the website from its current HTML-based coding to a new, Drupal-based, modern website platform that can increase functions available. Quotes for service have been received from a web-designer with the Think Tank, LLC who can build a new WFIWC website and provide tech support for two years after implementation. A handout is provided by the contractor and a prototype website has been built and is temporarily uploaded to: [wfiwc.thethinktankllc.com](http://wfiwc.thethinktankllc.com). Kathy Sheehan and Meghan Woods may be available to help with copying information and transitioning to a new website.

Cost to build website w/ tech support: \$1,500 (one-time fee)

The WFIWC website is currently hosted by space donated within Oregon State University (OSU) servers. Kathy and the Adhoc Technology Committee have discussed that it is not known how much storage space or bandwidth OSU is willing to provide or if their web administrators still realize they are hosting the WFIWC page. Content keeps being added to the WFIWC website including annual proceedings and Founder's Award Speech videos. Multiple servers are available to host the WFIWC website especially with the special 501(c)(3) non-profit organization status.

Cost for server to host website: free to non-profits through Dream Host or \$15-30 per month through commercial servers

The WFIWC website currently does not have its own domain name such as "www.wfiwc.org" and is "www.fsl.orst.edu/wfiwc"

Cost to purchase domain name: \$9-20 per year

Options for Executive Committee to consider:

1. Should WFIWC keep current website format?
2. Should WFIWC keep current website server?
3. Should WFIWC keep current website domain name?

## MEMORIAL SCHOLARSHIP SELECTION COMMITTEE REPORT

Darrell Ross, Chair  
Sandy Kegley  
Steve Munson  
Steve Seybold  
Ward Strong

Ward Strong resigned from the committee in fall 2013 citing his inability to get approval to attend the meeting for a number of years and his need to decrease some of his commitments. Since Steve Munson was added as an additional committee member in 2011, we still have the required number of committee members. However, the committee will work to find an additional member in the coming year.

The committee received only one application for the 2014 scholarship. The committee unanimously agreed to award the scholarship to Jordan Burke, a Ph.D. student at the University of British Columbia working with Dr. Allan Carroll. Jordan's dissertation research is focused on mountain pine beetle range expansion and evolution. Jordan will have the opportunity to give a presentation on his dissertation research at the 2015 WFIWC meeting in Santa Fe, New Mexico.

The committee encourages all qualified graduate students to apply for the 2015 Memorial Scholarship. The deadline to submit applications is February 15, 2015.

## COMMON NAMES COMMITTEE REPORT

During CY 2013, a total of 6 common name proposals submitted by the WFIWC CNC were approved by the Entomological Society of America Common Names Committee and are now in the ESA Common Names database. They are:

### Hemiptera

*Matsucoccus bisetosus* - ponderosa pine twig scale

*Masucoccus vexillorum* - Prescott scale

### Hymenoptera

*Neodiprion edulicolis* - pinyon sawfly

*Zadiprion rohweri* - Rohwer's pinyon sawfly

*Zadiprion townsendi* - bull pine sawfly

### Acariformes

*Eriophyes calaceris* - Rocky Mountain maple felt mite

The CNC continues to encourage and coordinate the submission of common names for insects discussed in Furniss and Carolin's "Western Forest Insects" that do not have ESA-approved common names. Approximately half of the common names used in this classic publication are not sanctioned by either ESA or ESC. We encourage authors who are revising sections of this publication to submit common names for the insects being revised as appropriate.

We also encourage proposals of common names for recently introduced and established exotic forest insects in the West. The established review and comment process, using links available on the WFIWC official website, continues to work well.

Members interested in submitting proposals for common names should use the form available on WFIWC Common Names website, seek peer review and comments, and submit their proposal to either Brytten Steed or Bill Ciesla.

Respectfully submitted,

/s/ Brytten E. Steed and /s/ William M. Ciesla, co-Chairs

For WFIWC – Common Names Committee



## **FINAL BUSINESS MEETING**

April 4, 2014  
Sacramento, California

### **Announcements and Old Business**

The meeting was opened by WFIWC Chair, Steve Cook, at 8:30 a.m.

1. Thanks to the organizers of this year's WFIWC.
2. Tom Smith has sign-up sheets for SAF certification credits, see him if interested.
3. There are additional swag bags available for whomever.
4. Steve thanked the hotel for excellent accommodations.
5. Meet at 3:15 today for Tour of the Capital
6. Memorial Scholarship bidding at the Silent Auction resulted in \$700.
7. Thanks to Joel Egan for videotaping the Founder's Award speech by Mike Wagner.

### **New Business**

*New motions:*

1. The 2015 meeting will be in Santa Fe, New Mexico hosted by Andy Graves and Region 3.
2. The Ad Hoc Technical Committee will now be a full Committee with Joel Egan as chair. Volunteers needed.
3. Student registration fees at future WFIWC's will be capped at 30 percent of total cost for standard members.
4. The new Secretary will be Beverly Bulaon replacing Laura Lowrey in 2015.
5. The new counselor replacing Glenn Kohler in 2015 will be Dr. Rob Flowers.
6. Motion to end the meeting was made by Glenn Kohler and a second motion by Bill Ciesla.
7. Meeting Adjourned at 8:46 a.m.

## **DISTINGUISHED SPEAKER**

### **Bright Lights and Big Challenges on California's Forests Today**

**Russ Henly**

California Natural Resources Agency, Sacramento, CA

There are many positives for California's 33 million acres of forestland. At the same time, these valuable natural assets face a variety of significant threats. Private forestland owners in the state have taken many steps toward sustainable forest management, including establishment of working forest conservation easements (estimated 160,000 acres), habitat conservation plans (over one million acres), and third-party certification (3.5 million acres). Many smaller forest landowners have demonstrated their commitment to sustainable forest management by enrolling in nonindustrial timber management plans (over 325,000 acres). Recent California legislation provides enhanced funding for the state agencies charged with regulating forest practices on private lands and directs those agencies to develop ecological performance measures. US Forest Service Region 5 has committed to ecological restoration as the "prime directive" for the 20 million acres of National Forest in the state. While identifying a need to treat these forests at the pace of 500,000 acres per year, resources have not been adequate to treat even half this amount. The threats that California's forests face are familiar to Westerners: drought, pests, wildfire, and climate change. The state is in the grips of one of its worst droughts, with most areas of the state having received record low precipitation in 2013. As of April 1, snowpack was only 32 percent of average. Increasing movement of people and goods is increasing the opportunity for new forest pests to be introduced, and climate stressors are making our forests more vulnerable to pests, native and exotic. Goldspotted oak borer (GSOB), a recent arrival in the state, is spreading in Southern California and has a real potential to spread throughout the state and beyond. For the extensive areas of the state already impacted by sudden oak death, arrival of GSOB could be a real 1-2 punch for our native oak populations. Wildfire threat has been enhanced by drought, denser stands of small trees, and longer fire seasons (i.e., climate change). Fire statistics show that large fires are increasing in size, intensity, and frequency.

California, through implementation of the state's Global Warming Solutions Act of 2006, has been a leader in addressing both climate change mitigation and adaptation. The Governor has proposed to make \$100 million of greenhouse gas emission allowance auction revenues available for forest-based mitigation actions. Draft updates to the state's climate mitigation plan and adaptation plan have recently been out for public comment, and final updates will be released later this year. While these plans have recognized the importance of the extensive area of federal lands in the state, they mostly focus on nonfederal lands and efforts by state and local agencies and private entities. While Region 5 Forest Service has shown initiative on climate change issues, they have been hamstrung by lack of Congressional leadership on this critical issue. We must all challenge ourselves to work to address climate change in our professional and private lives, keeping in mind that those who are likely to be most affected by it are least responsible for it and have the fewest resources to cope with it.

## **PLENARY SESSION 1**

### **Pattern and the Unprecedented: Examining Forest-Insect Interactions through the Lens of History**

**Constance I. Millar**

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

The theme for the 2014 Western Forest Insect Work Conference, “The New Normal”, underscores a brave new era that Earth has entered, and emphasizes that the present is very different from the past. In this talk I evaluated one aspect of this assertion in relation to pattern versus unprecedented in historic forest-insect interactions. The descriptor, “unprecedented”, is commonly used in regard to current and future climate dynamics, as well as in forest health literature. Its use, however, is subjective and inappropriate unless in the context of historic temporal and spatial references, and is warranted only if supported by historic analysis. When the context concerns ecosystem function, sustainability, species persistence, or biodiversity, the appropriate time period for reference, while difficult to determine, is very long (at least multi-millennial). To assess how present responses compare to the past requires that evaluations be made relative to the important climate modalities through which our native species have persisted, and to which they are adapted. These include the orbitally driven 40+ glacial-interglacial cycles of the Quaternary (past 2.6 million years). During this time, North American hemispheric temperatures fluctuated 5-7 °C, which compares to the most dramatic scenarios for 2100, and during which time greenhouse gases also cycled. Ecosystem responses were significant, with mountain species shifting more than 1000 m in elevation and lowland species migrating more than 2000 km to track favorable environments. Abrupt changes in temperature of over 6 °C are recorded during historic “flickering switches”, when climates re-organized over as little as two decades. Nested within the glacial-interglacial are century-scale cycles driven by regular changes in solar activity. Examples include the Medieval Warm Period (~ 900-1200 yrs ago), when temperatures were ~ 1-2 °C warmer than the mid-20<sup>th</sup> C, and the Little Ice Age (~ 90–550 yrs ago) when temperatures were ~ 1-2 °C colder than the mid-20<sup>th</sup> C. Vegetation responses were similar to Quaternary dynamics, but smaller in magnitude. Interdecadal and interannual climate modalities such as the Pacific Decadal Oscillation and the El Niño Southern Oscillation are further nested, and are driven by changes in ocean circulation. Ecosystems respond to these dynamics mostly *in situ*, with shifts in disturbance, mortality, and productivity.

I outlined six examples of historic forest-insect interaction (larch budmoth, Pandora moth, spruce budworm, spruce bark beetle, mountain pine beetle, and the hemlock decline event) that extend across three of these scales of climate change (inter-annual to multi-millennia), and examined their recurrence patterns, cyclicity over time, relation to climate forcing, and impact on forest productivity and adaptive species persistence. Many cases appear to 1) recur repeatedly at stable periodicities over centuries to millennia, often without apparent relation to climate variability or change, 2) improve forest productivity and species fitness through thinning and genetic adaptation, and 3) do not lead species into extinction vortices, even under conditions of “massive forest collapse”. Incorporating this knowledge into natural resource management suggests that while resistance and resilience strategies may be appropriate in the short term, for the long term we must embrace strategies that assist transitions and responses to rapidly changing

environments. The term “unprecedented”, when justified by historic analysis, should always be used in regard to a specified time depth and spatial scale.

**Rear-view Mirrors and Crystal Balls:  
Informing Guesses About Forest Insects Under Climate Change**

**Vince Nealis**

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

Climate and weather have a pervasive influence on the distribution and abundance of forest insects. So, climate change introduces additional uncertainty to our expectations of future threats to forest health. Two approaches to reducing this uncertainty are 1) to analyze the empirical evidence available from historical records, the rear-view mirror, and 2) to develop process-based seasonality models, the crystal ball, to examine the consequences of change in climate-related patterns such as temperature.

Historical data are often sparse to nonexistent. Even when available, their resolution of important specifics may be difficult to verify. Results of such empirical models are descriptive with limited ability to reveal underlying mechanism so extrapolation with climate change scenarios is questionable. These models have proved useful, however, in estimating the likely geographical range, if not impacts, of introduced species and providing hypotheses regarding critical climatic parameters for deeper analysis. Process models demand considerable investment in careful, replicated measurement, and technical impediments to functional understanding of critical life history events can be formidable. When reasonably complete, process models provide powerful and flexible analytical tools to examine geographic range and probable changes in risk of disturbance under a range of actual or potential climatic scenarios.

## **PLENARY SESSION 2**

### **Recent and Projected Changes in Western US Forest Wildfire Activity**

**Anthony Westerling**

University of California, Merced, CA

*No abstract received*

### **Past, Present, and Future in the Forests of California's Sierra Nevada: Variability in Forest Response to Environmental Change, and the Role of Management in Promoting Ecosystem Resilience**

**Hugh Safford**

Pacific Southwest Region, USDA Forest Service, Vallejo, CA

California forests face major changes over the next century, but the extent, intensity, and type of change is likely to be variable among different ecosystems. This variability in response will be driven by factors like the ecological tolerances of component species, site histories, the rate and nature of future environmental change, and management policies. In the Sierra Nevada of California, a major ecotone occurs between lower and upper montane forests, at approximately the altitude of deepest winter snowpack and the average freezing elevation in winter storms. Below this line, the Sierra Nevada is dominated by yellow pine and mixed conifer forests, which are mostly moisture-limited systems historically dominated by highly frequent fire; above this line the range is dominated by red fir and subalpine forests, which are mostly energy-limited systems dominated historically by relatively infrequent fire. Additionally, below this line most of the Sierra Nevada is comprised of "working forest", while above it much of the range is included in roadless and wilderness areas and National Parks. I contrast these two different environments with respect to their historical, current, and likely future conditions, focusing on the impacts of three classes of environmental stressors: climate change, wildfire, and invasive species. Vulnerabilities to these stressors differ appreciably between lower montane and upper montane forests, but climate warming and human population growth, among other things, will likely introduce many lower montane afflictions to the upper montane zone in the not-too-distant future. I discuss what sorts of management actions, both active and passive, might be employed in these different environments to increase ecosystem resilience to future change. At the same time, I caution that human expectations and assumptions about these ecosystems, their permanence and the services they provide must eventually be reconciled with the likelihood that the Sierra Nevada of one-hundred years hence may look little like the Sierra Nevada of today.

## MEMORIAL SCHOLARSHIP PRESENTATION



### **Assessing Host Colonization of the Walnut Twig Beetle, *Pityophthorus juglandis*, Vector of Thousand Cankers Disease of Walnuts**

**Stacy M. Hishinuma**<sup>1</sup>, Mary Louise Flint<sup>1</sup>, Richard M. Bostock<sup>1</sup>, and Steven J. Seybold<sup>2</sup>

<sup>1</sup>University of California at Davis, Davis, CA

<sup>2</sup>Pacific Southwest Research Station, USDA Forest Service, Davis, CA

Thousand cankers disease of walnuts is caused by the fungal pathogen, *Geosmithia morbida*, which is vectored by the walnut twig beetle (WTB), *Pityophthorus juglandis*. The disease threatens several native and introduced walnut (*Juglans*) species in North America. Disease severity may be affected by the host preference of WTB or by canker formation following *G. morbida* infection. We studied several phases of WTB host colonization behavior at two sites, a germplasm collection of over 16 walnut species and hybrids in Solano Co., California, and a former riparian area with a native stand of northern California black walnut, *Juglans hindsii*, in Yolo Co., CA.

Landing rates of WTB were assessed on unbaited branches of 6 species of live *Juglans* trees (May to October, 2012-2013) and on aggregation pheromone-baited cut branch sections of 5 *Juglans* species (September to October, 2013) at the first site. For both studies, clear plastic



sheets coated with Stickem Special were used as traps. Higher landing rates were recorded on unbaited and baited branches of *J. californica*, a black walnut species native to southern California.

In Yolo Co., 6 sets of paired cut branch sections of *J. hindsii* and English walnut, *J. regia*, were placed on a metal conduit pole either with or without a synthetic aggregation pheromone lure (May to August 2011-2013). Branches were dissected daily and all WTB were sexed and removed. In the presence of pheromone, WTB colonization incidence (a surrogate for landing rate) was higher on *J. hindsii* than on *J. regia* in this choice test. Our results suggest that WTB discriminates in flight among host branches in the absence or in the presence of its aggregation pheromone. It may exhibit further discrimination through close range gustatory or mechanical reactions once beetles have landed on a host branch or stem. Specific visual, tactile, or chemical components to host attractiveness have yet to be discovered.

## GRADUATE STUDENT SESSION

### **Clustering of Pine Mortality Attributed to the European Woodwasp, *Sirex noctilio***

**Christopher Foelker**, Dylan Parry, Christopher Whipps, and Melissa Fierke

<sup>1</sup>State University of New York, College of Environ. Sci. and Forestry, Syracuse, NY

Spatial colonization patterns can be an important component of understanding an insect's life history. Aggregation can play a key role in population biology by allowing insect herbivores to escape regulation by predators or overcome host defenses. Here, we analyze spatial colonization patterns of the European woodwasp, *Sirex noctilio*, at a pine plantation in the Adirondack region of New York State. *Sirex noctilio* is a recently-introduced invasive pest that has caused considerable economic loss in commercial pine plantation in the Southern Hemisphere and attacks and kills *Pinus resinosa* and *P. sylvestris* in North America. We used spatial statistics to test if pine mortality was A) aggregated within and between years and B) consistent as the extent of analysis increased in scope. Mortality was significantly aggregated both within and between years; however, this explained only a small amount of deviance in the models (2-10%). A scan statistic with multiple scanning window radii (5, 10, 20, and 30 m) was used to test if patterns of mortality were consistent as the scope of the analysis increased from a fine to coarse resolution. We found mortality attributed to *S. noctilio* was significantly clustered at each scanning window extent. However, patterns of mortality may not be attributed to the same underlying processes for each model. Future work should include the effects of additional biotic and environmental covariates on spatial pattern of *S. noctilio* mortality.

### **Emerald Ash Borer, From East to West**

**Stephen J. Burr**<sup>1</sup>, Richard W. Hofstetter<sup>1</sup>, and Deborah G. McCullough<sup>2,3</sup>

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<sup>2</sup>Department of Entomology and <sup>3</sup>Department of Forestry  
Michigan State University, East Lansing, MI

In 2013 Emerald ash borer (*Agrilus planipennis* Fairmaire) (Coleoptera: Buprestidae) was discovered in Boulder CO, what impact could *A. planipennis* have on western ash species? In Michigan we sampled *A. planipennis* populations in 24 green ash (*Fraxinus pennsylvanica*) sites, each 1 ha in size. Eight sites were located in each of three areas of southern Michigan representing (1) the original *A. planipennis* Core; (2) the invasion Crest, in south central Michigan, where *A. planipennis* populations were currently peaking, and (3) the invasion Cusp, in southwest Michigan where *A. planipennis* had recently become established.

Adult *A. planipennis* were captured in all 24 sites in both years of the study. We found *A. planipennis* populations continued to persist in Core sites, is high in the Crest, and is on the rise in Cusp sites. Despite the depletion of overstory ash in southeast Michigan, *A. planipennis* continues to infest and kill trees in Core sites. Mortality of overstory ash decreased across an east to west gradient across southern Michigan. Green ash was abundant in the understory of all

sites including Core sites. There was no evidence of current year ash germination in Core sites in southeast Michigan. If *A. planipennis* persists in these areas, regenerating ash will continue to become infested and killed, and potentially eliminating ash from these systems.

*Agrilus planipennis* has the potential to impact western ash populations in a similar manner observed in the eastern ash stands. Ash is not as contiguous in the west, but is an important part of riparian zones, and has been widely planted along urban streets. The ecological as well as the economic costs of *A. planipennis* could be substantial.

### **Limber Pine Stand Conditions after White Pine Blister Rust and Mountain Pine Beetle Caused Mortality in the Central and Southern Rocky Mountains**

**Christy Cleaver<sup>1</sup>, William Jacobi<sup>1</sup>, Kelly Burns<sup>2</sup> and Bob Means<sup>3</sup>**

<sup>1</sup>\*Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO

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<sup>3</sup>BLM Wyoming, Cheyenne, WY

Mountain pine beetle and white pine blister rust are causing extensive crown dieback and mortality in limber pine (*Pinus flexilis* James) in the central and southern Rocky Mountains. Ecologically valuable limber pines often grow in fragile ecosystems where few other trees can grow. The combined effects of mountain pine beetle, white pine blister rust, dwarf mistletoe, and climate change could greatly impact the biodiversity of these ecosystems. Information on stand conditions is needed to facilitate management and restoration efforts. The study objectives were to: (1) assess site, stand, and health characteristics of seedlings and mature limber pines in Colorado, Wyoming, and Montana, (2) determine factors that influence the occurrence and incidence of white pine blister rust, bark beetles, and dwarf mistletoe, and (3) determine factors that impact regeneration, including site, stand, and climate characteristics, and white pine blister rust.

In 2011 and 2012, we assessed 22,700 limber pines on 508 plots in limber pine-dominated stands in twenty-five study areas in Colorado, Wyoming, and Montana. Mean density of mature, live limber pine was 316 stems/ha. Fifty percent of all standing trees were classified as healthy, 26% were declining or dying, and 24% were dead. White pine blister rust was the primary damage agent and was widespread, occurring in 23 of the 25 study areas and average incidence was 24% (0 to 62%). Bark beetle-caused mortality occurred in all 25 study areas and 17% of standing limber pines were killed by bark beetles (5 to 36%). Limber pine dwarf mistletoe occurred within 20 study areas, on 32% of plots with an average incidence of 9% (0 to 27%). Live limber pine seedling density averaged 141 stems/ha. Of all standing live and dead limber pine seedlings, 1.5% were dying, 4.4% were dead, and white pine blister rust occurred on 5.3% of live seedlings.

We used statistical modeling to determine if any meteorological, macro and micro site factors and stand factors influenced the presence of white pine blister rust, bark beetles, and dwarf mistletoe on mature tree and regeneration. We also used statistical modeling to determine factors that predict density (stems/ha) of limber pine regeneration. Limber pine stands heavily impacted

by mountain pine beetle and white pine blister rust, combined with low regeneration density in some study areas suggest that some limber pine stands may not survive. These areas may be in need of additional monitoring so land managers can decide if restoration efforts are warranted.

Acknowledgements: This study was funded by U.S.D.A. Forest Service, Forest Health Monitoring, Evaluation Monitoring Program, BLM Wyoming, Colorado Agricultural Experiment Station, Colorado State Forest Service, and Boulder County Open Space.

## **Cone and Seed Insects of Southwestern White Pine, *Pinus strobiformis*, in Arizona and New Mexico, USA**

**Gennaro A. Falco<sup>1</sup>**, Kristen M. Waring<sup>1</sup>, Richard W. Hofstetter<sup>1</sup>, Joel D. McMillin<sup>2</sup>,  
Nicholas C. Aflitto<sup>1</sup>, and John Anhold<sup>3</sup>

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Cone and seed insects represent a diverse guild of forest pests that can cause significant damage on annual seed crops. We conducted a study to identify the cone and seed insects of southwestern white pine (*Pinus strobiformis*), one of the least studied five-needle pines in western North America and quantify their damage. We found 1,314 mature insect-infested pine cones from 44 sites across Arizona and New Mexico in August and September of 2012 and 2013. Cones were caged individually and 7 month rearing trials were conducted to collect emerging insects. Mean ( $\pm$ SE) insect infestation rate per site for 2013 was estimated to be 26.6%  $\pm$  2.3. Infestation was highly variable between sites, ranging from 0-100%; while within-site variation was considerably lower. To date, 330 insects have been collected representing the majority of tree families and populations sampled. Insect genera represented in collections include *Megastigmus* (seed chalcid), *Leptoglossus* (western conifer seed bug), *Dioryctria* (pine cone worm), and *Conophthorus* (pine cone beetle) species. Several hymenopteran and dipteran parasitoid species have also been collected. The most common pest observed was *Dioryctria spp.*, representing 90% and 51% of collections in 2012 and 2013, respectively. Future work will involve caging immature cones *in situ* throughout the summer of 2014. Final results will be synthesized into an identification guide intended for southwestern forest practitioners.

## **Evaluating High Release Rate MCH (3-methylcyclohex-2-en-1-one) Treatments for Preventing *Dendroctonus pseudotsugae* (Coleoptera: Curculionidae) Infestations**

**H.M. Brookes<sup>1</sup>**, D.W. Ross<sup>1</sup>, T. Strand<sup>2</sup>, H. Thistle<sup>3</sup>, I. Ragenovich<sup>4</sup>, and L. Lowery<sup>5</sup>

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The Douglas-fir beetle (*Dendroctonus pseudotsuga*) can kill large numbers of Douglas-fir trees (*Pseudotsuga menziesii*) across a landscape during periods of population outbreaks. High value trees and small stands of trees can be protected from Douglas-fir beetle infestation during outbreaks by applying the anti-aggregation pheromone, MCH (3-methylcyclohex-2-en-1-one). MCH treatments are economical and highly effective, but there are still opportunities to refine existing treatments to be even more cost effective.

Current recommendations for applying MCH are to space individual releasers on a 12 x 12 meter grid throughout areas to be protected. Previous field studies and a theoretical study using a puff dispersion model to predict pheromone concentrations have shown that wider spacing of releasers emitting the pheromone at higher release rates may be equally effective compared with the established standard treatment.

During 2012 and 2013, we tested higher release rates of MCH at corresponding wider spacings to keep the total amount of MCH released per unit area equal in all treatments. In 2012 near Challis, Idaho, treatments included the established standard release rate and spacing, four and six times the standard release rate with correspondingly wider spacings, and an untreated control. In 2013 near Ketchum, Idaho, treatments included the established standard release rate and spacing, five and seven times the standard release rate with correspondingly wider spacings, and an untreated control.

Results from both years indicated that all MCH treatments were equally effective in preventing Douglas-fir infestation. Using higher release rate formulations at wider spacings will reduce labor costs of installing MCH treatments. In addition to reducing labor costs, the revised treatment protocol may increase the feasibility of treating areas that currently may not be possible due to treatment costs.

## CONCURRENT SESSION 1

### **ISLAND FORESTS UNDER ASSAULT: NATIVE AND INVASIVE PEST ISSUES OF THE PACIFIC ISLANDS (Sheri Smith, Chair)**

#### **Island Forests Under Assault: Recent Insect Introductions and Outbreaks in the Hawaiian Archipelago**

**Robert Hauff**

Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife

The Hawaiian islands have experienced a spate of forest insect introductions over the past decade. Some of the worst invasive pests that threaten forests in Hawaii include the coconut rhinoceros beetle (*Oryctes rhinoceros*), Erythrina gall wasp (*Quadrastrichus erythrinae*), myoporum thrips (*Klambothrips myoporii*), and lobate lac scale (*Paratachardina pseudolobata*). Additionally the hala scale (*Thysanococcus pandani*) which has been on the island of Maui since the 1990s was recently detected on Oahu. On Hawaii island, an outbreak of an endemic moth recently defoliated over 70,000 acres of koa (*Acacia koa*) forest. The outbreaks appear to be normal occurrences, but interaction with recently introduced insects such as the koa psyllid (*Acizzia uncatoides*) and invasive plants may make these outbreaks more destructive than under past conditions. Managing this surge of insect introductions and outbreaks and preventing new ones will require better early detection and control tools. Biological control is especially important to limiting insect damage to forest resources.

#### **Biological Invasion of Forests on Guam and Other Islands in Micronesia**

**Aubrey Moore**

Cooperative Extension Service / Western Pacific Tropical Research Center  
College of Natural and Applied Sciences  
University of Guam, Mangilao, Guam

American affiliated island groups in Micronesia include the Territory of Guam, the Commonwealth of the Northern Mariana Islands (CNMI), the Republic of Palau, the Republic of the Marshall Islands, and the Federated States of Micronesia, which includes the states of Yap, Chuuk, Pohnpei, and Kosrae. As the name suggests, the 2,100 islands in Micronesia are small, with Guam being the largest at 212 square miles. Micronesia's forests are under severe attack from invasive species. The most important are:

**Ungulates.** Pigs and deer were imported for food and caribao (water buffalo) were imported as beasts of burden during colonial times. Prior to WWII, these ungulates were not a problem on Guam because populations were controlled by human hunters. However, access to hunters was denied on most of the one-third of Guam land occupied by the U.S. military. Subsequently, in the absence of predation from natural enemies, ungulate populations have become very high, destroying much of the native forest.

**Brown treesnake (BTS), *Boiga irregularis*.** Guam's avifauna was extirpated by BTS which arrived shortly after WWII. Cascading effects include loss of ecosystem services provided by birds and other vertebrates such as seed dispersal, insectivory and pollination. Extirpation of birds and other vertebrate insectivores by BTS predation has resulted in high populations of herbivorous invertebrates in Guam's forests.

**Cycad Aulacaspis scale (CAS), *Aulacaspis yasumatsui*.** The infestation of this armored scale was first detected on ornamental cycads on Guam in the fall of 2003 but it rapidly spread to Guam's wild, endemic *Cycas micronesica* population and later to wild cycads in the CNMI and Palau. This is a classic case of 'escape from natural enemies'. Plant mortality from the scale infestation was so severe that *C. micronesica* was placed on the IUCN list of threatened species in 2005. Only three years prior, in 2002, a forest survey found *C. micronesica* to be the most numerous tree in Guam's forests. This plant is still under attack by CAS and several other recently arrived invasive species. Mortality exceeds 90% in some forest plots and there is no reproduction.

**Coconut rhinoceros beetle (CRB), *Oryctes rhinoceros*.** CRB was first detected in Palau just after WWII and on Guam in 2007. Coconut palms, listed as Guam's second most numerous tree in a 2002 forest survey, can be killed by adults which bore into the crowns to feed on sap. Following a failed attempt to eradicate CRB, efforts on Guam are now aimed at developing integrated pest management.

**Little fire ant (LFA), *Wasmannia auropunctata*.** LFA was first detected on Guam in 2011 at about a dozen distinct sites. LFA devastates the forest by killing wildlife and other arthropods, except for phytophagous hemipterans which are protected in return for honey dew. To date, funds and other resources have not been identified to eradicate or otherwise control this pest.

A major impediment to controlling forest pests in Guam and the rest of Micronesia is a lack of professional capacity. During the past 20 years, the number of PhD level entomologists and plant pathologists practicing in the region has declined from 9 to 3 and from 4 to 1, respectively. During this same period, detections of invasive species affecting forestry and agriculture have increased greatly as a result of globalization and relaxed biosecurity. Coupled with 'the taxonomic impediment, these factors have led to a gross under-reporting of impacts of invasive species in Micronesia.

**EAST MEETS WEST 1: EASTERN INVASIVE INSECT SPECIES THAT THREATEN WESTERN FOREST ECOSYSTEMS  
(Tom Coleman and Steve Seybold, Chairs)**

Seybold and Coleman gave an overview of the two workshop periods planned for the week. The goals of the first session were to 1) introduce a series of discussion questions about the topic of invasive forest insects that had been established in eastern North American forests and 2) provide background for the group on some of the primary eastern invasive forest pests through presentations by invited experts. Seybold and Coleman had developed the discussion questions

through consultation with Andrew Storer (Michigan Tech. University), who was going to lead the second workshop period on April 3<sup>rd</sup>.

Seybold introduced the following questions and asked the participants to provide any additional discussion questions:

- 1) Should western forest health professionals/scientists prioritize the current group of eastern invasive forest insects and take any specific pro-active steps in preparation for their arrival in western urban areas/forests?
- 2) What research/management questions or opportunities will be necessary or available on these insects for western forest health professionals? As secondary points: Has the bulk of the work in the East already been done with only a bit of local adjustment necessary to address the anticipated impacts of these pests? Or, are there fundamental areas of basic or applied research that still need to be dealt with? Do we have the necessary manpower and infrastructure to tackle these issues? Should we foster collaboration between eastern and western North American specialists to assess potential impacts, risk, etc. for these species? Have we been too insular in our approach to these invasions?
- 3) Is there anything unique about the pre-existing native guilds or communities of western forest insects or western tree hosts that will influence future interactions with the eastern invasive pests?
- 4) What have we learned about the trends/velocity of invasions of eastern forests that can be applied to western forests?
- 5) Do we have sufficient detection tools for these eastern pests to insure rapid discovery of newly introduced populations?
- 6) Is it necessary to adjust current management practices in order to reduce the chances of a species from the East becoming established if it is introduced?

Participant Graves raised the additional question: Should we prepare a centralized, USDA-FS-wide on-line source of data on invasive insects for western forests?

Coleman introduced and moderated questions for the panel of eastern experts who gave the following presentations:

### **Biology and Detection of Emerald Ash Borer**

**Damon Crook**

University of Massachusetts, Amherst, MA

The emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), is an invasive pest of North American ash (*Fraxinus* spp.) introduced from Asia in the mid-1990s. Since its



discovery near Detroit, MI and Windsor, Ontario, Canada in 2002, the beetle has been detected in 21 additional U.S. states. To date, tens of millions of ash trees have been infested and have subsequently died. Symptoms of infestation such as D-shaped exit holes, epicormic branching, crown dieback, and bark deformities, are not noticeable until populations have become well established. One of the primary goals of the USDA APHIS PPQ Emerald Ash Borer Cooperative Project has been to develop an effective and sensitive monitoring system that is able to detect low density populations of *A. planipennis* when no visible symptoms of attack are apparent. Early detection is critical if effective management and control measures are to be implemented.

Visual, chemical, and behavioral studies that describe how *A. planipennis* selects mates and hosts have led to improved lures and trap designs over the last ten years. Trapping studies with glued plastic prism traps have shown that green (530-540 nm wavelengths) traps painted in the mid-range (22%-67%) of reflectance (brightness) and purple traps painted with a color originally shown to be attractive to buprestids are highly attractive to *A. planipennis*. Based on electroretinogram and color trapping assays, green and purple pigments have since been incorporated into multiple funnel traps as paints and plastics. These traps eliminate the need for an adhesive trap coating and provide a re-usable, user-friendly tool for surveyors. Studies using fluon-coated green multiple funnel traps (530 nm, 49% reflectance) were shown to be a promising tool for emerald ash borer survey.

Both bark and foliage volatiles from ash have been shown to be attractive to *A. planipennis* in field experiments. In 2007 a macrocyclic (3Z)-lactone was hypothesized to act as a female-produced pheromone. Several studies have since shown that the (3Z)-lactone can significantly increase male trap catch when combined with (3Z)-hexenol on green prism traps. Placement of the baited trap is also an important factor in capturing adult *A. planipennis*. Survey traps used by the USDA APHIS PPQ Emerald Ash Borer Cooperative Project are placed in the lower crown (usually on the lowest live branch) of host ash trees (~4 – 8 m above the ground). However, traps placed in the mid to upper crown (~13 m) have been shown to catch two to three times more beetles than those placed in the lower crown, but this can be logistically difficult in wide-scale monitoring programs. Several parasitic wasps are currently being studied and used in terms of biological control for the ash borer. These are *Oobius agrili*, *Tetrastichus planipennis*, *Spathius agrili* and *Spathius galinae*.

## **The Redbay Ambrosia Beetle and Laurel Wilt: Implications if East meets West?**

**Albert Mayfield**

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The redbay ambrosia beetle, *Xyleborus glabratus*, and one of its fungal symbionts, *Raffalea lauricola*, cause a vascular disease known as laurel wilt in members of the plant family Lauraceae. This insect-pathogen complex is native to Asia but was detected in coastal Georgia in 2002 and has spread widely in the Atlantic Coastal Plain during the last decade. Laurel wilt has caused extensive mortality of the ecologically and culturally valuable tree species redbay, *Persea borbonia*, and swampbay, *Persea palustris*, and also kills sassafras, *Sassafras albidum*,

and the commercially valuable avocado, *Persea americana*. The only member of the Lauraceae native to the western United States is California bay laurel, *Umbellularia californica*, a broadleaved evergreen tree abundant in the Pacific coastal regions of southwestern Oregon and western California and in the foothills of the Cascades and Sierra Nevada mountains. Recent research indicates that California bay laurel seedlings are susceptible to the laurel wilt pathogen, and the wood is attractive to the redbay ambrosia beetle and very suitable for brood production. Laurel wilt represents a serious threat to California bay laurel in the West if the insect/pathogen complex were to become established there and if the environmental conditions proved to be suitable for proliferation and spread. Effective traps and lures for redbay ambrosia beetle exist and could be used to start monitoring for this pest complex in the West.

### **East Meets West: Eastern Invasive Insect Species that Threaten Western Forest Ecosystems: Sirex Woodwasp**

**Chris Foelker**

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*Sirex noctilio*, the European woodwasp, was first identified in North America from a 2004 trap catch near Oswego, New York. Discovery of this non-native insect was of particular alarm because of its well-documented history as an economically damaging introduced pest in high-density, short-rotation pine plantations across the Southern Hemisphere. These plantations were comprised of North American species, primarily Monterey pine, *Pinus radiata*, and loblolly pine, *P. taeda*. Females use a specialized ovipositor to bore into tree xylem and deposit phytotoxic mucus that induces physiological changes depressing tree defensive responses. They also inject a fungal mutualist, *Amylostereum areolatum*, which colonizes xylem tissue and is consumed by developing *S. noctilio* larvae. Interestingly, thus far the impact of *S. noctilio* in northeastern forests has been minimal. It primarily kills weakened or stressed Scot's pine, *P. sylvestris*, and red pine, *P. resinosa*, in the invaded regions of New York, Pennsylvania, Vermont, and southern Ontario. However, there is concern on how this insect will perform in homogenous pine-dominated forests of western North America. These forests present considerably different environmental and biotic factors, such as frequent drought stress and a diverse community of subcortical insects. Pine insect communities of the west are comprised of native siricids, parasitoids, woodborers, and primary and secondary bark beetles. These communities complicate certain management options (i.e., biological control), but also may serve as a form of biotic resistance.

### **INSECT AND DISEASE COMPLEX INTERACTIONS (Martin MacKenzie, Chair)**

**You Cannot Separate the Insects from the Fungi They Facilitate, or Vice Versa;  
or Why I Decided Studying Insects Would Make Me a Better Pathologist"**

**Martin MacKenzie**

While observing the impact of Beech Bark Disease (BBD) as it swept over the Allegheny National Forest, in NW Pennsylvania, it became obvious that as the perturbation that the exotic scale insect brought rippled through the ecosystem it involved the development of ever increasing numbers of insects and fungi. BBD is an exotic insect and fungus mediated complex, which was initiated by the introduction of the scale insect (*Cryptococcus fagisuga*, Hemiptera; Eriococcidae). Along with the exotic insect came an exotic fungus *Neonectria faginata*. However, in many instances the death of the scale provided entry wounds by which the native fungus (*Neonectria ditissima*) gained a new host; American beech (*Fagus grandifolia*). As the scale swept in a SW direction across the forest it frequently turned the pale green bark of the beech trees white with the massive accumulation of white wooly female bodies. This biomass of scales led to a buildup of the predatory twice stabbed lady beetle (*Chilocorus stigma*, Coleoptera; Coccinellidae). The lady beetle cannot be used as a biological control agent because it has been shown that it vectors the *Neonectria* fungi. While the beech trees declined slowly under the onslaught of organisms making use of the entry courts the exotics caused, some beech trees attempted to seal over the wounds left by the, scale wound, invading fungi. One such native insect was the scale insect *Xylococcus betulae* (Hemiptera; Margarodidae), and while it was rare SW of the advancing *Cryptococcus fagisuga* front it was common behind it. Obviously the exotics were preparing a suitable habitat for it. As the chlorotic beeches began to decline they were frequently attacked by the pigeon tremex (*Tremex columba*, Hymenoptera; Siricidae) and when the giant Ichneumon (*Megarhyssa atrata* Hymenoptera Ichneumonidae) was observed it was assumed to be parasitizing the siricid, but rearings showed that the target was the divergent beech beetle (*Dicrea divaricata*, Coleoptera; Buprestidae). When the beech limbs began to snap it was observed that they frequently snapped at the point of multiple attacks by ambrosial beetles. Four ambrosial beetles were dug from declining beech, three native (*Monarthrum fasciatum*, *M. mali* and *Xyloterinus ploitus*); and one exotic *Xylosandrus germauus* (all Coleoptera; Curculionidae). Although several ambrosia fungi were also recovered and one is in the genus *Ambrosiozyma* none were identified to species and no attempt was made to recover the symbiotic fungus of the siricid (*Daedalea unicolor*).

This result of these observations led the author to conclude that it was not possible to separate the insects from the fungi they facilitate and that in the death of individual beech trees consequent to the introduction of the BBD complex had almost as much to do with organisms already present in the ecosystem as it had to do with the invading exotic scale and or fungus.

### **Symbiotic Fungi of the Red Turpentine Beetle: An Evolving Story**

**Donald R. Owen**

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This story starts with earlier research on symbiotic fungi of the red turpentine beetle (RTB) and ends with the recent work of Tearum et al. (2013). Special acknowledgement is due to **Nancy Gillette, Mike Wingfield, and Jianghua Sun** who facilitated international research on RTB.

Interest in RTB and its fungal symbionts largely developed due to the beetle's association with tree decline and mortality, although RTB is not known as a tree killer in its native range. Two fungi commonly associated with RTB in North America, *Leptographium terebrantis* and *L. procerum*, have received considerable study as possible pathogens. *L. terebrantis* has been recovered from RTB in both eastern (eNA) and western North America (wNA), while *L. procerum* has only been recovered from RTB in eNA. RTB is a tree-killing invasive species in China and genetic studies indicate it originated from wNA (Cognato et al. 2005).

After a visit to China in 2001, I was sent a collection of fungi isolated from RTB in China by Jianghua Sun. *L. terebrantis* is commonly isolated from RTB in California and I fully expected it to be among the Chinese isolates. Instead, the collection was dominated by a *Leptographium* sp. I had not seen and tentatively identified as *L. procerum*. Lu et al. (2009) confirmed that *L. procerum* is the dominant fungal associate in China. *L. terebrantis* has never been found there. The question thus arises, "How did a beetle believed to be from wNA end up in China with a fungus believed to be from eNA?" In order to shed light on this situation, Tearum et al. (ibid) produced the most comprehensive survey, to date, of fungi associated with RTB in NA. When Tearum et al. (ibid) compared fungal isolates from eNA, wNA, and China, they found a surprising amount of diversity and limited overlap. Of 30 Ophiostomatalean species identified, eNA and wNA shared the most species (4); eNA and China shared the next most (3), and wNA and China shared the least (1). *L. procerum* was isolated more than any other fungus, but was only isolated from eNA (46% of isolates) and China (61% of isolates). *L. terebrantis*, which previously was identified from populations of RTB in both eNA and wNA, was identified as two genetically distinct (morphologically similar) and geographically-separated species - *Leptographium sp.1* from wNA and *Leptographium sp.2* from eNA. Because the fungal associates of RTB vary significantly between eNA, wNA, and China, this raises significant biosecurity concerns. It also is a red flag for all invasive bark beetle / fungal associations.

Some persistent questions remain: Is wNA or eNA the source of RTB in China? Could *L. procerum* have been brought to China by a beetle other than RTB? To what extent are populations of RTB in WNA and ENA isolated? Does *L. procerum* exist in WNA?

Cognato, Sun, Anducho-Reyes, Owen. 2005. Agric. For. Entomol. 7:87-94.

Lu, Zhou, de Beer, Wingfield, Sun. 2009. Fungal Divers. 38: 133-145.

Tearum, Doung, de Beer, Gillette, Sun, Owen, Wingfield. 2013. PLoS ONE 8(10):e78126.

### **Fungal Symbionts of Polyphagous Shot Hole Borer (*Euwallacea* sp.), an Ambrosia Beetle Causing Branch Dieback and Tree Mortality on Avocado and Other Host Plants in California**

**Akif Eskalen**<sup>1</sup> M. Twizeyamana<sup>1</sup>, Richard Stouthamer<sup>2</sup>, Paul-Rugman Jones<sup>2</sup>, Tim Paine<sup>2</sup>

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The polyphagous shot hole borer (PSHB) is an invasive ambrosia beetle that forms a symbiosis with *Fusarium euwallaceae*. Together, they cause fusarium dieback (FD), a pathogen/insect

complex that affects trees in agriculture, ornamental landscapes, and native forests in California. PSHB was first reported on black locust in California in 2003 but there were no records of fungal damage until 2012, when *Fusarium euwallaceae* was recovered from the tissues of several backyard avocado trees infested with PSHB in Los Angeles County. Since early 2012, FD has been confirmed on more than 120 species of tree in landscape and urban forest in Los Angeles, Orange, San Bernardino and San Diego counties. The objective of this study was to identify, and characterize fungal species associated with the PSHB in California.

Beetles from infested trunks were collected from four different tree species including *A. negundo*, *Persea americana*, *Quercus agrifolia*, and *Ricinus communis* in Los Angeles county. Beetle samples were collected from galleries and put directly into a 1.5 ml tube containing 90% ethanol. All samples were brought to the laboratory (University of California, Riverside). The separate beetle tubes were then vortexed for 10 s followed by three serial washings with sterilized distilled water. The beetles were aseptically dissected. The head of the beetle was individually macerated in a 1.5 ml tube containing 200  $\mu$ l of sterile water with a sterile blue pestle. Tubes were vortexed and a suspension of 50  $\mu$ l was spread onto potato dextrose agar (Difco) amended with 0.01% tetracycline hydrochloride (PDA-tet). The relative abundance of fungal species associated with the Polyphagous shot hole borer (PSHB) in different hosts was determined by counting colony-forming units (CFUs) of each fungal species identified within the head of ten beetles each from four different hosts. *F. euwallaceae* and *Graphium* sp. and *Acremonium* sp. were most frequently recovered from the head of the female beetles. No fungi were recovered from the male heads. These data suggest the beetle carries more than one fungal species, and this beetle–disease complex potentially may establish in a variety of plant communities locally and worldwide.

## **SPECIAL EVENING PRESENTATION**

### **Forestry and Forest Health Protection in South Africa**

**William M. Ciesla** and Patricia M. Ciesla  
Forest Health Management International, Fort Collins, CO

South Africa has a variety of forest and woodland ecosystems. Most of the natural forests are savannah woodlands whose primary value is wildlife habitat. Natural closed forests are concentrated on the eastern and southern coastal regions and are mostly in national parks and reserves. Commercial forestry is based exclusively on plantations of exotic species, predominantly pine and eucalyptus. Plantations are intensively managed on short rotations using genetically improved stock. Insect and disease pests are primarily introduced species that have become established. Several native insects have also adapted to the exotic plantations and are causing damage. The Forest Agricultural and Biotechnology Institute (FABI), based at the University of Pretoria, provides technical assistance in forest health issues and mass rears natural enemies for classic biological control programs.

**2013 FOUNDER'S AWARD PRESENTATION**

**Global Climate Change Implications for Forest Entomology: Contributions of Northern Arizona University Students**

**Mike Wagner**

Northern Arizona University, Flagstaff, AZ



## CONCURRENT SESSION 2

### **EAST MEETS WEST 2: HOW SHOULD WESTERN FOREST PEST SPECIALISTS PREPARE FOR THE NEXT WAVE OF EASTERN INVASIVE INSECT SPECIES?**

**(Steve Seybold and Tom Coleman, Chairs)**

Seybold reviewed the highlights from the Tuesday session and noted, among other points, that both Crook and Mayfield had pointed out that even after much of the host type had been killed by emerald ash borer and redbay ambrosia beetle that small numbers of the pests were still detectable in the stands in smaller diameter trees. The primary host is almost never completely removed during epidemics and some beetles always remain in the stand. Detection of the three eastern invasive species was variable with better tools available for emerald ash borer and redbay ambrosia beetle than for *Sirex*. He also noted that the presentation on *Sirex* emphasized the historical role that biological control had played in the southern hemisphere and that identification of *S. noctilio* among the native western species complex of siricids might present difficulties for western forest entomologists. Seybold then reminded the attendees of the discussion questions from Tuesday and announced that Andrew Storer was not able to attend to lead the discussion. Seybold introduced co-moderator Coleman, who delivered an overview of Asian longhorned beetle based on a slide set prepared by Kevin J. Dodds (USDA FS FHP, Durham, NH).

#### **Asian Long-horned Beetle in North America**

Tom Coleman<sup>1</sup> and Kevin Dodds<sup>2</sup>

<sup>1</sup>Forest Health Protection, USDA Forest Service, San Bernardino, CA

<sup>2</sup>Forest Health Protection, USDA Forest Service, Durham, NH

The Asian longhorned beetle, *Anoplophora glabripennis*, has been introduced numerous times into North America, establishing populations in New York, NY (1996), Chicago, IL (1998), New Jersey (2002), Toronto, Ontario (2003), Worcester (2008) and Boston (2010), MA, and southern Ohio (2011). The wood-boring beetle is native to eastern China and Korea and has a wide host range. In the northeastern U.S., *A. glabripennis* prefers to attack maples, *Acer* spp., but will also attack elm, *Ulmus* spp., willow, *Salix* spp., horse chestnut, *Aesculus* spp., birch, *Betula* spp, and ash, *Fraxinus* spp., trees. These susceptible hosts represent 34 to 78% of the forest type in northeastern hardwood forests (MA, NH, NY, and VT). The exotic beetle can complete development in one to two years, re-attack host trees, and infest healthy hosts. In Massachusetts, *A. glabripennis* attacked maples across all diameter size classes, injured maples in various canopy positions, and preferred to attack red maple, *A. rubrum*, over other tree species. *Anoplophora glabripennis* has the potential to cause economic (e.g., tourism, timber production, and maple syrup production) and ecological impacts to urban and natural forest stands. To limit the impact and spread of *A. glabripennis*, Animal and Plant Health Inspection Service (APHIS) established quarantines to eradicate the infestations in the northeastern U.S. The quarantine efforts include annual tree surveys, removal of infested trees, and preventative insecticide treatments of susceptible hosts. In several of the quarantine areas, APHIS has removed >10,000 trees for eradication efforts.



## Discussion

In response to Coleman's presentation, Curtis Takahashi briefly described the California Department of Agriculture's efforts at detecting warehouse introductions of ALB in the Sacramento area (McClellan Park). Wakarchuk wondered why the western forest insect community is focused on ALB and not placing greater emphasis on detecting the citrus longhorned beetle, *Anoplophora chinensis*. From these comments and questions related to ALB, moderators Seybold and Coleman encouraged the participants to weigh in on topics related to the discussion questions. Schaupp suggested that what resource managers might focus on is regular inspections or surveys of collections of exotic vegetation like Huntington Botanical Gardens (San Marino, CA) and major arboreta such as the Los Angeles County Arboretum (Santa Anita, CA) or San Francisco Botanical Garden (Golden Gate Park, San Francisco, CA), etc. The logic being that invasive species might readily find hosts in these areas and the collections of plants might facilitate earlier detection of the pests. The invasive pests may reconnect with their ancestral or native hosts that are growing as exotics in these plant collections. The value of the California agricultural border stations was briefly discussed and the hurdles of the cost of establishing stations like these in other states was contemplated. Graves lamented the lack of general funding within the FS budget for addressing problems related to invasive insect species. Base funding is provided for the EDRR detection program, but beyond that he noted that funding was scarce.

The discussion turned to pre-emptive actions, including the potential for planting sentinel tree species around ports and other high probability areas of introduction (for detection), as well as to the topic of the utility of pre-emptive biological control measures for some of the pests that would be on the way. Schaupp discussed his postdoctoral experiences of developing factitious hosts for gypsy moth natural enemies prior to the introduction of the moth in Minnesota. The discussion turned to natural enemies of greater specificity. The value of the fungus *Entomophaga maimaiga* in slowing down the progressive invasion of the gypsy moth in the eastern U.S. was raised. What was also envisioned was an arsenal of viruses targeting each invasive pest. The overall dearth of information on insect pathology was noted by several participants. The suggestion was made that we should be looking domestically and in places like China for viruses that might effectively control invasive insects. Cliff Bradley (Montana Microbial Products) noted that a barrier to these control methods is that they have to be registered as bioinsecticides with EPA. Schaupp noted that the efficacy of nematodes used to control *Sirex* may actually have been a consequence of a virus carried by the nematode. Wood offered a historical example that the European spruce sawfly, *Gilpinia hercyniae*, an eastern invasive in the northeastern U.S. and Canada, was controlled effectively by a virus as well.

The notion of conducting pre-emptive research on eastern invasive species at western sites was considered and the model for this was a sudden oak death facility at Dominican College in San Rafael, California. The idea was raised that diversification of the future urban forest was the key to maintaining urban tree cover when these invasive species arrived. The group also noted that we should discriminate against certain hosts like sycamore (polyphagous shot hole borer); ash (emerald ash borer); maples (Asian longhorned beetle); and bay laurel (redbay ambrosia beetle). There appears to be a major opportunity for outreach and public education in informing city foresters and private developers about the impacts of their choice of landscaping plants. These

decisions are usually influenced by price (buying in bulk from supplier) rather than host susceptibility to potential pests. Water use and temperature tolerance may also be future drivers of what host trees are selected for replanting in urban areas. In western states, the future urban forest may emphasize the use of xeriscaping with minimal planting of the primary hosts of invasive forest insects presently at large in the East.

Seybold ended the discussion with a reference to the history of WFIWC as a discussion-oriented organization and hoped that future workshops would set aside time for participants to engage in a more free-flowing discussion like the one that had just occurred.

## **CLIMATE AND FOREST INSECTS** **(Jeff Hicke, Chair)**

### ***Choristoneura occidentalis* and Weather: Inferences from the Dendrochronological Record**

**Ann M. Lynch** and Thomas W. Swetnam  
Laboratory of Tree-Ring Research, University of Arizona

The dendroentomology literature provides strong evidence for an association between WSBW outbreaks and periods of increased precipitation. This pattern is found in a wide range of geographical locations, including New Mexico, Colorado, and Oregon, and with SBW in Minnesota. Furthermore, the Swetnam *et al.* (1995) Blue Mountains (Oregon) reconstruction shows a strong positive association between WSBW and precipitation over three centuries, with the association persisting with both high-frequency climate cycles in the 1700s and with low-frequency climate cycles in the 1800s and 1900s.

Evidence for a lagged association between drought and WSBW is increasing. The analyses that demonstrate an association between WSBW outbreaks and precipitation also demonstrate strong associations between drought and no-WSBW. A preliminary superposed epoch analysis of Swetnam's various reconstructions (not corrected for differences in the original reconstruction methods) between drought (PDSI) and the initial years of the most severe growth suppressions shows significant correlations of WSBW-related growth suppression starting during and immediately following extreme wet years, and after extreme dry years. It is not clear if this pattern is an artifact of the positive association between WSBW and periods of increased precipitation (which by default must follow dryer periods) or if drought, or the switch from dry to wet, initiates a host tree, budworm, or natural enemy response that contributes to outbreak development.

Some investigators focus on a search for commonalities across the entire WSBW range. However, given the wide range of climate that WSBW and its hosts thrive under, gene flow amongst different *Choristoneura* species and the various budworm-relevant environmental processes that dendrochronology cannot reconstruct, it should not be surprising to find that associative patterns between WSBW and climate vary across the insect's range. For example, outbreaks in the Southwest are associated with wet periods, but in southern interior British

Columbia are associated with drier than average winter conditions. Precipitation in New Mexico is most abundant in the latter portion of the growing season (July-October), declines slowly through February and may increase gradually beginning in March. In central British Columbia, precipitation is relatively high for a long period, May through January, and early spring drought in that region may be mediated by residual snowpack, and in any case, on average, is not as dry as spring and summer droughts in New Mexico and Oregon. Precipitation in the eastern Cascades in Oregon is most abundant in the winter (November-February), and weather is generally dry the rest of the year, sometimes with a small peak in May. Likewise, “warm and dry” spring conditions at northern latitudes are probably different than in the Southwest, where “warm and dry” is the normal in spring. WSBW has adapted to a variety of local conditions, and some different associations between WSBW and climate should be expected, not surprising.

Analysis of tree-ring data can reveal many interesting and useful features of forest insect outbreaks, but there are many environmental events and processes that dendrochronology does not capture. These include foliage- and budworm-killing frost events except for those severe enough to damage the bole cambium, tree flowering events, bud abundance, natural enemy population densities, tree and insect phenologic processes, wind or other weather during moth flight periods, winter minimum temperatures, and soil:air temperature differentials. Some of these factors and processes can be inferred with knowledge of the ecological system and tree responses to environmental variability, but the limits of the dendrochronologic methodology must be accepted. Dendrochronology enables exploration of long-term data at relevant temporal and spatial scales that manipulative and insect biology studies do not. But other approaches may be needed to identify all factors contributing to outbreak development.

A review of some terminology used in the literature will facilitate interpretation of the dendroentomology literature and comparison of results amongst regions. **Duration** refers to the length of period encompassing growth suppression (*e.g.*,  $14.3 \pm 2.7$  years). **Interval** refers to the length of period between the beginnings of two successive events (*e.g.*,  $37.4 \pm 12.6$  years). **Cyclical components** refer to periodicity, and are presented as cycle lengths or frequencies (25 years and 0.04 cycles per year are synonymous, but the latter is inherently obtuse for describing decadal-scale regimes). Cyclical components are somewhat analogous to variance components, in that multiple frequencies explain X% of temporal variance. Significant periods can cover a range of significant values with a peak, (*e.g.*, 35-41 years peaking at 37 years). Multiple peaks represent different maxima in the series, with a longer cycle sometimes a near-multiple of a shorter cycle, often suspected to be coincidence of multiple entraining factors. **Autocorrelation analysis** of two series estimates the strength of temporal coincidence between them. Correlation at time step zero indicates the association between the two series in the same year. Lagged correlations indicate that one series has a consistent response one or more years after the other (*e.g.*, bark beetle outbreaks can lag drought by 1 or 2 years). The two series can be of different nature (insects and precipitation) or from different places (central and southern British Columbia).

Interpreting the literature takes some attention to detail, as methods and descriptive statistics can appear similar but incorporate important differences, and reference terms and analytic variables can differ in small but important ways. For example, reconstructions can be based on the

number of trees recording outbreaks, the number of sites recording outbreaks, or the proportion of trees or sites recording outbreaks, which are not identical. If one publication says 25.4 years and another says 28.3 years, are the reference terms commensurable? More importantly, measures of central tendencies and cyclical components can characterize and contrast very different statistical populations. The average interval between two successive outbreaks in multiple places is not the same as the average interval between multiple outbreaks on the same site, or as when based on regional chronologies. Likewise, when both are computed, mean intervals and cyclical components are often “similar but different” and describe different phenomena. As used so far in the literature, interval provides information about the length of time between initiation of successive events, but cyclical components (and autocorrelation analyses) focus on the bulkiness (period of maximum involvement amongst trees or sites) of the events. Since outbreaks are of variable duration, and some build rapidly while others build slowly, cycles and intervals are not exactly comparable.

Interpretation of the literature also requires that the reader be fully aware of the proxy nature of dendrochronological reconstructions. Tree growth reflects comprehensive integration of several processes and environmental conditions, and is a robust indicator of environmental conditions. However, tree-ring reconstructions of insect outbreaks are proxy representations of insect population densities. Particular care should be taken when inferring relationships between WSBW outbreak initiation and climatic patterns. Insect epizootics result from population release from environmental controls such as predators, parasites, or persistent entomopathogens, or responses to a suite of possible population-promoting or -dampening factors. Populations must then increase to levels where defoliation impairs radial growth such that it is detectable with dendrochronological methods. Likewise, once populations collapse to endemic levels, trees must recover the capacity for radial growth. These processes may be rapid or slow, depending on insect-host relationships and various endo- and exogenic factors. Dendrochronology excels at revealing the general timing of events, quantifying the extent and strength of temporal and spatial variability in outbreak frequency and duration, at determining the nature of population oscillations, and at determining the presence and strength of associations with other phenomena. But, given the lags that are possible between population release and suppression of radial growth, dendrochronology does less well at confidently identifying the precise year of outbreak initiation. WSBW is notable amongst forest defoliators for exhibiting a wide range of outbreak development rates at multiple scales, and the initial year of detectable growth suppression is zero to several years after the budworm populations began increasing. Analyses based on radial growth in the upper tree crown are superior in this regard, but are logistically impractical and provide for shorter chronologies. Furthermore, unless outbreaks erupt synchronously over large areas (sometimes/places they do, but often not), there is no certainty that reconstructions based on relatively few sites actually capture outbreak initiation. Outbreaks did not necessarily start where or when they are first detected in the tree-ring series. Intensive structured sampling is needed to detect such patterns.

### **Climate and Spruce Beetle (*Dendroctonus rufipennis*) Effects Across Latitudinal and Forest Productivity Gradients in Southwest Alaska**

**Rosemary L. Sherriff<sup>1</sup> and Amy E. Miller<sup>2</sup>**

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Increased productivity at the northern and western margins of the North American boreal forest appears to be offsetting declines in growth and productivity in the interior. How this variation in tree growth and forest change plays out geographically is poorly understood, particularly in the transition zone between the colder, drier forests of the interior, and the warmer, wetter maritime systems of western Alaska that are also seeing high levels of spruce beetle activity. In south-central and southwest Alaska, approximately 1.5 million ha of spruce forest have been affected by the spruce beetle since 1989. Mean annual temperature in south-central Alaska has also increased by approximately 1.5 °C in the last half century. In this study, we investigated the effects of climate and spruce beetle activity on tree growth and stand dynamics in *Picea glauca* forests across latitudinal (ca. 59 to 61° N) and forest productivity gradients in southwest Alaska (30 sites and 1302 tree cores). We hypothesized that in lower-elevation and higher productivity (closed canopy) forests at the northern, interior end of the gradient, temperature is at or exceeding a critical threshold for growth. In the highest elevation (treeline) and lower productivity (open woodland) forests at the southern, maritime end of the gradient, we expected that rising temperatures would continue to favor tree growth. Our disturbance chronologies (mid-1700s to present) suggest that recent spruce beetle outbreaks (1990s to present) in southwest Alaska are within the historical *geographic* range, but that outbreaks since the 1990s show greater spatiotemporal synchrony (i.e., more sites record high-severity infestations) than at any other time in the past ca. 250 years. We found substantial increases in radial growth since the 1970s across forest types and latitudinal zones, with the greatest increase in growth at treeline sites at the northern end of the gradient. Temperature-related increases in growth at the southern sites have occurred only since 2000. With the exception of treeline sites, however, the relationship between temperature and growth, and the rate of tree growth, has decreased since the late 1980s. Growth in lower elevation, closed-canopy forests show a weaker response to temperature (correlation of >0.50 to 0.26), or a complete shift from positive to negative correlation with summer temperature (correlation of >0.50 to -0.21), since ca. 1986. In many low elevation-closed canopy stands, recent warming-related spruce beetle outbreaks have significantly affected tree growth (i.e., stressed trees) and mortality levels. These results suggest that persistently warm summer temperatures (i.e., 11-12.6°C average June temperature) and continued warming (e.g., an increase of 1-2°C since 1986) may be inducing stress as trees experience temperatures beyond an optimum level for growth in many areas of southwest Alaska. This may be especially true for older trees (pre-1910 establishment) and closed-canopy stands at lower elevations in the study area.

### **Whitebark Pine and Mountain Pine Beetle Outbreaks in the Western United States: Quantifying the Influence of Climate**

**Jeffrey A. Hicke<sup>1</sup>, Polly C. Buotte<sup>1</sup>, Haiganoush K. Preisler<sup>2</sup>, and  
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Whitebark pine is a high-elevation, keystone tree species currently subjected to multiple threats, including attack by mountain pine beetle, an aggressive bark beetle that has recently killed whitebark pines over hundreds of thousands of acres in the western US. Climate is an important factor in outbreaks of this beetle through effects on the beetle via warming and on the host tree via stress associated with warming and drought. Future climate change is expected to increase the number, frequency, and/or severity of these epidemics. Our goal was to increase the understanding of the causes of recent mountain pine beetle outbreaks in whitebark pine forests, and to estimate future outbreak potential given future climate change. To accomplish this, we developed empirical models of beetle outbreaks in the Greater Yellowstone Ecosystem that considered beetle populations, climate, and stand structure. We used observations from USDA Forest Service aerial surveys to compute the presence of whitebark pine mortality within 1-km grid cells, which we used as our response variables. Our explanatory variables were chosen to represent processes affecting mountain pine beetle development and host tree susceptibility based on previous research, and included climate variables ranging from simple climate variables to outputs of process models of temperature suitability as well as the number of attacking beetles and stand structure. Our models captured the temporal patterns of observed outbreak area and outbreak severity well. We found that summer precipitation (drought), winter temperature, and fall temperature were important variables for explaining observed outbreak patterns. Our models indicated that the most recent outbreaks were due to a co-occurrence of high fall and winter temperatures that remained favorable during outbreak periods together with intermittent drought. We estimated future outbreak potential in the Greater Yellowstone Ecosystem using our models applied to downscaled climate change projections from the CMIP5 archive. Our preliminary results suggest that future climate will be more favorable for mountain pine beetle outbreaks in whitebark pine. Our findings inform land management decisions and US Fish and Wildlife Service considerations of listing whitebark pine as threatened or endangered.

**DEFOLIATING INSECTS IN THE WESTERN UNITED STATES**  
**(Rob Progar, Chair)**

**That Other Budworm: Western Blackheaded Budworm in Washington**

**Glenn R. Kohler**

Washington Department of Natural Resources, Olympia, WA

Conditions of a recent outbreak of western blackheaded budworm (WBB), *Acleris gloverana*, in Washington State were reported. Approximately 14,200 acres of WBB defoliation was observed in western Washington in 2013. Damage occurred primarily on the eastern side of the Olympic Peninsula and southwest of Mt. Rainier. Both western hemlock and Pacific silver fir were moderately defoliated. This represented a significant increase from the 200 acres of damage observed near Baker Lake in 2012. WBB damage undetectable in aerial surveys has been reported in western Washington since 2010. At least one third of WBB pupae collected during ground surveys in 2012 and 2013 were infested with parasitic ichneumonid wasps identified as *Phaeogenes* species. The last WBB outbreak in Washington occurred from 2002 to 2003 in the central Cascades near Snoqualmie and Stevens Passes. The history of outbreaks in Washington,

Oregon, Alaska, and British Columbia over the last 60 years was discussed. The biology, identification, outbreak cycles, host impacts, and management of WBB were also discussed.

## **Westside Story: The Western Oak Looper in Oregon and Washington**

**Elizabeth A. Willhite<sup>1</sup>**

<sup>1</sup>Forest Health Protection, USDA Forest Service, Sandy, OR

Western oak looper occurs throughout the range of its principle host, Oregon white oak, in Oregon, Washington, and south coastal British Columbia. It has long been referred to as one of three recognized subspecies of hemlock looper, *Lambdina fiscellaria*, based on larval host or adult pheromone differences. However, several studies examining morphological differences in genitalia and wing patterns and genetic differences in mitochondrial DNA among the subspecies have led some authors to conclude that the eastern hemlock looper, *Lambdina fiscellaria fiscellaria*, western hemlock looper, *Lambdina fiscellaria lugubrosa*, and western oak looper, *Lambdina fiscellaria somniaria* comprise a single transcontinental, highly polymorphic species without clear subspecific divisions.

Information is presented on western oak looper life history, damage, and outbreak behavior. Outbreaks tend to recur in the footprint of previous outbreaks, are spottily distributed, and shift location from year to year, lessening potential impacts to any one location. Duration is usually short, typically lasting two to three years and then declining due to the combined action of parasites, predators, and disease. In Oregon and Washington, western oak looper outbreaks have occurred in valley and coastal lowland locations west of the Cascades. In 2013, a western oak looper outbreak was recorded in the mid-Willamette Valley in Oregon and on Joint Base Lewis-McChord near Tacoma, Washington. Compiled grey literature and aerial survey records document nine oak looper outbreaks in Oregon and Washington since the mid-1920s. Aerial survey documentation of western oak looper outbreaks is spotty due to the timing of the signature, non-commercial host, and location in interior valley agricultural or military no-fly areas, which are not typically included in annual aerial surveys. A 1930 report by F.P. Keen on an oak looper outbreak in Polk County, Oregon refers to local anecdotal accounts of oak looper defoliation occurring every three to four years. Since the early 1960s, outbreaks in this area have been documented every 12-15 years.

Recent unusual defoliation of Oregon ash during 2011-2013 on the W.L. Finley Wildlife Refuge in Benton and Linn Counties, Oregon was caused by what appears to be western oak looper acting in concert with a foliar pathogen, ash leaf blight, *Mycosphaerella faxinicola*. Oregon ash was uncharacteristically preferred as a larval host over intermixed Oregon white oak in this area. Some phenotypic differences in larval coloration from oak-feeding populations located forty miles north, perhaps attributable to diet-related effects, were apparent in the ash-feeding population. A small number of specimens were reared from both larval populations, with the result that ash-feeding adult moths appeared indistinguishable from those feeding on oak.

## **No Need to Panic: A Review of Oregon's Largest Recorded Outbreak of Pine Butterfly (*Neophasia menapia*)**

**Robbie Flowers<sup>1</sup>, Ari DeMarco<sup>2</sup>, David Shaw<sup>2</sup>, and Lia Spiegel<sup>3</sup>**

<sup>1</sup>Oregon Department of Forestry, Salem, OR

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<sup>3</sup>USDA Forest Service, Forest Health Protection, La Grande, OR

The pine butterfly (*Neophasia menapia*) is a native insect that is commonly observed at endemic levels in forests of the Pacific Northwest. Pine butterfly epidemics appear to occur at widely-spaced, irregular intervals with each lasting approximately 3-5 years. During outbreaks in pine-dominated forests, large areas can be completely defoliated for several consecutive years, and can result in tree mortality in association with attacks by pine bark beetles, drought, and other factors. The most recent outbreak in eastern Oregon, which began in 2008, has affected over 250,000 acres and is the largest ever documented in the State. As previous outbreaks have not been well-described, a cooperative research effort was undertaken to examine infestation characteristics and assess the effects of severe defoliation within affected areas of the Malheur National Forest. From 2012-2013, 75 plot transects were installed within 25 stands that experienced severe defoliation by pine butterfly. Approximately 750 trees have been tagged within these sites and will be re-assessed annually for up to 4 years. Initial findings indicated that this outbreak was of similar duration to previously documented outbreaks and that there has been low incidence of tree mortality. Pine butterfly populations appeared to be regulated by insect natural enemies and larval starvation, among other factors. Mean defoliation was not found to be significantly different by stand density, structure, crown class, or position within the canopy. Therefore, it appears that general silvicultural guidance for managing ponderosa pine is sufficient for areas that may be affected by pine butterfly. Future research plans include evaluating radial growth loss, examining the natural enemy complex of pine butterfly, and geospatial analyses of historic outbreaks relative to environmental conditions.

## **Balsam Woolly Adelgid in Western North America: Extent, Impact and Severity**

**Laura Lowrey<sup>1</sup>, Robert Progar<sup>2</sup>, and Kathryn Hrinkevich<sup>2</sup>**

<sup>1</sup>Forest Health Protection, USDA Forest Service, Boise, ID

<sup>2</sup>Pacific Northwest Research Station, USDA Forest Service, La Grande, OR

Warmer than average temperatures are resulting in increased damage at high elevations and other places previously thought inhospitable to Balsam woolly adelgid (BWA). Recent combined efforts with Forest Health Protection Region 1, 4, 6, Idaho Department of Lands and MT DNRC cooperated to assess the BWA range and conduct impact evaluations. This effort has resulted in an updated range that includes widespread infestation of Idaho and Montana and parts of western Wyoming. Impacts are being assessed through long-term monitoring plots in those areas. Preliminary results suggest up to 30 percent mortality and up to a 70 percent infestation rate of subalpine fir, the preferred western host, during the first five years post plot establishment. Additionally, a Severity Index for BWA is being developed to standardize the evaluation of the



level of infestation in the western US. We are also developing a model to evaluate the risk of infestation of currently uninfested habitat.

### **CONCURRENT SESSION 3**

#### **SOMETHING NEW UNDER THE SUN? APPLICATIONS OF I&D GRAY LITERATURE AND CURRENT STATUS (Beth Willhite, Chair)**

##### **Using Gray Literature to Put Forest Pest Conditions into Historical Perspective: Region 5 Examples**

**Daniel R. Cluck**

Forest Health Protection, USDA Forest Service, Susanville, CA

Forest Health Protection entomologist and pathologists often use gray literature focused on past forest pest events and prevention and suppression treatments to help understand current insect or disease activity and assist with making recommendations to land managers. Gray literature such as biological evaluations, pest detection and conditions reports, aerial survey reports, white papers and raw data can supplement published literature with local information, fill in knowledge gaps, help evaluate past treatment effectiveness and see how forests have responded to past pest activity. Historic accounts of insect and disease outbreaks also allow for proper identification of truly unprecedented events that may be the result of changing forest conditions and climate.

This type of gray literature provides a critical link for new forest entomologists and pathologists to the observations and activities of their predecessors, providing a solid local knowledge base that allows for a more rapid understanding of forest ecosystem processes and recurring pest problems. It also provides critical examples of forest insect and disease response to historic disturbance events such as wind throw, fire and drought, allowing for more informed decision making regarding future management.

Specific examples of the use of gray literature for assessing current forest pest activity in northeastern California were presented including historic information on outbreaks of Jeffrey pine beetle, fir engraver beetle, Douglas-fir beetle, mountain pine beetle, and Douglas-fir tussock moth. Records of personnel observations, mortality surveys, data collection, photographs, maps, management recommendations and treatment monitoring have proven extremely useful in dealing with current outbreaks of these pests. An examination of gray literature on forest pest activity during historic drought periods has also revealed recurrent spatial and temporal patterns of tree injury and mortality. Some of these patterns are beginning to occur with the current California drought.

##### **Gray Literature: The Process and the Payoff**

**Amanda M. Grady**

Arizona Zone Forest Health, USDA Forest Service, Flagstaff, AZ

The process of inventorying and creating a regional repository for Forest Health Protection's (FHP) gray literature (non-peer-reviewed documents) has been an ongoing process in the Southwestern Region. For the past several years, Dan Ryerson, New Mexico Zone has inventoried and scanned nearly 700 documents including annual conditions reports, site visit letters, biological evaluations and other reports that were created between 1917 through 2013 and Crystal Tischler, New Mexico Zone has been compiling the spatial data from historic aerial detection surveys (ADS) flown in New Mexico. Our goals are to collect, preserve and provide public access to gray literature documents and historical forest pest spatial data collected during forest health aerial detection surveys in the Southwestern Region. In 2012 and 2013, the Arizona Zone applied for and received Forest Health Monitoring, Data Analysis funding to create a regional repository of all gray literature produced in the Southwestern Region that was consistent with standards and guidelines created in the Pacific Northwest Region, to catalog gray literature documents with the Forest Service FSINFO Library, to create a Regional geo-database with all historical and contemporary ADS data from Arizona and New Mexico and to eventually make it publically accessible. In 2012, the focus was on creating the geo-database for ADS data. Accomplishments in FY2012 included hiring two students that inventoried historical paper maps, geo-rectified and digitized all historical ADS maps from Arizona, received cataloging training from the FSINFO Library and cataloged nearly 200 documents. In 2013, we scanned and geo-rectified the historic New Mexico maps and began digitizing and merging the data. We also preformed quality checks on the attributed spatial information to verify national standards were met. We continue to catalog gray literature documents with the FSINFO Library and are working towards completion of the geo-database and providing the public with access to the Southwestern Region's complete ADS data.

A gray literature repository and access to historical ADS data in a contemporary geo-database provide numerous benefits to the Southwestern Region's Forest Health Protection staff, federal land managers, academia etc. The FHP staff has used the gray literature to help with the forest plan revision process, to help new entomologists and pathologists get to know the agents and where they have historically been active in the region, to determine where range expansions could be occurring and what new previously undocumented locations are being impacted by native forest pests. Also, documentation of previous drought conditions and subsequent bark beetles outbreaks provide insight on better management practices under warming temperatures and increasing frequency of drought occurrences which are predicted for the Southwest. The repository of gray literature has also been used by academia and research entomologists on numerous occasions.

### **Using Historic Forest Health Information to Enhance Management Decisions**

**Joel M. Egan**

Forest Health Protection, USDA Forest Service, Missoula, MT

Historic information is pertinent to forest health-related management recommendations commonly made by forest entomologists to mitigate negative resource impacts caused by insect pests. Theoretically, this information is important as insect outbreaks are stochastic events that are driven by controlling factors that have a high degree of spatial and temporal variability.

Experimental research studies are able to assess mechanistic relationships but are often limited in number and scope as they are conducted under discrete spatio-temporal conditions that occurred within the study period and location. Discrete conditions that influence insect populations include ambient forest structure and composition, drought severity, timing of melting snowpacks, seasonal temperatures, and insect density or population pressure. Thus, extrapolating findings from studies to other discrete spatio-temporal conditions is not always appropriate. As such, accumulations of non-replicated case studies, adaptive management monitoring, and professional experience that is documented within gray literature and other formats can provide a context for appropriate spatio-temporal extrapolation of scientific findings. Write-ups can also fill in gaps with best-available information where rigorous experimental studies have not occurred.

Historic forest health information has been beneficial for many practical uses within the western United States. Examples discussed in the workshop included 1) reconstructing spruce beetle (*Dendroctonus rufipennis* Kirby) outbreaks within Utah and Wyoming during the 20<sup>th</sup> century to document outbreak frequency, 2) reconstructing Jeffrey pine beetle (*Dendroctonus jeffreyi* Hopkins) outbreaks within the Lake Tahoe Basin from 1912-2010 to provide a context for research findings of resilient forest conditions for U.S. Forest Service (USFS) forest plan revisions, and 3) documenting known and persistent disease locations to promote local management recommendations for high-value areas.

Interest in archiving historic forest health information has increased throughout western United States in recent years and two prototype database structures have been developed to store information digitally. One is the gray literature repository, pioneered by USFS Region 6, which houses digitized historic documents with searchable text and keywords in the National USFS Archives. The other, pioneered by USFS Region 5, is a repository for historic insect and disease incidence and occurrence information within a spatially searchable database. Recent discussions from USFS forest health specialists within Regions 1, 4, and 5 concluded that the most useful archiving format for forest health information includes the capacity to be spatially searchable, searchable through keywords, and the ability to house historic documents in a standard format (e.g., .pdf). We would like to promote the convergence of attributes from both the prototypes developed to promote nationwide utility.

### **U. S. Forest Service Digital Collections**

**Sally A. Dunphy**

National Forest Service Library, USDA Forest Service, Fort Collins, CO

The National Forest Service Library (NFSL) is committed to support of the goals of the Forest Health Protection grey literature project and is anxious to implement it fully as a showcase example of this kind of work. Though other Forest Service staffs have similar needs to preserve like material, the case of forest health is particularly compelling, since historic descriptions of past events can give insight into current conditions and outbreak events.

The Library's role has been to advise regions on implementation of digitization projects according to accepted standards; to train Regional participants in creation of relevant, authority-controlled metadata; to develop a web form for submission of digital objects (documents) and

associated metadata; and to provide a repository space (USFS Digital Collections) capable of hosting a variety of content formats with customizable collection and privacy settings. Documents are full-text searchable and unrestricted sections of the repository are fully discoverable via search engines.

Accurate, complete, metadata describing the materials is essential to the function of the collection, and therefore it is the focus of our training and quality assurance reviews. In addition to meeting scanning and metadata standards, material submitted to the USFS Digital Collections must meet three additional criteria: 1) it must be relevant to the Forest Service, 2) it must not fall under copyright restrictions, and 3) it must conform to our file size limits.

## **TOOLS FOR TREE PROTECTION (Don Grosman, Chair)**

### **A Review of Chemical Application Systems**

**Don Grosman**  
Arborjet Inc., Woburn, MA

Over 475 native and exotic invasive insect species now reside in the United States. Many of these species impact both urban and natural forest ecosystems. Several pest management options are available, including tree removal, semiochemicals, foliar and bark spray, soil drench, and trunk injections. The advantages and disadvantages of each option were presented.

Injection of systemic insecticides has advantages over the other options by reducing pesticide load and eliminating drift, worker exposure and/or nontarget insect/animal mortality. Several injection systems are currently being manufactured or in development. Some (Mauget, Tree Tech and M3 capsules, ArborSystem's Wedgle Tip, BioForest's Ecoject and Chemjet) are generally designed for low volume applications. Others (Arborjet's Tree IV, Quikjet and Air Hydraulic, ArborSystems's Portle, Sidewinder, and Rainbow's IQ, Pine Infuser and Macroinjection) are designed for high volume applications. Over the past 10 years, the author has evaluated several injection systems (Mauget, M3, Pine Infuser, Portle, Chemjet, Tree IV, Quickjet, Sidewinder) while employed with the Texas A&M Forest Service using criteria that focuses on system cost, safety, time to fill, install and clean system, time to inject product, and efficacy of treatment. Based on these evaluations, Arborjet's Tree IV system was found to be the best overall for systemic chemical application into both hardwoods and conifers. Lastly, factors that influence tree uptake of chemicals and an suggestions for improving tree injection applications were presented.

### **Recent Advances in Insecticide Tools and Tactics for Protecting Conifers from Bark Beetle Attack in the Western United States**

Chris Fettig<sup>1</sup>, Don Grosman<sup>2</sup>, Steve Munson<sup>3</sup>, **Darren Blackford**<sup>3</sup>, and Laura Lowrey<sup>4</sup>

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Bark beetles cause extensive tree mortality in coniferous forests of the western U.S., and play an important role in the disturbance ecology of these systems. Recently, significant outbreaks of several species have occurred from Alaska to New Mexico heightening public awareness of the issue and, in many cases, the need for information on appropriate management strategies. Protection of individual trees from bark beetle attack has historically involved applications of liquid formulations of insecticides to the tree bole using ground-based sprayers. Several formulations are available and effective if properly applied. Researchers looking for more portable and environmentally-friendly alternatives are now examining the effectiveness of injecting small quantities of systemic insecticides directly into trees. We synthesize information on the efficacy, residual activity, and environmental safety of insecticides commonly used to protect trees from bark beetle attack, and share novel research findings.

### **Injecting Systemics into IPM of an Exotic Woodborer: EAB SLOW Ash Mortality Project (SLAM)**

**Nathan W. Siegert<sup>1</sup>**, Deborah G. McCullough<sup>2</sup> and Rodrigo J. Mercader<sup>3</sup>

<sup>1</sup>US Forest Service, Northeastern Area State & Private Forestry, Durham, NH

<sup>2</sup>Dept. of Entomology & Dept. of Forestry, Michigan State University, East Lansing, MI

<sup>3</sup>Department of Biology, Washburn University, Topeka, KS

The SLOW Ash Mortality (SLAM) Pilot Project was a multi-agency effort conducted from 2008 to 2011 to develop, implement and evaluate a strategy to integrate available management options to suppress a building population of emerald ash borer (EAB), *Agrilus planipennis*, located in Moran and St. Ignace, Mackinac County, Michigan. The primary goal of the SLAM pilot project was to reduce local EAB population growth to slow the onset and progression of ash mortality within a localized area. A secondary goal was to affect spread of the EAB infestation by reducing the number of dispersing beetles and the establishment of new satellite populations.

The SLAM strategy included the use of systemic insecticides and clusters of 2-4 girdled trees functioning as population sinks. Sinks were to be established in areas with relatively high EAB densities to attract and retain adult beetles, reduce dispersal, and reduce population growth upon removal prior to adult emergence. Sinks were to be surrounded with a buffer of trees injected with the systemic insecticide TREE-äge<sup>®</sup> (emamectin benzoate) to reduce survival and population growth of dispersing adult EAB. Trees surrounding smaller, disjunct EAB populations along the periphery of the infestation would similarly be girdled and/or injected. Logistical issues and unforeseen land-use restrictions, however, affected implementation of treatments. As a result, injected trees and sinks were not ideally distributed with respect to the EAB population.

Despite these circumstances, our analyses to-date indicate that both treatments significantly reduced EAB population growth. In particular, injected trees reduced the number of larvae detected up to 2 years following treatment. Interestingly, the number of injected trees affected

EAB populations but the area of treated phloem did not, indicating that it is more useful to treat many trees than to selectively treat large trees. Sinks reduced population growth the following year but the effect did not persist for two years, likely due to the attraction of beetles to the immediate vicinity. Sinks significantly reduced dispersal (based on data from detection trees), although they became less effective as local EAB population densities increased.

The reduced population growth and dispersal resulting from the injected trees and sinks are particularly notable, given that a tiny fraction of the ash could be treated and the distribution of treatments was less than ideal. These results suggest that coupling sinks with injected trees as originally envisioned would likely improve the efficacy of similar adaptive management at other isolated EAB infestations. The SLAM strategy effectively buys time for planning, advances in research, and mitigation activities while delaying catastrophic ash mortality, thereby reducing the social, ecological and economic impacts associated with an EAB invasion.

### **Beyond Verbenone and MCH.....What's New In Tree Protection?**

**David Wakarchuk**

Synergy Semiochemicals Corp., Burnaby, BC, Canada

The use of MCH as a tree protection semiochemical was patented in 1977 but wasn't until 1994 that it was registered by EPA. Similarly, the use of verbenone as a pine protection semiochemical was patented in 1985 yet verbenone was not registered for use until 2001. Obviously, the experimental development of tree protection semiochemicals takes a long time. Part of the barrier to having these products available lies in the legal designation of semiochemicals as pesticides, and this makes registration of these products both expensive and slow. Currently there is comparatively little development of new semiochemical products for conifer-infesting bark beetles.

Synergy Semiochemicals has developed a new method for discovering bark beetle semiochemicals that may be used in host recognition. A library of oxidized terpenes has been constructed using the major monoterpenes found in conifers. The library of several hundred compounds was screened using GC-EAD with Douglas-fir beetle, mountain pine beetle and spruce beetle. Beetles recognize approximately one third of the oxidized terpenoids. These compounds fall into three general groups: compounds with known structures and known biological activities, compounds with known structures and unknown biological activities, and unidentified structures and unknown biological activity.

EAD active compounds were initially screened via trap challenge assays. Carveol a limonene oxidation product, has been shown to inhibit mountain pine beetle in a trapping study. Single tree protection assays were conducted using carveol on baited ponderosa pine in 2012 and lodgepole pine in 2013. In both years carveol devices have successfully protected trees from attack by Mountain pine beetle at 67 to 90 % efficacy. New compounds have also been found to inhibit both Douglas-fir beetle and Spruce beetle in trap challenge studies. Clearly there more potential semiochemical tools other than verbenone or MCH, for the management of tree killing *Dendroctonus* species.

**BIOLOGICAL CONTROL OF FOREST INSECTS AND WEEDS**  
**(Justin Runyon, Chair)**

**Fungal Bioinsecticides:**  
**Developing New Tools for Bark Beetle Management**

**Clifford Bradley<sup>1</sup>**, Janina Bradley<sup>1</sup>, Egan Jankowski<sup>1</sup>, Brytten Steed<sup>2</sup>, Christopher Fettig<sup>3</sup>, and Robert Progar<sup>4</sup>

<sup>1</sup>Montana BioAgriculture Inc., Missoula, MT

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<sup>4</sup>Pacific Northwest Research Station, La Grande, OR

Montana BioAgriculture Inc. (MBAI) and colleagues are developing fungal insect pathogens as biological insecticides for bark beetle control. Certain species of fungi are important natural controls on insect populations. Several species of fungal insect pathogens in the genera *Beauveria*, *Metarhizium*, *Isaria* and *Verticillium* have been developed as bioinsecticides for use in agriculture. However commercial fungal bioinsecticides have not been developed for forestry. We are pursuing a two part strategy, 1) working with a commercial formulation of *B. bassiana* as a first generation product to test application strategies, and 2) developing an improved second generation product. MBAI is pursuing two approaches: First isolating strains with greater virulence and speed of infection against bark beetles especially *Dendroctonus* and *Ips* species, and second combining the fungal pathogen with a natural biochemical to deter beetle boring and increase exposure to spores.

Laboratory bioassays demonstrated that mountain pine beetle becomes infected from spores in the commercial formulation applied to bark. In 2013 MBAI and USFS collaborators conducted initial field trials on lodgepole and ponderosa testing the commercial *B. bassiana* formulation in individual tree protection. The trial used a high-pressure hydraulic sprayer to treat individual, baited trees, 30 trees/treatment, spaced at 100 m intervals. *B. bassiana* treatment did not protect baited, heavily hit trees. Assays of spore coverage on trees in the trial showed a need for greatly improved spray coverage. Sampling of trees from the lodgepole trial did show effects on beetle reproduction with significantly less total gallery length and fewer egg galleries in *B. bassiana* treated trees compared to controls.

MBAI has isolated a number of fungal insect pathogens from soil, duff and vegetation samples taken from lodgepole and ponderosa habitats. In laboratory bioassays five of the new isolates show significantly greater virulence to mountain pine beetle than the commercial *B. bassiana* strain. Screening experiments have identified several natural products biochemicals that delay boring behavior of mountain pine beetle.

Field work in 2014 will evaluate alternative spray equipment to improve coverage and field trials comparing the commercial strain with the best of the new fungal pathogen isolates. MBAI is also coordinating with other research groups to set up laboratory bioassays and field trials of the new fungal pathogen isolates against multiple species of *Dendroctonus* and *Ips*.



## **Predators of Hemlock Woolly Adelgid in the Pacific Northwest: Potential for Biological Control in the East**

**Darrell W. Ross**<sup>1</sup>, Glenn Kohler<sup>2</sup>, Sarah Grubin<sup>3</sup>, Kimberly Wallin<sup>4,5</sup>, Nathan Havill<sup>6</sup>, and Stephen Gaimari<sup>7</sup>

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<sup>6</sup>USDA Forest Service, Hamden, CT

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*Adelges tsugae* (hemlock woolly adelgid), introduced to the eastern US from southern Japan, is causing widespread mortality of *Tsuga canadensis* (eastern hemlock) and *Tsuga caroliniana* (Carolina hemlock). Current efforts to reduce hemlock mortality in eastern forests are focused on classical biological control. Once thought to be introduced in western North America as well, it is now known that hemlock woolly adelgid is native to that region. A diverse suite of predators is associated with hemlock woolly adelgid in the Pacific Northwest, but three adelgid specific predators are the most abundant and frequent associates throughout Oregon and Washington. The three predators are a predacious beetle, *Laricobius nigrinus* (Derodontidae), and two predacious silver flies, *Leucopis argenticollis* and *Leucopis piniperda* (Chamaemyiidae). *L. nigrinus* has been introduced and established in the East, but has not significantly reduced hemlock woolly adelgid populations at release sites. Field studies in the Pacific Northwest have demonstrated that the *Leucopis* spp. are nearly as abundant and likely as important in the population dynamics of hemlock woolly adelgid as *L. nigrinus*. Laboratory feeding trials have shown that both *Leucopis* spp. can feed and develop on other adelgid species, but both prefer hemlock woolly adelgid. Release of both *Leucopis* spp. in the East could potentially increase effectiveness of the biological control program.

## **Moving Beyond the Lottery Method: Can We Predict Effectiveness of Weed Biocontrol Agents?**

**Justin B. Runyon**

Rocky Mountain Research Station, USDA Forest Service, Bozeman, MT

Predicting the effectiveness of potential biocontrol agents is one of the great challenges in biocontrol. Our ability to predict host specificity of potential biocontrol agents has improved greatly in recent decades, but we still struggle to predict which agents are most likely to be effective. Because plant chemistry is a central factor regulating plant-insect interactions, it could provide information that can be used to better choose effective agents. One example is induced-plant responses – defenses produced in response to insect feeding – which can be costly for plants to produce. Loss of fitness due to commitment of resources to defense could play a role in determining the success or failure of biocontrol.

The costs of induced defenses in invasive houndstongue (*Cynoglossum officinale*) were measured by activating defenses in the absence of herbivores using methyl jasmonate (JA) in nature. Plants treated with JA produced more trichomes and released significant amounts of plant volatiles. The height, width, number of leaves, and weight of nutlets were each reduced in plants with defenses activated. These results suggest that induced defenses are costly for houndstongue to produce and could contribute to the overall impact of herbivory. The potential importance of induced-plant defenses to biocontrol and the selection of potential agents are discussed.

### **Biological Control of Weeds in California**

**Michael J. Pitcairn**

Pest Detection / Emergency Projects Branch, California Dept. of Food and Agriculture  
Sacramento, CA

Since 1940, a total of 36 weed species have been targeted for biological control in California. Most species are perennial species (58%) followed by biennial (25%) and annual (17%) life histories. Most are weeds of rangelands and natural areas but some species occur in aquatic and riparian habitats. For 16 species, enough time has passed to allow some assessment of success. Of these, eight species are considered to be successfully or partially controlled: *Hypericum perforatum* (St. Johnswort), *Opuntia* (prickly pear cactus, Santa Cruz Island), *Chondrilla juncea* (rush skeletonweed), *Senecio jacobaea* (tansy ragwort), *Tribulus terrestris* (puncturevine), *Salvinia molesta* (giant salvinia), *Lythrum salicaria* (purple loosestrife, northern CA only), *Carduus nutans* (musk thistle) (northern CA only), suggesting a success rate around 50%. During this time period, 72 natural enemies (68 insects, two mites, two plant diseases) were introduced and resulted in an establishment rate of 76%.

## **CONCURRENT SESSION 4**

### **(ALL NEW!) REGIONAL REPORTS: AN OPEN DISCUSSION FORUM ON THE STATE OF FOREST INSECTS IN THE WEST (Beverly Bulaon, Chair)**

Open discussion on regional conditions.

### **IMPACTS OF BARK BEETLES ON GOODS AND SERVICES OF WESTERN FOREST ECOSYSTEMS (John Lundquist, Chair)**

#### **Issues of Economic Impact Analysis**

**Eric L. Smith<sup>1</sup> and Dan McCollum<sup>2</sup>**

<sup>1</sup>Forest Health Protection, USDA Forest Service, Fort Collins, CO

<sup>2</sup>Rocky Mountain Research Station, USDA Forest Service, Fort Collins, CO

The bark beetle impacts considered in this project are useful to communicate the types and magnitude of resource changes resulting from these major outbreaks. But, since we share Earth with scolytids, the next logical step in the analytical process would be to use what we've learned from these events to compare future management alternatives, so as to mitigate the net impacts. The economic formulation appropriate for this analysis is generally known as "cost plus net value change". This concept was applied for an efficiency analysis of fuel treatment costs, potential fire suppression costs, and the net change in the stream of forest resources value impacts over time. The future impacts vary, depending on the allocations to fuel treatments and suppression costs.

The major challenge for this type of analysis is to deal with what is known as "incommensurate values". These are things which cannot be readily compared because they are measured in fundamentally different ways. Our approach here is to present individual impact assessments of different resource impacts in ways which do not pretend that they are commensurate: i.e., that everything can be measured as dollars (or even that "dollars" are always comparable). Except for alternatives which have worse outcomes for all aspects, we generally have no agreed upon basis for saying what is "best". Additional issues which cause problems in comparing alternatives include choice of an appropriate discount rate, the geographic and temporal scope of the analysis, and the trade-offs among members of society when there are different "winners" and "losers". Ultimately, determining the "the greatest good of the greatest number in the long run" is not so easy.

### **Impacts of the Western Pine Beetle (*Dendroctonus brevicomis*) Outbreak in Southern California on Ecological Goods and Services**

**Christopher J. Fettig**

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

In the early 2000s, the mountain ranges of southern California started to experience elevated levels of tree mortality attributed to a prolonged drought (i.e., precipitation was the lowest in recorded history during 2001-02) and elevated populations of bark beetles and woodborers. Western pine beetle, *Dendroctonus brevicomis*, activity peaked in 2002-03 when western pine beetle was reported to be the most common mortality agent associated with dead and dying pines throughout the ranges. By 2004, mortality was dispersed across >259,000 hectares and concentrated in several plant associations. In some areas, mortality of large-diameter ponderosa, *Pinus ponderosa*, and Coulter pines, *P. coulteri*, exceeded 80%.

This outbreak of western pine beetle was unique in that it occurred in an area proximal to the largest population center in the western United States (i.e., ~21 million people live in southern California). Furthermore, San Bernardino National Forest, where most of the outbreak occurred, is one of the most heavily-recreated forests in the United States. Therefore, unlike many other bark beetle outbreaks in the western United States, impacts related to the southern California outbreak centered on regulating and cultural services. Concerns regarding hazard trees, fire risk, transportation and accessibility, and power line maintenance were paramount and discussed in detail.

**Mountain Pine beetle (*Dendroctonus ponderosae*) in Colorado:  
The Good, the Bad and the Ugly**

**Bob Cain<sup>1</sup>** and Jose Negron<sup>2</sup>

<sup>1</sup>Forest Health Protection, USDA Forest Service, Lakewood, CO

<sup>2</sup>Rocky Mountain Research Station, USDA Forest Service, Fort Collins, CO

From 1996-2013, approximately 4.3 million acres of lodgepole, limber and ponderosa pine forests were affected by the largest mountain pine beetle epidemic recorded in the Colorado Rockies and adjacent forests in southern Wyoming. The event occurred in highly used recreational forests and wildland urban interface and generated intense public interest locally, nationally and even internationally for several years. Early attempts to manage insect populations through silvicultural and sanitation treatments, and to protect trees from attack by preventive insecticide spraying, eventually gave way to safety concerns from hazardous fuels and falling trees. The US Forest Service and local communities formed bark beetle cooperative groups beginning in 2005 with the Northern Colorado Cooperative. As the epidemic continued the Northern Front Range Mountain Pine Beetle Working Group and a southern Wyoming working group formed as the beetle epidemic expanded rapidly into new areas. The USFS formed an incident management team to coordinate efforts on the White River, Arapaho-Roosevelt and Medicine Bow- Routt National Forests. Action plans and strategies were developed and resources such as timber management specialists, work crews, and GIS personnel were transferred from other National Forests in the Region to assist with the effort. Meanwhile the collaborative groups worked to generate public and partner support and resources:

- Areas were prioritized for treatments;
- The Good Neighbor policy was used to allow work on adjacent federal lands in WUI areas;
- Sort yards were established for landowners to bring woody material;
- State and Federal Legislation to streamline and fund treatments was sought;
- Timber industry support to work in priority areas was gained;
- Public awareness materials were generated cooperatively with the USFS and Colorado State Forest Service.

HFRA authority, stewardship contracts and agreements allowed streamlined treatment activity for treatment of low value material on federal lands. Through 2011, hazardous trees were cut along 600 miles of roads, 442 miles of trails, 411 developed administrative/ recreation sites, and on nearly 45,000 acres of wildland urban interface within the mountain pine beetle affected National Forests. Working with Western Area Power Association, 1,000 miles of power line corridors were treated. Ski Areas within the affected areas also must deal with the cost of removing trees and closing off runs for the safety of skiers. Settlement sales allow the USFS to sell the low value timber at low cost to the ski areas, but the cost of cutting and hauling the low value product has resulted in much of it being left on the ground.

New industries developed in response to the abundant woody material killed in northern Colorado. Pellet mills have been built in three locations but the pellet market has become increasingly competitive and some mills have struggled to make a profit. A company converting dead trees into WoodStraw® used as an erosion control material opened up in steamboat springs, CO. Woodworkers and artisans have made a variety of specialty products and furniture from the uniquely blue stained wood. A formerly closed saw mill in Saratoga, Wyoming was purchased and reopened, creating 80 new jobs in the small community and making a profit cutting studs from the beetle killed trees. Wood chipped material is being used for mulch and to run wood fired power plants. A new wood fired power plant in Gypsum Colorado produces enough energy to meet the needs of over 10,000 homes and has a guaranteed supply of material in part due to a 10 year stewardship contract with the USFS.

Research studies have looked at potential uses of the wood as well as ecological affects and changes on the landscape due to the epidemic. Work at the Madison Wood Products Lab revealed the ethanol yield was 7% higher from 4 year dead beetle killed trees than from corresponding live trees. Hydrologic studies conducted by the Rocky Mountain Research Station, Colorado State University, University of Wyoming and others are ongoing and showing mixed affects. Vegetation response under dead lodgepole overstory has helped reduce runoff concerns on many sites and various localized affects appear to be greatly diluted downstream. There has been no affect to public water supplies as some had speculated. Work by Jennifer Klutsch and Jose Negron found affected stands lost an average of 71% basal area and tree size shifted dramatically to smaller diameters. They also looked at projected tree fall and its effect on future fuel loading using forest service fuel models and field data. Wildlife studies have most focused in birds and small mammals like red squirrels and other are ongoing. A good review of current studies in mountain pine beetle affected areas was prepared by Victoria Saab and others and will be published in an upcoming edition of Forest Science.

Social impacts have varied over time to fear from economic impacts and quality of view sheds to trying to make the best of it with beetle inspired festivals in resort communities. The social license to cut trees may be short lived as time goes on. A bumper crop of new lodgepole pine seedlings is already established in both treated and untreated beetle-killed areas.

### **Four Bugs, Five Minutes: Spruce Beetle and Western Balsam Bark Beetle Response to Defoliator and Sap-Sucking Damage**

**Ann M. Lynch**

Laboratory of Tree-Ring Research, University of Arizona, Tucson, AZ

Impact assessments of forest insect outbreaks usually focus on individual species. However, activity of one species often affects the population dynamics of other insect species, with cascading ecological effects. During the late 1990s and early 2000s successive insect outbreaks occurred in the high-elevation forests of the Pinaleno Mountains in southeastern Arizona U.S.A., with early damage contributing to subsequent outbreaks. Here I summarize the effects that these outbreaks had on ecosystem services.

In the late 1990s Janet's looper (*Nepytia janetae* (Lepidoptera: Geometridae)) severely defoliated Engelmann spruce and corkbark fir three years in succession. At the end of the defoliator outbreak, spruce aphid (*Elatobium abietinum* (Hemiptera: Aphididae), an exotic specific to spruce, established within the defoliated zone. Spruce beetle and western balsam bark beetle populations were modestly elevated, perhaps at incipient outbreak levels, at the beginning of the looper outbreak because of a winter storm in 1993 that caused modest damage in some parts of the spruce-fir forest. The beetle populations exhibited rapid population increased in the defoliated zone and then progressed to encompass the entire Engelmann spruce and corkbark fir populations in the mountain range, including both spruce-fir and mixed-conifer. By the time the bark beetle populations had run their course in the mid-2000s, 85% of the Engelmann spruce and approximately 70% of the corkbark fir over 15 cm dbh were dead. Initial bark beetle activity was clearly associated with defoliation severity, and subsequently with spruce aphid damage severity. Spruce aphid damage may have contributed to the longer duration of the spruce beetle outbreak compared to the western balsam bark beetle outbreak, but other factors may have played a role as well. Spruce aphid continues to negatively affect Engelmann spruce, especially on sub-canopy trees.

With respect to ecosystem services, the most serious impacts were to preserving services, especially endangered species, and regulating services, particularly fuels conditions and carbon sequestration. The insect outbreaks impacted large areas of endangered species habitat, including protected activity centers for Mexican spotted owl and critical habitat for Mount Graham red squirrel. The Mount Graham red squirrel is found only in the Pinaleno Mountains, and the effects of the insect outbreaks were catastrophic. Squirrel midden (food larders) occupancy declined from 40-60% to <3% in the spruce-fir, and the number of squirrels fell from over 220 in 1995 to 61 in 2002, with these numbers closely associated with reduced seed production by Engelmann spruce. Recovery is expected to take many decades. The distribution of fuels was significantly modified by extensive and severe tree mortality. The extreme amounts

of tree mortality, especially concentrated in large size classes and in close proximity to an astrophysical complex, affected firefighting operations during the 2004 Nuttall Complex Fire, such that burnout operations were repeated from the same fire line with helicopter-dropped incendiary devices, contributing to burn severity. Currently, the quantity of large woody debris in overlapping layers from fallen trees, and snag hazards, contribute to firefighter safety issues in future fires, making ground-based firefighting operations even more hazardous. These conditions also make it virtually impossible to physically remove fuels to mitigate hazardous conditions.

### **Douglas-fir Beetle *Dendroctonus pseudotsugae* (Hopkins) Outbreak Following the Yellowstone Fires of 1988**

**Robert Progar**

Pacific Northwest Research Station, USDA Forest Service, LaGrande, OR

In western North America, the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) (DFB) is the most important enemy of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). When DFB populations are at endemic levels, they tend to attack recently killed trees or trees weakened by ice, fire, or wind. Under normal environmental conditions, small groups of trees can be killed, but when large numbers of trees are weakened by drought, disease or fire, DFB populations can increase and attack larger numbers of trees. The Yellowstone fires of 1988 together formed the largest wildfire in the recorded history of Yellowstone National Park in the United States. Starting as many smaller individual fires, the flames quickly spread out of control with increasing winds and drought and combined into one large conflagration, which burned for several months. Only the arrival of cool and moist weather in the late autumn brought the fires to an end. A total of 793,880 acres (3,213 km<sup>2</sup>), or 36 percent of the park was affected by the wildfires. Within two years (1989 and 1990), 67 percent of the Douglas-fir had been infested by bark beetles (primarily the Douglas-fir beetle) and wood borers. By 1992, 79 percent of the Douglas-fir were infested by bark beetles. Other researchers monitoring the impact of the Yellowstone fires found significant effects resulting from the Douglas-fir beetle infestation on forest stand conditions: a reduction in basal area by 40-70 percent; tree diameter (live avg.) decreased by 8-40 percent; the Douglas-fir component of the overstory decreased by more than 15 percent; average Douglas-fir diameter reduced for the next 100 to 200 years; regeneration and herbage production will increase in beetle-caused forest openings; annual stream-flow and water yield may increase where the outbreak was extensive and intensive. Additionally, there was a reduction in the abundance foliage gleaning birds, followed by an increase in wood peckers and cavity nesters.

### **Status and Impact of Walnut Twig Beetle in Forests and Orchards**

**Steven J. Seybold**

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

The walnut twig beetle (WTB), *Pityophthorus juglandis* Blackman, vectors the phloem pathogen, *Geosmithia morbida*, and together the organisms, cause a progressive crown dieback of walnut and butternut trees known as thousand cankers disease (TCD). The WTB has expanded its distribution from 4 counties in 3 U.S. states (1960) to 11 counties in 14 states and to northern Italy (2014). The distribution now overlaps with the native range of eastern black walnut, *Juglans nigra*, which has an estimated stumpage value of over \$540 billion. The primary eastern U.S. states that hold the *J. nigra* growing stock are Missouri, Kentucky, Ohio, Illinois, and Indiana. In addition to its value as a source of high quality wood products, *J. nigra* provides wild nuts for human food consumption and wildlife mast. WTB and TCD are also widespread in California where the edible walnut industry is based on English (Persian) walnut scions, *J. regia*, grafted on black walnut rootstock. Surveys of several orchards in the Central Valley have revealed rates of TCD ranging from 5 to 12% of trees. The annual income from the nut harvest has ranged from \$1 billion to \$1.5 billion over the past 4 years with extensive export markets developing in China and elsewhere in Asia. The investment in the California orchard industry has not been quantified, but likely exceeds \$100 billion. Tree mortality caused by WTB can take 3-5 years after symptoms are first observed. There has been a substantial, but unquantified, loss in shade and amenity value and removal costs as large, diseased *J. nigra* have had to be removed from the urban landscapes of the Colorado front range and the interior West. The loss of orchard trees in California has been low to date, but cases of TCD have been on the increase in places like Tulare County where some orchards have had to remove 10 or more dead or dying English walnuts over the last few years.

### **Impacts of the 1990s Spruce Beetle (*Dendroctonus rufipennis*) Outbreak on the Ecosystems and Communities of the Kenai Peninsula**

**John E. Lundquist,**

Forest Health Protection and the Pacific Northwest Research Station, USDA Forest Service,  
Anchorage, AK

During the 1990s, an insect outbreak the magnitude of which had never previously occurred in North America by any bark beetle occurred in spruce stands on the Kenai Peninsula. Because of its magnitude and because so many aspects were studied in its aftermath, this outbreak remains one of the most thoroughly studied bark beetle outbreaks ever. The impacts on ecosystem goods and services were vast and diverse. On the negative side, dead forests kept many tourists and fishermen away, more auto accidents occurred involving moose and bear, hazards associated with falling trees increased, scenic beauty was lost, spiritual consciousness was impacted. New roads built to reach infested stands enabled increased access to remote areas. Increased access led to spreading housing settlements in previously untrammeled locations. On the positive side, abundance of some bird and other wildlife species increased, falling trees added wood debris to waterways and enhanced salmon habitat, lost canopy cover stimulated berry crops and other lower vegetation improving bear and moose habitat improved, timber revenues increased from export of wood chips from salvaged trees. Different communities differed in their perceptions of impact. For some, it was an ecological disaster; but, for others, it offered an economic windfall. Even after decades of recovery, the impacts of this outbreak are still evident.



**PEST EXCLUSION EFFORTS FOR INVASIVE INSECTS IN CALIFORNIA**  
**(Cynthia Snyder, Chair)**

**California Firewood Task Force**

**Donald R. Owen**

California Department of Forestry and Fire Protection

The **California Firewood Task Force** ([www.firewood.ca.gov](http://www.firewood.ca.gov)) was formed as a result of a resolution passed by the California Forest Pest Council at its annual meeting in 2010, with the intent of protecting the State's native and urban forests from invasive pests that can be moved on firewood. Such pests are established both within and outside of California, e.g., gold spotted oak borer, polyphagous shot hole borer, Asian longhorned beetle, and emerald ash borer. Preventing the spread of invasive pests is a principal goal of this and other Pest Council Task Forces. Strategies to address the firewood issue are outlined in the recommendations of the National Firewood Task Force (2010). Similarly, outreach campaigns have been initiated both nationally (Don't Move Firewood) and regionally (Buy it Where You Burn it) to educate various segments of society about the risk. To maintain consistency with other western states, The California Firewood TF chose to model its outreach campaign after the "Buy it Where You Burn it" campaign initiated by Oregon, Washington, and Idaho.

Key elements to launching a successful campaign in California were engagement of stakeholder groups and funding for Task Force efforts. Over twenty governmental and non-governmental groups have partnered with the Task Force. Grant funds have been provided by the US Forest Service and the California Department of Forestry and Fire Protection, and have been used by The California Department of Agriculture and University of California to develop outreach media and activities. Products include a website, placement of educational posters in campgrounds statewide, public service announcements, billboards on major travel routes, posters at CalTrans rest stop kiosks, training for CDFA and US Customs Border Station personnel, information tables at Fairs and Conferences, outreach information on Partner Websites, articles in professional publications, inclusion of information with Campfire and Firewood Collection Permits, and Google Ad Words. Goals for the Task Force in 2014 are to evaluate the effectiveness of outreach efforts and set priorities for the future.

## **POSTER PRESENTATIONS**



### **Trunk Injection of Emamectin Benzoate: Long-term Control of EAB and the Wound Response of Ash Trees**

J. Docola, D. Smitley, T. Davis, J. Aiken, D. Cox, P. Wild, and D. Grosman.

The exotic emerald ash borer (EAB, *Agrilus planipennis*) is causing nearly 100% mortality of ash (*Fraxinus* spp.) trees unless they are treated with efficacious insecticides. Trials were conducted to 1) confirm that a single application of emamectin benzoate (EB) would provide multiple year control of EAB larvae, and 2) to evaluate how green ash in various states of health responded to wounding caused by standard trunk injection treatments. Trunk injections of EB reduced the density of EAB larvae found in treated trees by nearly 100% compared with control trees. A single trunk injection of EB at the 0.4 g ai/2.54 cm dbh rate applied to ash trees with a 36 cm dbh gave 100% control of EAB larvae for three years. Data collected from felling, sectioning and examining vascular tissue around 63 injection sites in 14 trees gives no indication of any compromise in structural integrity, no signs of infection, and no indication of negative impacts on tree health due to trunk injection of insecticides. This study suggests that tree injections are well tolerated in healthy green ash and have a potential role as a tool to protect trees against exotic and destructive pests.

### **Evaluation of TREE-äge® (Emamectin Benzoate) for Protection of Loblolly Pine from Black Turpentine Beetle**

D. Grosman, W. Upton, L. Spivey, and D. Cox.

The black turpentine beetle, *Dendroctonus terebrans* (Olivier), or BTB, is one of five common species of pine bark beetles in the southeastern U.S. that attack loblolly pine, *Pinus taeda* L.. Historically, prevention treatments have consisted of bole spraying the base of trees to about 3 m with approved insecticide. It is of interest to determine if trunk injection of TREE-äge® (emamectin benzoate) is effective against BTB and if treatment rate or injection height will affect treatment efficacy. The injection treatments, regardless of application rate and height, were effective in significantly reducing the number and success of BTB attacks. The trial results indicate that TREE-äge applied to loblolly pine at as little as 2.5 ml/inch DBH is effective in protecting trees for at least one full year.

### **Distribution of Oak Pit Scale and Associated Crown Dieback of Oregon White Oak in Washington**

Glenn R. Kohler and Aleksandar Dozic  
Washington Department of Natural Resources, Olympia, WA

Oak pit scale (OPS) infestations have caused dieback and occasional mortality of Oregon white oak (*Quercus garryana*) in the Columbia River Gorge area of Washington in recent years. In 2013, the Washington Department of Natural Resources (WDNR) conducted a survey of OPS populations and damage throughout the range of *Q. garryana* in Washington. Over 1,100 branches were collected at 37 plots from the San Juan Islands to Klickitat County and examined for OPS populations; their presence was confirmed in 92% of the plots. The majority of infested plots (79%) had low populations of OPS; from one to ten individuals per 30 cm branch length, on average. OPS populations tended to be higher at sites east of the Cascade Mountains. The golden oak scale, *Asterodiaspis variolosa* (Ratzeburg), was the only species of OPS identified in the survey. Signs of parasitoid emergence from OPS were present in 79% of infested plots. In 85% of plots with signs of parasitism, it was evident on fewer than half of infested branches. Crown symptoms of OPS are branch tip dieback paired with foliage that appears clumped due to epicormic shoot growth and delayed leaf expansion. These symptoms were recorded in 38% of plots, the majority of which were east of the Cascade Mountains. Crown symptoms of OPS were recorded as far north as the San Juan Islands, but whole tree mortality was rare outside of Klickitat County.

### **Development and Registration of a Novel Semiochemical-based Tool (SPLAT® Verb) for Protecting Lodgepole Pine from Mortality Attributed to Mountain Pine Beetle**

Christopher J. Fettig,<sup>1</sup> A. Steven Munson,<sup>2</sup> Michael Reinke,<sup>3</sup> and Agenor Mafra-Neto<sup>3</sup>

<sup>1</sup>Pacific Southwest Research Station, USDA Forest Service, Davis, CA

<sup>2</sup>Forest Health Protection, USDA Forest Service, Ogden, UT

<sup>3</sup>ISCA Technologies Inc., Riverside, CA

Verbenone (4,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-one) is the principal antiaggregant of the mountain pine beetle, *Dendroctonus ponderosae*. Several formulations are registered for tree protection, but failures in efficacy are not uncommon. A novel formulation of (–)-verbenone was developed (SPLAT<sup>®</sup> Verb) and evaluated for protecting individual lodgepole pines, *Pinus contorta*, and small stands of lodgepole pine from mortality attributed to mountain pine beetle.

Applications of SPLAT<sup>®</sup> Verb to individual lodgepole pines resulted in complete tree protection while 93.3% mortality was observed in the untreated controls in two studies. In the second study, significantly fewer lodgepole pine were killed by mountain pine beetle within 0.041-ha circular plots (11-m radius) surrounding trees treated with SPLAT<sup>®</sup> Verb compared to the untreated control. In a third study, a smaller percentage of lodgepole pine were colonized and killed on 0.4-ha plots treated with SPLAT<sup>®</sup> Verb compared to the untreated control. No significant differences were observed between the untreated control and another formulation of verbenone (7-g pouch) or between the 7-g pouch and SPLAT<sup>®</sup> Verb. In a trapping bioassay, no significant differences were observed among captures at 1, 2 or 4 m for the point of release of SPLAT<sup>®</sup> Verb. Significantly fewer mountain pine beetle were collected at 1 and 2 m compared to 8 m. Significantly more mountain pine beetle were captured at the farthest distance evaluated (16 m) than at any other distance.

Our data indicate that SPLAT<sup>®</sup> Verb is effective for protecting individual lodgepole pines and small stands of lodgepole pine from mortality attributed to mountain pine beetle during what we considered to be high levels of beetle “pressure”. The high level of tree protection observed is attributed to the ability of applying release points (dollops) at high densities per unit area, and a larger zone of inhibition provided by each dollop than reported for other formulations of verbenone. SPLAT<sup>®</sup> Verb [10% (–)-verbenone, ISCA Technologies Inc., Riverside, CA] was registered by the United States Environmental Protection Agency for use on pines in August 2013.

### **Effects of Western Spruce Budworm on Stand Dynamics in Northern New Mexico**

Adam Polinko and Kristen M. Waring  
Northern Arizona University, Flagstaff, AZ

Western spruce budworm (*Choristoneura occidentalis* Freeman) is one of the most destructive native defoliators in the western United States. Northern New Mexico forests have been experiencing elevated western spruce budworm population levels and corresponding defoliation since the 1990s. The effects of prolonged outbreaks on forest stand species composition, structure and regeneration in the Southwest are still relatively unknown. As the Southwest transitions to a warmer climate, forest pest outbreaks are likely to increase in severity and duration. Thus, understanding the influence of prolonged defoliation events on forest stand dynamics will be increasingly more important. Our research investigated the impact of western spruce budworm on stand dynamics in the dry mixed conifer and lower spruce-fir forest types of northern New Mexico. Data collection was completed in the summers of 2012 and 2013. Overstory tree measurements including height, diameter, defoliation severity, and status (live or

dead) were taken along with a subsample of increment cores. Understory data included abundance and species composition of all trees less than 5" diameter at breast height. We will present results for the spruce fir forest type and discuss management implications.

### **Impacts of Spruce Beetle Outbreaks on Forests in Utah and Western Wyoming**

Daniel Ott<sup>1</sup>, Christopher J. Fettig<sup>2</sup>, A. Steven Munson<sup>3</sup>, Darrell W. Ross<sup>1</sup>, and Justin B. Runyon<sup>4</sup>

<sup>1</sup> College of Forestry, Oregon State University, Corvallis, OR

<sup>2</sup> Pacific Southwest Research Station, USDA Forest Service, Davis, CA

<sup>3</sup> Forest Health Protection, USDA Forest Service, Ogden, UT

<sup>4</sup> Rocky Mountain Research Station, USDA Forest Service, Bozeman, MT

Spruce beetle, *Dendroctonus rufipennis* Kirby, causes extensive levels of tree mortality in high-elevation forests dominated by Engelmann spruce, *Picea engelmannii* Parry ex Engelm., in the Intermountain West, and plays an important role in the disturbance ecology of these ecosystems. Greater than 180,000 hectares have been impacted since the late 1980s, with substantial levels of tree mortality observed in Colorado, Utah and Wyoming in recent years. In areas of suitable host, outbreaks are expected to further intensify as a result of anthropogenic-induced climate change.

Bark beetle outbreaks modify stand structure and composition by causing tree mortality, and may impact timber and fiber production, fuel conditions, fire risk and severity, water quality and quantity, fish and wildlife populations, recreation, grazing capacity, real estate values, human safety, biodiversity, carbon pools, aesthetics, endangered species and cultural resources, among other factors. However, only limited research has been conducted to determine the impacts of spruce beetle outbreaks on ecological goods and services in the Intermountain Region. The objective of our research is to document changes in stand structure and composition following spruce beetle outbreaks in Utah and western Wyoming. We concentrate on impacts to ground, surface and aerial fuels; stand age, tree size and species diversity; regeneration; invasive plants; and snag demography. In 2013, 0.081-hectare plots ( $N = 40$ , to date) were randomly distributed among areas recently (1990-present) impacted by spruce beetle on the Bridger-Teton National Forest, Wyoming, and Dixie, Fishlake, Manti-La Sal, and Uinta-Wasatch-Cache national forests, Utah. Each tree  $\geq 7.62$  cm dbh (at 1.37 m in height) was permanently tagged and the species, dbh, height, height to the base of the live crown, crown width, crown position, status (live or dead), and presence and impact of insect and disease agents was recorded. Downed woody debris was recorded along three modified Brown's-planar transects radiating from plot center. Litter, duff and fuel bed depth were measured at the beginning and middle of each fuel transect. At the beginning of each transect, tree regeneration was also recorded on a 0.004-hectare subplot. Other flora were categorized and an average height was quantified in a 1-m<sup>2</sup> subplot at the beginning of each transect. Invasive plants were surveyed on the entire plot. Data collection and preliminary analyses are ongoing.

**WESTERN FOREST INSECT WORK CONFERENCE 2014  
FIELD TRIP SUMMARIES**

*Stops 1 and 2 had to be cancelled due to heavy snowfall impeding access to these locations. As such, buses left Negro Bar, California State Park at about 900 and returned about 1530.*

**WEDNESDAY, 2 APRIL**

**Buses leave hotel at 900.**

**Stop 1: Mormon Emigrant Info Site (1030 to 1130)**

- ~1.5-hr. drive from hotel on Highway 50; arrive ~1030
- Mixed-conifer, ~4,500 ft. elevation
- ~1 hr. stop, includes 3 presentations and time for discussion
- Paved road; stop is roadside
- Expect cool/cold weather

**Presenters:**

*Malcolm North, Pacific Southwest Research Station – PSW-GTR-220; implications to management in the Sierra Nevada*

*Marc Meyer, Region 5 – Natural range of variation in mixed-conifer systems; influences of past management on disturbance regimes*

*Don Errington, Eldorado National Forest – Forest-level project planning and goals*

**Stop 2: Parking area at Jenkins Lake Trailhead (1145 to 1345)**

- ~15 min. drive from Stop 1; arrive ~1145
- Mixed-conifer, ~4,400 ft. elevation
- 30 min. lunch, provided
- ~1.5 hr. stop, includes 3 presentations/demonstration and time for discussion
- Some hiking involved
- Expect cool/cold weather

**Presenters:**

*Danny Cluck, Forest Health Protection – Insect complexes in mixed-conifer forests; Douglas-fir beetle activity in northern California*

*Pete Angwin, Forest Health Protection – *Annosum* in true-fir stands in California; removal of fire-killed trees and root disease prevention*

**Stop 3: Negro Bar, California State Park, downtown Folsom (1430 to 1530)**

- ~45 min. drive from Stop 2; arrive ~1430
- Gray pine, ~600 ft. elevation
- ~1 hr. stop (duration can be adjusted), includes 2 presentations and time for discussion



- Paved road
- Expect warm/cool weather

**Presenters:**

*Don Owen, California Department of Forestry and Fire Protection* – Northern California’s drought situation

*Beverly Bulaon, Forest Health Protection* – Insects associated with gray pine; gray pine decline

*Phil Cannon, Forest Health Protection* – Possible factors contributing to gray pine decline

*Chris Fettig, Pacific Southwest Research Station* – Tree injections: Review of related R&D; and  
*Don Grosman, Arborjet Inc.* – Demonstration of technique

**Buses leave park at ~1530, arrive back at hotel ~1615.**

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## **THURSDAY, 3 APRIL**

**Leave (walk) hotel at 1530.**

### **Tour of California State Capitol Grounds (1530 to 1700)**

- ~5 min. walk from hotel
- ~1.5 hr. tour, includes 3 presentations and time for discussion
- Paved road
- Expect warm/cool weather

#### **Presenters:**

*Capitol Park Volunteers, Dept. of General Services* – History and management

*John Melvin, California Department of Forestry and Fire Protection* – Management of urban trees in California

*Sacramento Tree Foundation* – Urban planning and goals; improving tree resilience/resistance in urban environments









## GROUP PHOTOGRAPHS



**Back: Pete Angwin, Don Owen, Steve Cook**  
**Front: Dan Ott, Martin MacKenzie, Eric Smith, Carroll Williams, Bill Riel**



**Back: Robert Hodgkinson, Darci Carlson, David Wakarchuk, Amanda Grady, Chris Fisher**  
**Front: Aubrey Moore, Chris Takahashi, Jennifer Burleigh, Joel McMillan, Tom DeGomez**





**Back: Anthony Westerling, John Lundquist, Corwin Porter, Steve Seybold  
Front: Rich Hofstetter, Stacy Hishinuma, Sky Stephens, Rebecca Powell, Ann Lynch, Phil  
Mocettini**



**Back: Sheri Smith, Andy Graves, Tom Coleman, Jason Moan, Beverly Bulaon, Joel  
Egan, Laura Lowrey, Danny Cluck  
Front: Stephen Burr, Robbie Flowers, Damon Crook, Glen Kohler, Chris Fettig**





**Back: Lori Nelson, Bob Cain, Darrell Ross, Darren Blackford, Tom Smith**  
**Front: Pat Ciesla, Gina Davis, Justin Runyon, Don Grosman, Bob Rabaglia**



**Back: Cynthia Snyder, Kathy Bleiker, Andy Eglitis, Beth Willhite, Roger Burnside**  
**Front: Dave Shaw, Nancy Gillette, Kirsten Waring**

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