68th Western Forest Insect Work Conference
Denver, Colorado
26–29 March 2018

Coming Together Along the Great Divide

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TABLE OF CONTENTS

68TH WESTERN FOREST INSECT WORK CONFERENCE

26–29 March 2018
Sheraton Denver Downtown, Denver, CO

Program: Chris Fettig (Chair), Darren Blackford, Jordan Burke, Seth Davis, Erika Eidson, Robbie Flowers, Monica Gaylord, Andy Graves, Sky Stephens, Caroline Whitehouse
Local Arrangements: Sky Stephens
Registration and Souvenirs: Sky Stephens
Field Trips: Sky Stephens
Silent Auction: Monica Gaylord
Poster Session: Monica Gaylord, Darren Blackford
Banquet: Sky Stephens
Photographs: Bill Ciesla
Student Sessions: Erika Eidson
Local Transportation: Sky Stephens
Proceedings: Chris Fettig
Technology: Jordan Burke (Chair), Tim Ebata, Joel Egan, Jason Moan

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WESTERN FOREST INSECT WORK CONFERENCE OFFICERS

Executive Committee:

Chair	Joel Egan
Secretary	Jason Moan
Treasurer	Karen Ripley
Councilor	Rob Flowers
Councilor	Sky Stephens
Councilor	Caroline Whitehouse

Common Names Committee: Brytten Steed (co-Chair), Bill Ciesla (co-Chair), Beverly Bulaon, Amy Gannon, Rich Hofstetter, Lee Humble, Lee Pederson, Iral Ragenovich

Founder's Award Committee: Joel McMillin (Chair), Steve Seybold, Bill Riel, Lorraine MacLauchlan, Stacy Hishinuma, Steve Cook

History Committee: Mal Furniss (co-Chair), Sandy Kegley (co-Chair), Glenn Kohler and Carl Jorgensen

Memorial Scholarship Committee: Darrell Ross (Chair), Tom Coleman, Steve Seybold

Memorial Scholarship Fundraising Committee: Monica Gaylord (Chair), Dan Miller, Andrea Hefty, Sky Stephens


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“Coming Together Along the Great Divide”

68th WESTERN FOREST INSECT WORK CONFERENCE
SHERATON DENVER DOWNTOWN HOTEL
1550 COURT PLACE, DENVER, COLORADO
MARCH 26–29, 2018

OFFICIAL AGENDA (All times MDT, presenters in italics)

MONDAY, 26 MARCH

1500-2000 Registration Open

1600-1700 Executive Meeting

1800-2000 **MEET AND GREET SOCIAL**

TUESDAY, 27 MARCH

0700-1000 Registration Open

0700-0800 Coffee and Tea

0800-0815 **WELCOME TO DENVER/HOTEL DETAILS/HOUSEKEEPING**
Sky Stephens, Forest Health Protection

0815-0845 **KEYNOTE SPEAKER**

Scarab beetles in Colorado ecosystems
Dr. Frank Krell, Denver Museum of Nature and Science

0845-0915 **KEYNOTE SPEAKER**

Forest health: How Smokey Bear contributed to this mess
Mr. Brian Verhulst, Rocky Mountain National Park

0915-0945 **MEMORIAL SCHOLARSHIP (2017) PRESENTATION**

Great basin bristlecone pine resistance to mountain pine beetle

Ms. Erika Eidson, Idaho Department of Lands

0945-1015 BREAK

1015-1145 CONCURRENT SESSION 1

1) **SPRUCE BEETLE IMPACTS ON HIGH ELEVATION FORESTS**
Seth Davis, Colorado State University

What is happening to our spruce-fir forests? Case studies from the Intermountain Region
Danielle Malesky and Liz Hebertson

Resistance is futile: Silvicultural practices for increased resilience to spruce beetle in northern Utah
Marcella Windmuller-Campione

Recent advances in spruce beetle semiochemical repellents
Matt Hansen

Carbon biomass as metric for assessing the impacts of spruce beetle across spatial and temporal scales
Jesse Morris

Drought drives temporal and spatial patterns of spruce beetle outbreak in the southern Rocky Mountains
Sarah Hart

Engelmann spruce chemodiversity affects spruce beetle at multiple scales
Seth Davis

2) **INVASIVE FOREST INSECTS**
Jordan Burke and *Stan Pokorny*, University of British Columbia

Ecological roles of exotic Carabidae
Jim LaBonte

The walnut twig beetle: An endemic invader in North America and a threat to global walnut resources
Jackson Audley, Paul Dallara, Richard Bostock and Steve Seybold

Native invasives? Southern pine beetle moves northward
Carissa Aoki, Jeffrey Lombardo, Kevin Dodds, Lynn Fleming and Matt Ayres

Host mediated invasion dynamics of beech scale (*Cryptococcus fagisuga*) in American beech
Devin Goodsman and Jonathan Cale

Discussion

1145-1300 LUNCH (on your own)

1300-1430 CONCURRENT SESSION 2

3) **NEW TOOLS AND APPROACHES FOR LARGE-SCALE INSECT AND DISEASE ASSESSMENTS**
Andy Graves and *Robbie Flowers*, Forest Health Protection

Using landscape-level susceptibility data to support mountain pine beetle risk assessments
Joel Egan

Landscape-level forest insect and disease assessments using aerial detection surveys and state-and-transition models
Andy Graves, Dan Ryerson, Priya Shahani and Tom Coleman

Identifying priority treatment areas and cross-boundary landscape level opportunities
Sheri Smith, Danny Cluck and Meghan Woods

Using landscape departure analyses to inform insect and disease assessments
Mike Simpson

4) **POLLINATORS ACROSS FORESTED LANDSCAPES**
Lisa Mason, Colorado State University and Colorado State Forest Service

Habitat characteristics to sustain healthy pollinator populations
Arathi Seshadri

Influences of Douglas-fir beetle (*Dendroctonus pseudotsugae*) and forest habitat structure on bee communities within Douglas-fir forests of Idaho
Gabriel Foote, Chris Fettig, Darrell Ross, Justin Runyon, Tom Coleman, Monica Gaylord, Andy Graves, Laura Lowrey, Joel McMillin, Leif Mortenson and Agenor Mafra-Neto

The Pawnee montane skipper and the Hayman Fire: Information from a decade of monitoring

John Sovell

Assessing bee diversity and abundance using citizen science
Lisa Mason

1430-1500 BREAK

1500-1630 **GRADUATE STUDENT SESSION I**
Erika Eidson, Idaho Department of Lands

Tradeoffs between environmental tolerance and pathogenicity of an entomopathogenic fungus in the spruce beetle study system
Andrew Mann and Seth Davis

Response of spruce beetle flight phenology to thermal variation suggests two populations in Colorado
Isaac Hans Dell and Seth Davis

Effects of mite and temperature manipulations on mountain pine beetle associated fungi
Sneha Vissa and Richard Hofstetter

Response of mountain pine beetle to simulated climate change: Results from a field reciprocal translocation experiment
David Soderberg, Karen Mock, Richard Hofstetter and Barbara Bentz

1630-1700 **INITIAL BUSINESS MEETING**

1730-1830 SHERYL COSTELLO MEMORIAL FUN RUN
Darren Blackford, Forest Health Protection

1900-2100 **POSTER SESSION/SILENT AUCTION FOR MEMORIAL SCHOLARSHIP**
Monica Gaylord, Forest Health Protection

<u>WEDNESDAY, 28 MARCH</u>

0700-1000 Registration Open

0700-0800 Coffee and Tea

0800-0900 **DISTINGUISHED VISITING SPEAKER**

Management of bark beetles in Germany: A different approach?
Dr. Horst Delb, Forest Research Institute of Baden-Württemberg, Germany

0900-1030 CONCURRENT SESSION 3

5) DEFOLIATORS ON THE MOVE: CHANGES IN DISTRIBUTION, HOST AND CONTROL METHODS
Caroline Whitehouse, Alberta Agriculture and Forestry and *Samuel Farhrner*, University of Minnesota

In the pursuit of synchrony: Northward shifts in western spruce budworm outbreaks in a warming environment
Allan Carroll and Amberly Marciniak

Characterization of western spruce budworm outbreaks in Interior British Columbia - an ecological shift
Lorraine Maclauchlan and Lori Daniels

Developing a mycoinsecticide to control spruce aphids
Amanda Grady, Clifford Bradley and Richard Hofstetter

Estimating the potential for larch casebearer to establish on alpine larch
Samuel Fahrner and Brian Aukema

Keeping gypsy moth where they are: Investigating how far gypsy moth larvae can move
Jake Wittman, P.H. Chaloux, S.W. Myers and Brian Aukema

6) SOCIAL ASPECTS OF BARK BEETLE RESEARCH
Stu Cottrell, Colorado State University

Bark beetle impacts to social-ecological systems: What have we learned and where do we go from here?
Jesse Morris, Stu Cottrell, Chris Fettig, Winslow Hansen, Rosemary Sherriff, Vachel Carter, Jennifer Clear, Jessica Clement, Justin DeRose, Jeff Hicke, Philip Higuera, Kathie Mattor, Alistair Seddon, Heikki Seppä, John Stednick and Steve Seybold

Public perceptions of bark beetle disturbance: Implications for human dimensions of natural resources, recreation and tourism
Stu Cottrell, Pavlina McGrady, Arne Arnberger, Martin Ebenberger, Ingrid Schneider, Alexander Schlueter, Eick von Ruschkowski, Jessica Clement, Rob Venette, Jana Raadik Cottrell, Stephanie Snyder, Paul Gobster and Michael Czaja

Communicating the effects of mountain pine beetle to drinking water in the Interior West
Kathie Mattor, Stu Cottrell, John Stednick, Eric Dickinson, Mike Czaja and Alan Bright

Adaptive capacity framework for bark beetle research: Link to an SES approach
Stu Cottrell, Kathie Mattor, Jesse Morris, Pavlina McGrady, Chris Fettig, Dorothy Maquire, Patrick James, Jennifer Clear, Zach Wurtzebach, Yu Wei, Andrea Brunelle, Jessica Clement, Reed Maxwell, Marissa Rotar and Ryan Roberts

Facilitated discussion

1030-1700 **FIELD TRIPS**
Sky Stephens, Forest Health Protection

Denver Zoo and the Denver Museum of Nature and Science

1800-2200 **2017 FOUNDERS AWARD BANQUET**

Feeling blessed, a wonderful career with colleagues and friends
Steve Munson, Forest Health Protection

THURSDAY, 29 MARCH

0700-0800 Coffee and Tea

0800-0830 **KEYNOTE SPEAKER**

Bark beetle outbreaks and range expansion in Canada: The effect of weather is 365 days a year
Dr. Kathy Bleiker, Canadian Forest Service

0830-1000 **GRADUATE STUDENT SESSION II**
Erika Eidson, Idaho Department of Lands

Climate and vegetation effects on ground arthropod communities along an elevational gradient
Derek Uhey, Richard Hofstetter and Karen Haubensak

Assessing woodpeckers (Picinae) as biological control agents of mountain pine beetle in recently invaded habitats
Stanley Wolf Pokorny and Allan Carroll

The light at the end of the tunnel: Photosensitivity in developing mountain pine beetle
Debra Wertman, Katherine Bleiker and Steve Perlman

Dispersal of the emerald ash borer parasitoid *Tetrastichus planipennisi* (Hymenoptera: Eulophidae) along an ash corridor in western New York
Mike Jones, Juli Gould, Melissa Warden and Melissa Fierke

1000-1030 BREAK

1030-1200 CONCURRENT SESSION 4

7) **MANAGEMENT OF BARK BEETLES WITH SEMIOCHEMICALS**
Chris Fettig, Pacific Southwest Research Station

Management of western bark beetles with semiochemicals: A review
Steve Seybold, Barb Bentz, Chris Fettig, John Lundquist, Rob Progar and Nancy Gillette

Searching for new semiochemicals: Selections from the vault
Dave Wakarchuk, Brian Sullivan, Will Shepherd, Jorge Macias-Samano and Evert Wakarchuk

Effective management of bark beetles with semiochemical tools and solutions
Agenor Mafra-Neto, Chris Fettig, Steve Munson, Jesse Sarroli, Carmem Bernardi, Rodrigo Silva, Joey Palomera, Rob Progar, Brytten Steed and William Urrutia

Thirty-six years of semiochemical use in the Northern Rockies – The good, the bad, and the ugly
Ken Gibson and Sandy Kegley

8) **THE ROAD TO RESTORATION: PAVED WITH GOLD OR YELLOW BRICKS?**
Liz Heberston, Forest Health Protection

Forest restoration policies and practices in the western United States
Roy Mask

Forest restoration policies and practices in British Columbia, Canada
Lorraine Maclauchlan

Facilitated discussion

1200-1315 LUNCH (on your own)

1315-1345 FINAL BUSINESS MEETING

1345-1515 CONCURRENT SESSION 5

9) BALSAM WOOLLY ADELGID IS CREEPING ACROSS THE WEST: CAN WE DO ANYTHING TO MANAGE IT?
Rob Progar, Pacific Northwest Research Station

Determining the distribution of balsam woolly adelgid in Montana
Amy Gannon

Balsam woolly adelgid in Utah: Current action and looking forward
Danielle Malesky

Reflecting and futuring after 35 years of balsam woolly adelgid in Idaho
Gina Davis

Previous attempts to manage balsam woolly adelgid
Robert Progar

Open discussion: What can we do to manage balsam woolly adelgid?

10) DIRECT CONTROL OF BARK BEETLES
Darren Blackford, Forest Health Protection

Bole sprays: A review and alternative timing of carbaryl treatments in ponderosa and lodgepole pines
Chris Fettig, Steve Munson, Ken Gibson, Darren Blackford, Laura Lowrey, Leif Mortenson and Joel McMillin

Systemic injections for management of bark beetles and associated fungi
Don Grosman, Chris Fettig, Darren Blackford and Steve Munson

Acoustic tools for detection and management of bark beetles
Richard Hofstetter, David Dunn and Carol Bedoya

An economic analysis of mountain pine beetle management in Alberta
Bryan Bogdanski, Nicholas Hotsko and *Bill Riel*

Variability in stand characteristics can influence the distribution of tree mortality caused by the mountain pine beetle in ponderosa pine: Implications for restoration
Jose Negrón and Laurie Huckaby

1515-1545 BREAK

1545-1715 CONCURRENT SESSION 6

11) LINKING BARK BEETLE SPATIAL DYNAMICS TO APPLIED FOREST ECOLOGY
Jeff Hicke, University of Idaho and *Joel Egan*, Forest Health Protection

Something wicked this way comes: The invasive dynamics of mountain pine beetle in the boreal forest
Barry Cooke

Spatial proximity and forest density drive Jeffrey pine beetle-attack during epidemic stage of an outbreak
Joel Egan, O. Khormali, E. Smirnova, D. Patterson, J. Graham, T. Cardoso and J. Sloughter

Development and evaluation of the Mechanistic Model of Outbreaking Bark Beetles-Mountain Pine Beetle (MMOBB-MPB)
Jeff Hicke, Polly Buotte and Ken Raffa

12) OPEN SESSION
Monica Gaylord, Forest Health Protection

Opportunities to collaborate with (or receive funding from) the Western Integrated Pest Management Center
Amanda Crump, Matthew Baur and Steve Elliott

To list or not to list? A question regarding possible threatened or endangered insects
James LaBonte

Severe drought and fire alter oleoresin composition and volatile emissions of ecology significant terpenoids in Jeffrey pine, *Pinus jeffreyi*
Jason Maxfield, Lori Nelson, Andy Graves, Steve Seybold and Nancy Grulke

Fungal associates of endemic stage Jeffrey pine beetle, details about their dissemination, and interaction with a common yeast
Javier Mercado, Beatriz Ortiz-Santana, Danielle Francis and Eddyliz Rosado-Camacho

A short history of spruce beetle in Alaska
John Lundquist

Efficacy of emamectin benzoate and propiconazole for protection of California sycamores against polyphagous shot hole borer and its associated fungi
Don Grosman and Akif Eskalen

1715 Meeting adjourns

INITIAL BUSINESS MEETING
27 March 2018

- 108 registrants; attendees from 3 countries, 9 states and 14 universities
  - 2018 WFIWC will likely have <$2,000 loss

- Treasurer
  - WFIWC has sound financial status
  - $25,000 in operating; $66,000 in Memorial Scholarship Fund
    - Memorial Scholarship Fund had a net increase of $1,225.35 in 2017; $625 had already been contributed in 2018 through meeting sponsorships and vendor contributions
  - ~$3,500 loss on Jackson Hole Meeting
  - Tax return filing rules changed in 2013 and a tax return hasn't been required since then because WFIWC gross receipts are <$50,000. Must still file an electronic notification form 990-N annually by May 15.

- Future Meetings
  - 2019: Anchorage, Alaska

- Common Names Committee
  - New members: Rich Hofstetter (2017), Amy Gannon
  - No new submissions

- History Committee
  - New members: Glenn Kohler (2017), Carl Jorgenson
  - Retired member: Sandy Kegley

- Memorial Scholarship Selection Committee
  - 2018 recipient: Sam Farner Ward

- Memorial Scholarship Fundraising Committee
  - Soliciting new members

- Technology Advisory Committee
  - Jordan Burke was unable to attend

- Founder's Award Committee
  - Soliciting a new graduate student member

WFIWC Executive Committee Nominations

Joel Egan opened up the floor for nominations for Chair and two Councilors.

WFIWC Chair
Joel Egan nominated Sky Stephens (USDA Forest Service)

WFIWC Councilor
Robbie Flowers nominated Darcy Dickinson (USDA Forest Service)

WFIWC Councilor
Lorraine MacLauchlan nominated Marnie Duthie-Holt (B.C. Forests, Lands, Natural Resource Operations and Rural Development)

Respectfully submitted by Jason Moan (jason.moan@alaska.gov), Secretary, September 2018

EXECUTIVE COMMITTEE REPORT

Councilor Caroline Whitehouse (Alberta Agriculture and Forestry) was unable to attend.

Topics discussed:

Declines in USDA Forest Service participation associated with budget cuts and meetings management approval processes and restrictions. For example, the 2018 meeting was originally approved for only 8 USDA Forest Service personnel to attend. The Southern Forest Insect Work Conference has been declared “mission operational” (i.e., we need to find out who led that effort and any repercussions).

As Treasurer, Karen Ripley can make financial decisions on behalf of the organization. WFIWC Councilors review and sign off on meeting costs. Amazon Smile may be an option for garnering donations for WFIWC.

The Santa Fe WFIWC Proceedings are still pending.

The 2019 Western Forest Work Conference is scheduled for the week of 22 April 2019 in Anchorage. There are some concerns regarding travel costs.

Respectfully submitted by Jason Moan (jason.moan@alaska.gov), Secretary, September 2018

HISTORY COMMITTEE REPORT

Julie Johnson, Information Specialist R6, has posted on *Flickr* a large number of historical photos related to forest entomology in the Pacific Northwest and California. They appear chronologically beginning in 1902 when the Division of Forest Insect Investigations was created in the USDA Bureau of Entomology. Search categories include personnel, insects, control methods, etc. Photos are accompanied by captions and additional information. The collection consists of photos from the former Portland Station Laboratory collection, now at the Forestry Sciences Lab in La Grande, Oregon, supplemented with subsequent photos from various sources. The photos are grouped 100 per page. They may be accessed at https://www.flickr.com/photos/151887236@N05/. The photos also appear in themed albums at https://www.flickr.com/photos/151887236@N05/albums. Mal Furniss assisted with acquisition of catalogs of photos from the Bureau's California and Portland labs.

A manuscript by Mal Furniss *Battle for old growth ponderosa pine in northeastern California. Efforts to control the western pine beetle in remnant old growth stands ca. 1920s* appeared in the *American Entomologist* in spring 2018 [64(1):16─18]. The photo essay features photos by John Patterson and John Miller from a 1935 album publicizing the killing of old-growth ponderosa pine in northeastern California by the western pine beetle. Early in the last century, logging was extending into this still vast stretch of old-growth pine. Coincidently, the western pine beetle was devastating stands that lay beyond reach of the loggers. The article illustrates the strenuous efforts expended to suppress beetle populations in an attempt to preserve old-growth trees until they could be harvested.

Several hundred historic forest entomology reports that were located in the Coeur d'Alene and Missoula Field Offices and dated 1905─1990s have been scanned. Many were from the Bureau of Entomology and Plant Quarantine in the early decades of the 1900s. Electronic versions are currently being entered into *EndNote*, and will eventually be available in the Forest Health Protection Historical Digital Collection through the National Forest Service Library (https://nfsl.contentdm.oclc.org/digital/collection/p17053coll1/search).

Submitted by Mal Furniss (MalFurniss@turbonet.com) and Sandra Kegley, March 2018.

TREASURER'S REPORT

Account balances:	Checking:	Savings:	CDs:	Total:
January 1, 2017	$ 5,328.77	$ 19,837.03	$ 64,888.74	$ 90,054.54
December 31, 2017	$ 4,429.17	$ 87,276.10		$ 91,705.27
February 28, 2018	$ 4,429.17	$ 87,283.16		$ 91,712.23

	Operating Funds:	Memorial Scholarship Funds
January 1, 2017	$ 25,165.80	$ 64,888.74
December 31, 2017	$ 25,591.18	$ 66,114.09
Change:	$ 425.38	$ 1,225.35

WFIWC has sound financial status. Although interest rates are very low (0.5% on a savings account), we have solid account balances that increased slightly in 2017.

1) The 2017 WFIWC Jackson Hole, WY meeting expenses had a net cost of $3,498.30. WFIWC paid $8,980 in deposits to the Snow King Resort. After settling all the meeting accounts, the Utah State Conference Center service paid us $7,175.70, of which $5,481.70 was operating revenue and $1,694 was Memorial Scholarship Fund revenue.

2) In 2017, the Memorial Scholarship fund had a net increase of $1,225.35. WFIWC awarded a $1,000 scholarship to Erica Eidson and paid $83.50 for her plaque. Earnings to the fund included: $114.85 in interest; $1,194 from the Jackson silent auction; $400 from the Jackson vendor booths; and $600 donated in memory of Boyd Wickman.

3) The estimated expenses for the 2018 Denver WFIWC are about $29,800. There may be a small shortfall, depending on final hotel room bookings and walk-in registration earnings.

4) $625 has already been contributed to the Memorial Scholarship Fund in 2018 through meeting sponsorship and vendor contributions. Other fund raising events are planned. A $1,000 scholarship will be awarded in 2018.

5) The 2010 and 2011 Tax Returns are posted on the WFIWC website. The 2012 Tax Return is also available but has not been posted. Filing requirements changed in 2013 and since then a Tax Return has not been required because our gross receipts are less than $50,000. We file the electronic notification Form 990-N, and have done so since then. The 2017 tax year notification (also 990-N) is due May 15, 2018.

6) The recent banking records, check register and U.S. Tax information are available and will be reviewed by the Councilors.

Submitted by Karen Ripley (klripley@fs.fed.us), March 2018.

FOUNDER'S AWARD COMMITTEE REPORT

It is with great pleasure that the Founder's Award Committee announces the selection of Dr. B. Staffan Lindgren as the 2018 WFIWC Founder's Award recipient. Staffan and his nominator, Ken Raffa, have been notified of his selection. The selection will be announced to the WFIWC membership at this year's meeting in Denver.

The 2017 Founder's Award recipient was Steve Munson who will present his address during the Founder's Award Banquet at the 2018 WFIWC meeting in Denver. Craft Trophy in Ft. Collins, Colorado did an excellent job once again on creating the plaque that will be bestowed to Steve at the meeting. Steve's nominator, Liz Hebertson, will present the plaque to Steve and introduce him at the banquet.

Based on our approved resolution to add a graduate student to the Founder's Award Committee, Stacy Hishinuma accepted an offer to join the Committee in April 2015. Although this is a 2-year term, the term was extended until the spring of 2018 as WFIWC was not held in 2016. The Committee will seek a graduate student replacement for Stacy at the 2018 meeting in Denver. We thank her for serving on the Committee over the last 3 years.

After serving on the Founder's Award Committee for 10 years, Ken Raffa stepped down in 2017. The Committee worked during 2017 to appoint a new member to replace Ken. An offer was extended to Steve Cook, Professor of Entomology at University of Idaho, and he graciously accepted in June 2017. Steve has a long history with WFIWC, and will make an excellent addition to the Committee.

The Committee updated a poster that displays the amazing legacy of the WFIWC Founder's Award, and includes pictures of prior recipients. The poster was presented at the 2017 WFIWC in Jackson, WY and will be on display again this year in Denver. Also on exhibit will be the 2 "traveling" plaques that list all the previous recipients' names.

The Committee received an inquiry as to whether previous Founder's Award recipients could be nominated a second time in order to recognize significant contributions made after they originally received the award. While a second nomination is not prohibited, the Committee feels a better approach would be to explore other ways to honor new contributions of previous recipients. Suggestions include having interested parties present a poster at WFIWC that highlights the recent contributions of a specific past recipient and/or including photographs in the annual photo salon to showcase more recent achievements of past Founder's Award recipients. These suggestions could be communicated to WFIWC members through the WFIWC Founder's Award website and at the WFIWC banquet.

As a reminder, information concerning previous Founder's Award recipients is on the WFIWC website. We acknowledge and appreciate the Technical Committee's assistance in our efforts to update the Founder's Award portion of the WFIWC website (www.wfiwc.org/awards/founders-award), including recording and uploading videos of Founder's Award presentations.

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.

Respectfully,

Joel McMillin
jmcmillin@fs.fed.us
Founder's Award Committee Chair

Committee members: Steve Cook, Stacy Hishinuma, Lorraine Maclauchlan, Bill Riel, Steve Seybold

TECHNICAL ADVISORY COMMITTEE REPORT

Updates of recent activities:

- Recent publications were added to the website, which lists publications from members of the forest entomology community. Jordan Burke updates this regularly, members are free to email submissions to wfiwc.website@gmail.com or to submit them through the site.
- Jason Moan has taken over administration of the list-serve. Any changes requested from members can be emailed to wfiwc.website@gmail.com or to Jason directly.
- Job postings have been mostly emailed to our address directly. Jobs can be submitted through the website without an account, but emailing them to us is also acceptable.
- USDA Forest Service Publications and Resources have been added to the website, with links to some current and historical resources. If anyone has changes or additions, please email them to Jordon Burke. The "USFS FHP R6 Gray Literature Initiative" (http://wfiwc.org/content/usda-forest-service-publications-and-resources) section should get updated, so please email Jordan Burke if there have been additions and if there are hyperlinks we can add.

Respectfully,

Jordan Burke
jordan.burke@ubc.ca
Technical Advisory Committee Chair

MEMORIAL SCHOLARSHIP SELECTION COMMITTEE REPORT

The committee received 4 applications for the 2018 Memorial Scholarship. The committee selected Samuel Fahrner Ward as the 2018 recipient. He is currently a PhD student at the University of Minnesota. His dissertation research is focused on understanding how climate may drive outbreaks of larch casebearer (*Coleophora laricella* Hübner).

Respectfully submitted by Darrell Ross (darrell.ross@oregonstate.edu), September 2018.

MEMORIAL SCHOLARSHIP FUNDRAISING COMMITTEE REPORT

The 2018 Western Forest Insect Work Conference was held in Denver, CO during the week of March 26th. The Silent Auction was held Tuesday, March 27th, in conjunction with the Poster Session. The items were all set up and displayed in the South Convention Lobby. This year, 133 items were donated to the auction by 28 individuals or organizations and 45 individuals purchased items.

Pat Ciesla, Sky Stephens, Liz Hebertson, Danielle Malesky, Amy Chambers, Marianne Davenport, and Liz Graham helped with setup of the auction and collection of money after the event.

Bidding began at 1900 and ended at 2100 with 106 (80%) of the items bid upon during that time. The total amount raised was $998.01. In addition, $213 were given in donations, and $600 were brought in from corporate sponsorships from Arborjet Inc., ISCA Technologies Inc., and Rainbow Treecare, bringing the grand total raised this year to $1,811.01.

The donation that earned the highest bid was the Alder Wood Platter ($50), donated by Pat Werner. Special thanks also to the Ogden Field Office, which donated 55 items, 39 of which sold, bringing in $336. The second highest donation total was $81 from the ten items donated by Synergy Corp.

We are always seeking new fundraising ideas and appreciate any and all suggestions.

A detailed spreadsheet with items, donors, bidders and money collected/item will also be submitted.

Respectfully submitted by Monica Gaylord (monicalgaylord@fs.fed.us), Dan Miller, Andrea Hefty and Sky Stephens, May 2018.

COMMON NAMES COMMITTEE REPORT

As of March 2018, the Common Names Committee (CNC) included 6 members: Beverly Bulaon, Amy Gannon, Rich Hofstetter, Lee Humble, Iral Ragenovich, Lee Pederson, and Co-Chairpersons Brytten Steed and Bill Ciesla. Two of the members; Amy Gannon and Rich Hofstetter, are new since 2017. Bobbie Fitzgibbon, recently retired, is no longer a member.

The CNC portion of the WFIWC website has been updated. Since 2005, a total of 42 common names have been proposed, 36 of which have been accepted by the Entomological Society of America (ESA). All common names proposed since 2005 are on the WFIWC website.

The CNC continues to encourage submission of common names for insects discussed in *Western Forest Insects* that do not have ESA-approved common names. We encourage authors who are revising sections of this publication to submit common names for the insects being revised, as appropriate. Those insects included in *Western Forest Insects* that do not have ESA-approved common names are listed on the Common Names section of the WFIWC website. 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 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 by Brytten Steed (bsteed@fs.fed.us**)** and Bill Ciesla**,** September 2018

FINAL BUSINESS MEETING

29 March 2018

A moment of silence was held to remember former WFIWC members who have passed recently.

Other items of interest not contained in Committee reports:

1) The photo salon winners were announced.

2) All individuals nominated for open Executive Committee positions were seconded and voted in.
   a. New WFIWC Chair: Sky Stephens
   b. New WFIWC Councilor: Darcy Dickinson
   c. New WFIWC Councilor: Marnie Duthie-Holt

3) Location for 2020: Alberta
   a. Caroline Whitehouse serves as the primary contact
   b. There is some concern about difficulties getting there

4) Gina Davis discussed a survey regarding Forest Health Protection (USDA Forest Service) services and publications.

Respectfully submitted by Jason Moan (jason.moan@alaska.gov), Secretary, September 2018

KEYNOTE SPEAKER

Scarab Beetles in Colorado Ecosystems (Coleoptera: Scarabaeoidea)

Frank-Thorsten Krell

Denver Museum of Nature and Science

While Scarab beetles are nowhere close to a focus group for forest entomologists, they are present everywhere in terrestrial habitats where beetles can exist with the exception of extreme environments such as Antarctica. With around 35,000 species worldwide, Scarabaeoidea are one of the largest beetle groups, easily recognizable by the lamellate antennae (antennomeres of the club expanded to 1 side). We found records of 235 species from Colorado with another 59 species from adjacent counties in surrounding states, in such varied groups as dung beetles, flower chafers, or stag beetles. Their feeding habits are equally diverse. Many species are phytophagous, such as June bugs or chafers, others are excrement and carrion feeders, sap and fruit juice lickers, xylosaprophagous species, pollen and flower feeders, and so forth. Some chafers and a few saprophagous dung beetles are considered pests, mainly in urban or agricultural habitats. One of those, the Japanese beetle, *Popillia japonica*, arrived in the Denver area in the 1990s and in the last years has spread over the southern part of the metro area, Boulder, Fort Collins and other cities in Colorado. The enormous population sizes let us assume that this species is here to stay.

From a forest entomology perspective, the most concerning species might be some chafers of the genus *Phyllophaga*, but their damage affects predominantly nurseries rather than forests. A large group of scarab beetles, with 9,800 species world wide and 85 in Colorado, is the dung beetles. Coprophagous scarabs break up and bury large portions of dung, which helps maintain soil quality through fertilization and aeration. They are more prevalent in open habitats, but are present in Colorado forests as well.

Since our knowledge of ecology and distribution of Colorado Scarabaeoidea is far from comprehensive, we started the Colorado Scarab Survey about a decade ago to collect and preserve specimens from all over the state, with the goal of publishing an illustrated book on all Colorado scarab species with distribution maps and as much biological and ecological information as possible. You are all invited to contribute your specimens (with good collection data) to this endeavor. Your help would be greatly appreciated.

KEYNOTE SPEAKER

How a Little Bear Cub Transformed Western Forests

Brian Verhulst

Rocky Mountain National Park

The current condition of western forests has been shaped by man-kinds' fire suppression efforts; one turning point in recent history was the advent of a national icon, Smokey Bear, derived from a cub rescued near Capitan, New Mexico by firefighters in 1950. Smokey Bear became a representative of forest conservation, and the resulting campaign to suppress wildland fire has had a profound effect since the 1960s: the number of wildfires decreased. Meanwhile, the average size of individual fires increased, and the sum total of acres burned annually steadily increased. Research of fire return intervals in Rocky Mountain National Park shows that in forest types that typically burn every 150–200 years (e.g., lodgepole pine), the last recorded fires happened in the late-1700s to early-1900s, approximately 100 to 200 years ago! In the absence of fire disturbance, western forests have become mono-typic, overstocked, even-aged, and disease weakened, and thus lacking size and age class variability forests became susceptible to insect infestations. Insect outbreaks have recently capitalized on stand density, drought stress, species continuity, and mild winter conditions.

While weather and climate trends have had their influence, along with a growing urban interface throughout the West and changes in timber and vegetation management including introduction of non-native vegetation species, perhaps none has been so great as the increasing capacity of man-kind to suppress fires. Fire detection systems spot ignitions, engines carry more water through more rugged terrain, heavy equipment clears vast suppression lines, helicopters and air-tankers deliver water dumps to remote locations, and firefighters suppress fires early and often.

Public land managers are prioritizing response to fire threats to wildland urban interface in the following ways: 1) providing for the safety of employees and the public; 2) protecting communities, infrastructure, and resources with Integrated Pest Management tools such as prescribed fire and mechanical fuels reduction; and 3) restoring fire-adapted ecosystems and improving forest resilience by creating patchwork tree composition and variable forest structure. The National Park Service does this in accordance with our 1916 Mission Statement: "...for the enjoyment, education, and inspiration of this and future generations."

DISTINGUISHED VISITING SPEAKER

Management of Bark Beetles in Germany: A Different Approach?

Horst Delb

Forest Research Institute of Baden-Württemberg

In southwest Germany, the management of bark beetles is a critical task for foresters in order to ensure adequate timber supply. Numerous bark beetle species affect almost every tree species, but due to the distribution and susceptibility of Norway spruce (*Picea abies*) (forest coverage: 34%), European spruce bark beetle (*Ips typographus*), and to some extent the six-toothed spruce bark beetle (*Pityogenes chalcographus*), are most impactful.

Taking the potential natural tree species composition into consideration, Norway spruce is much more widespread today than it was historically. Many forests were converted to Norway spruce as a consequence of forest utilization history due to overexploitation during early industrialization or the so-called "reparation clear-cuttings". This was mainly a result of the availability of inexpensive seeds and seedlings, its tolerance to game browsing, and the anticipated yields of Norway spruce sufficient to meet timber needs. Norway spruce forests are now widely distributed at lower elevations and on other unsuitable sites, and are highly susceptible to storms, snow, drought, pathogens and especially insects (e.g., *Ips typographus*).

Fir engraver beetle (*Pityokteines curvidens*) and small fir bark beetle (*Cryphalus piceae*) are also important in European silver fir (*Abies alba*) (8%), and six-toothed pine bark beetle (*Ips sexdendatus*) and pine shoot beetles (*Tomicus piniperda*, *T. minor*) are important in Scots pine (*Pinus sylvestris*) (6%). In European larch (*Larix decidua*) (2%), the large larch bark beetle (*Ips cembrae*) is an important pest. In comparison to conifers, bark beetles exert little influence in deciduous trees within the region. But regardless of tree species, about the same management strategy is carried out.

Nowadays >90% of sanitation fellings due to insects occur in conifers, particularly Norway spruce. Outbreaks of bark beetles in Germany are predominantly initiated by abiotic disturbances like storms and snow damage followed by warm, dry weather conditions. Subsequently, still healthy standing trees get attacked and killed. *Ips typographus* undergoes 1–3 generations per year in southwest Germany, on average 2 plus up to 2 sibling broods. The rate of the beetle's development is very much dependent on weather and site conditions (i.e., elevation).

Bark beetle management in Germany is based on the principles of integrated pest management according to the German Plant Protection Act, which itself follows the directives of the EU. Prevention is the primary focus. One of the most important decisions initially is the selection of suitable tree species for planting and/or retention, and therefore precise site maps based on soil, climate and topography are developed for public forests and private forest owners taking into consideration future climate scenarios. Besides prevention, our "search and take out" approach is a kind of first-line therapy. Here, inspections of every susceptible forest stand are conducted on a regular and recurrent basis. Breeding material resulting from storm or snow break damage, for instance, as well as currently-infested trees are eliminated from the stand by sanitation or salvage felling. The search for early symptoms of bark beetle attack are boring dust, resin flow and later crown discoloration and woodpecker signs. The stands are checked frequently every week, depending on the course of infestation and weather, over the vegetation period from April to September when the beetles are active. Sanitation cuttings of infested trees aim at removing insects from the forest to prevent them from spreading to nearby trees. This material is removed and transported offsite (>500 m) to sawmills or to wet or dry storages, and is debarked, chipped, milled or burned as soon as possible. As a last resort, insecticides may be used to treat logs stored along forest roads.

Although in many parts of southwest Germany forestry aims at converting inadequate Norway spruce stands to “closer to nature forests”, a certain number of spruce monocultures will remain. After a quick opening of forest stands due to storms, snow breakage or bark beetles, the light demanding and competitive spruces will flourish again. For conversion to more shade tolerant trees (e.g., beech), careful and controlled light management is required. This can only be done without substantial disturbance. Moreover in naturally-mixed stands containing Norway spruce, future bark beetle outbreaks will occur. To secure our basic needs for wood products, it is beyond all question that in commercial forests bark beetle management is required permanently. For that reason, research for optimizing bark beetle management is still conducted at the Forest Research Institute of Baden-Württemberg. Furthermore, a robust group of trained professionals is employed to conduct bark beetle management on 870 forest districts, each 4,000 acres and run by a forester supported by several forest workers. An intensive forest inventory and elaborate forest road system aid in the endeavor.

KEYNOTE SPEAKER

Bark Beetle Outbreaks and Range Expansion: The Effect of Temperature is 365 Days a Year

Katherine Bleiker

Canadian Forest Service

In its historic range west of the Rocky Mountains in British Columbia, temperature has played a key role in regulating mountain pine beetle (*Dendroctonus ponderosae*, MPB) populations. MPB infestations are limited by cold winter temperatures (e.g., -40 °C isotherm) and cool summers where degree days are inadequate for the life cycle to be completed in 1 year (<833 degree days above 5.6°C). Even in benign winter climates like southern British Columbia, winter mortality is often the single largest source of mortality. MPB is subject to a new climate with harsher winters in its recently-invaded range east of the Rocky Mountains in north-central Alberta. Although we know the "-40 °C for 2 weeks will kill them" rule of thumb, there are significant knowledge gaps on the lethal temperature thresholds for different life stages, the effect of cold severity and duration of exposure on mortality, and the conditions that lead to cold acclimation and de-acclimation, which are relevant to predicting early and late season mortality associated with extreme fall/spring weather events. I presented results cautioning against the use of lower lethal temperatures alone (e.g., super-cooling points) to infer cold tolerance as some life stages, such as eggs, are subject to significant pre-freeze mortality and die at temperatures much warmer than their super-cooling points over time. Our results to date indicate that eggs, pupae, and teneral adults are unlikely to survive a typical winter in Canada's boreal forest. Late instar larvae acquire cold tolerance over an extended period of time (~60–70 d), but appear to be the most cold tolerant life stage; however, research on early instar larvae is incomplete. Larvae in northern Alberta are more cold tolerant than larvae from southern British Columbia, indicating a cost associated with cold hardiness.

Temperatures during the growing season are also important because MPB needs to maintain a synchronous, one-year life cycle: survival will be maximized if the most cold tolerant life stage overwinters. We tend to think of central Alberta and Canada's boreal forest as being cold, and they are in the winter; however, temperatures during the growing season in the southern boreal are warm compared to areas of the beetle's traditional range in British Columbia. In some years at some sites in northern Alberta, MPB brood received 40% more thermal sums (degree days) in a year than needed for a one-year life cycle – this could be potentially devastating to the beetle if they develop "too far" (i.e., pupate) before winter. A flight phenology model found that MPB's flight in northern Alberta was synchronous and 2 wk ahead of southern British Columbia. Despite advanced phenology at some sites, most insects maintained an adaptive seasonality, staying in the 4^{th} instar larval stage and entering the winter in this cold hardy stage. I presented evidence that larvae used the experience of 'winter' for a cold period to help regulate their development.

Given the presence of a suitable food source, temperature likely has the largest overall impact on MPB. Weather influences annual population trends and the likelihood of outbreaks, while climate determines the potential distribution over the long term. Understanding the relationship between temperature and MPB will allow us to assess the potential for further range expansion and identify habitats at risk in the future under climate change.

Dr. Frank Krell

Mr. Brian Verhulst

Dr. Horst Delb (left)

Dr. Kathy Bleiker

MEMORIAL SCHOLARSHIP PRESENTATION

Great Basin Bristlecone Pine Resistance to Mountain Pine Beetle

Erika L. Eidson[1], Karen E. Mock[1,2] and Barbara J. Bentz[3]

[1]Wildland Resources Department, Utah State University, [2]Ecology Center, Utah State University, and [3]Rocky Mountain Research Station, USDA Forest Service

The mountain pine beetle (*Dendroctonus ponderosae*, MPB), a native insect herbivore in western North America, can successfully attack and reproduce in most species of *Pinus* throughout its native range. However, successful MPB attacks on Great Basin bristlecone pine (*Pinus longaeva*) are lacking, despite recent climate-driven increases in beetle populations at the high elevations where Great Basin bristlecone pine grows. We evaluated MPB attack preference and offspring performance in Great Basin bristlecone pine to test the preference-performance hypothesis, which predicts that ovipositing phytophagous insects will prefer host plants that are well-suited for their offspring and avoid host plants that do not support offspring performance (survival, development and fitness).

To test attack preference, we used no-choice attack box experiments that confined sets of live MPBs onto tree boles. We placed attack boxes on 36 pairs of living Great Basin bristlecone and limber pines (*P. flexilis*), a well-documented MPB host, and compared beetle activity after 48 hours. To test the role of induced tree defenses in MPB attack preference, we then repeated the tests on 20 paired sections of Great Basin bristlecone and limber pines that had been recently cut, thereby removing their capacity for induced defensive reactions to an attack. Beetles placed on Great Basin bristlecone pine rarely initiated attacks relative to those placed on limber pine in both studies. Our results indicate that MPB has a low attack preference for Great Basin bristlecone pine, even when induced defenses are compromised.

To test MPB offspring performance in Great Basin bristlecone pine, we infested cut bolts of Great Basin bristlecone pine and 2 susceptible host species, limber and lodgepole (*P. contorta*) pines with adult MPBs and compared reproductive success. Although MPBs constructed galleries and laid viable eggs in all 3 tree species, extremely few offspring emerged from Great Basin bristlecone pine. This low offspring performance in Great Basin bristlecone pine corresponds with the low preference documented in the attack box experiments. A low preference-low performance relationship supports the preference-performance hypothesis, and suggests that Great Basin bristlecone pine resistance to MPB is likely to be retained through climate-driven high-elevation MPB outbreaks.

<u>**2017 FOUNDER'S AWARD PRESENTATION**</u>

Feeling Blessed, a Wonderful Career with Colleagues and Friends

Steve Munson

Forest Health Protection, USDA Forest Service

GRADUATE STUDENT SESSION 1

Erika Eidson
Idaho Department of Lands

Tradeoffs between Environmental Tolerance and Pathogenicity of an Entomopathogenic Fungus in the Spruce Beetle Study System

Andrew Mann and Thomas Seth Davis

Department of Forest and Rangeland Stewardship, Colorado State University

Effective application of fungi as biological control agents of insects relies on matching fungal traits to ecological conditions. In this study, 14 isolates of *Beauveria bassiana*, which derived from sources in the Intermountain West, were tested for their ability to grow, persist, and reduce survival of spruce beetle (*Dendroctonus rufipennis*, SB) under a suite of environmental conditions including temperature, nutrients, and 2 previously unstudied environmental factors unique to the SB study system – an array of Engelmann spruce, *Picea engelmannii*, tree defense chemicals and competition with 6 isolates of a SB symbiotic fungus, *Leptographium abietinum*. Using functional trait data gathered through evaluating *Beauveria bassiana* in the SB study system, we addressed 3 questions: (1) Is there evidence for phenotypic variation between *Beauveria bassiana* isolated from sources in the Intermountain West? (2) Do *Beauveria bassiana* isolates vary in their ability reduce SB survival? (3) Do tradeoffs exist between environmental tolerance and pathogenicity?

Thermal thresholds were at 5 °C and 35 °C, while optimal growth occurred between 20 °C and 25 °C for all isolates. Significant differences in growth between the isolates occurred at 15 °C and 30 °C. There were significant differences between isolate growth when exposed to 0.1% terpinolene, 0.1% ß-pinene and 1% 3-carene. *Beauveria bassiana* and *Leptographium abietinum* competed equally well for growing space and each fungus species protected the captured space. Exposure to a nutrient-limited media containing chitin resulted in one strain growing at a statistically significantly faster rate than the rest of the isolates. Median survival time of SBs ranged from 6 to 10 days when introduced to isolates of *Beauveria bassiana*, leading to a statistically significant difference between the *Beauveria bassiana* isolates. Since tradeoffs between fungus growth and virulence were not prevalent we conclude that a 2-isolate formulation which, in combination, is able to tolerate every study system factor tested would be best suited as a mycoinsecticide for control of SB in Colorado.

Evidence of a Higher Percentage of Univoltine Spruce Beetle, *Dendroctonus rufipennis*, Broods at Warmer Sites in Colorado

Isaac Hans Dell and Thomas Seth Davis

Department of Forest and Rangeland Stewardship, Colorado State University

Spruce beetle (*Dendroctonus rufipennis*, SB) was Colorado's most widespread and damaging forest insect for the 6th consecutive year: 1.78 million cumulative acres of spruce have been affected by outbreaks since 1996. To best deal with outbreaks there is a need for understanding population dynamics. Comparing the flight phenologies of populations from sites classified by thermal variability could elucidate these dynamics. For instance, duration of host seeking flight could be of greater duration at warmer sites, which could contribute to worse outbreaks. SB are biologically inactive until temperatures rise above a lower threshold and require thermal accumulation (degree days) to develop. Most undergo a 2-year life cycle entering a diapause and overwintering as 4th instar larvae, however, if temperatures are warm enough, they can undergo a 1-year life cycle (univoltine). The presence of univoltine broods increases the risk of a beetle outbreak or can accelerate the rate of spruce mortality in an established outbreak. Sex ratios and variance in beetle size at sites classified by thermal variability are important indicators of voltinism. Fifteen sites, along a latitudinal gradient, were selected by proximity to 2015–2016 aerial survey polygons of SB-caused mortality of Engelmann spruce. To ensure that temperature loggers were recording and multi-funnel traps (baited with a standard pheromone lure, enhanced for the Rocky Mountains, containing: frontalin, MCOL, and spruce terpenes) were in place before this temperature threshold was passed and beetles began flight, we placed them in the field before 31 March 2017. In our presentation, we addressed the following findings: 1) Sites with SB populations can be classified by thermal variability into colder sites and warmer sites: We ran a hierarchical cluster analysis (Ward's method) based on 7 thermal variables, using bootstrap resampling and found a statistically significance difference between sites with thermal variability. 2) Flight phenology varies between sites classified by thermal variability: Beetles from warmer sites were seeking hosts for over a month (32 days) longer on average than beetles from colder sites. 3) Beetles vary in size and sex ratio between sites classified by thermal variability, consistent with a higher percentage of univoltinism at warmer sites than at colder sites: If beetles from warmer sites, experiencing higher temperatures over a longer period of time, were semivoltine like beetle populations from colder sites, they should be larger due to greater development time. We found that the pronotal widths of beetles from warmer sites were significantly smaller than the pronotal widths of beetles from colder sites. Univoltine beetles are significantly smaller than semivoltine beetles (Hansen and Bentz 2003, Safranyik 2011). The presence of univoltine broods increases the risk of a SB outbreak and accelerates the rate of spruce mortality in an established outbreak. Populations from warmer sites are all in, or next to, counties MOST affected by previously uninfested acres in 2017. Monitoring efforts need to be tailored to the site level, with special attention given to warmer sites with univoltine populations that pose the greatest risk for causing new outbreaks and for increasing the rate of tree mortality in current ones.

Effects of Mite and Temperature Manipulations on Mountain Pine Beetle Associated Fungi

Sneha Vissa and Richard Hofstetter

School of Forestry, Northern Arizona University

The mountain pine beetle (*Dendroctonus ponderosae*, MPB) is an important bark beetle pest in western North America, and is associated with a suite of blue-stain fungi and phoretic mite (Acari) species. Temperature plays an important role in the success of these beetles causing range expansion and population explosions. Here, we explore the effect of increasing temperature on the mite and mite-fungal communities of southwestern populations of the MPB. White pine tree bolts containing mating pairs of MPB from 2 populations (1 from Arizona and 1 from Utah) were placed in a natural field setting in either an ambient cool environment or a warm environment across an elevational gradient in Northern Arizona. Following a full life cycle, emerging beetles were analyzed for mites. Mites were in turn analyzed for potential fungal associations. Six different mite species were found associated with these beetles, 2 of which are known to be mycophagous (*Trichuoropoda* sp. and *Tarsonemus* sp.). The most abundant mite species, *Tarsonemus* sp., also drives differences in mite communities between Arizona and Utah beetle populations. Significantly more mites are found in the cool ambient environment in Utah beetle populations, whereas significantly more mites are found in the warm environment for Arizona beetle populations. Thus, the relative abundance of mites is affected by temperature. Fungi were also found associated with *Tarsonemus* sp. mites, showing morphological differences between warm and cool sites for both populations.

Response of Mountain Pine Beetle to Simulated Climate Change: Results from a Field Reciprocal Translocation Experiment

David Soderberg[1], Karen Mock[1], Richard Hofstetter[2] and Barbara Bentz[3]

[1]Department of Wildland Resources, Utah State University, [2]School of Forestry, Northern Arizona University, and [3]Rocky Mountain Research Station, USDA Forest Service

Understanding how native species will respond to climate change is important for management of future forests. Population persistence depends on dispersal to suitable environments, phenotypic plasticity, and capacity for adaptation. Mountain pine beetle (*Dendroctonus ponderosae*, MPB) has recently responded to a warming climate with range expansion northward and population persistence at high-elevations, although the potential for population expansion southward and future adaptation to changing conditions is unclear. Warming temperatures increase survival and impact generation times in ways which promote synchronous emergence and successful mass attacks on host trees. The duration of MPB life-cycle completion, larval cold tolerance, beetle size, and sex-ratio are proxies for MPB fitness, but the plasticity and speed of adaptive responses of these traits have not been investigated in the field. Moreover, although considerable variability is known to exist in regional adaptation among MPB populations, the plasticity of trait response within different climates is uncertain. We are conducting a reciprocal MPB population translocation experiment in the Coconino National Forest near Flagstaff, Arizona and the Uinta-Wasatch-Cache National Forest near Logan, Utah to simulate changing climate and assess the response of MPB. Preliminary data confirms genetic differences in fitness traits and provides new information on genetic differences between locally adapted Arizona and Utah MPB populations.

GRADUATE STUDENT SESSION 2

Erika Eidson
Idaho Department of Lands

Climate and Vegetation Effects on Ground Arthropod Communities along an Elevational Gradient

Derek Uhey, Richard Hofstetter and Karen Haubensak

School of Forestry, Northern Arizona University

The soil food web governs the most critical ecological processes for terrestrial life; decomposition and primary production. Climate and vegetation are the primary drivers of the soil food web, determining its composition (i.e., what groups of organisms are present). Our study looks at soil food web composition in response to climate and vegetation, using an elevational gradient to proxy their effects to try to understand how soil food web composition may be affected by changes in climate. Soil food web composition can be expressed in 2 ways, taxa diversity (i.e., the assemblage of species present) or functional groups (i.e., the assemblage of detritivores, predators, etc. present). We found that taxa groups show strong elevational patterns, while functional groups remain relatively similar across elevations. To understand the mechanisms behind this, we used structural equation modeling which demonstrated 2 important trends. First, the direct effects of climate far outweigh the indirect effects of climate through vegetation. Second, climate associations with taxa are roughly 3 times greater than with functional groups, and climate and vegetation together explain 10 times the variation in taxa compared to functional groups. These results indicate that climate and vegetation exert stronger effects on taxa compared to functional groups. This reflects observed patterns along the elevational gradient of taxa turnover and consistent functional group abundance. We conclude that while soil food web diversity is threatened by climate change, soil food web function may remain intact.

Assessing Woodpeckers (*Picinae*) as Biological Control Agents of Mountain Pine Beetle in Recently Invaded Habitats

Stanley Wolf Pokorny and Allan Carroll

Department of Forest and Conservation Sciences, University of British Columbia

One of the most dramatic and destructive examples of a native invasive response to recent climate change is the ongoing outbreak and range expansion of mountain pine beetle (*Dendroctonus ponderosae*, MPB). Novel pine hosts in Alberta (naïve lodgepole pine [*Pinus contorta*], jack pine [*Pinus banksiana*] and lodgepole x jack hybrids) have proven to be highly susceptible to mass attacks by epidemic phase MPB populations. However, observations from the native range indicate that in order to persist long term and continue to spread in the expanded outbreak range, MPB will need to establish and maintain endemic phase populations after epidemic source populations have

collapsed. The potential for MPB to successfully transition to and persist in the endemic phase in novel pine habitat is in part dependent on interactions with resident competitor and natural enemy assemblages. Beginning in June 2014, we conducted a series of intensive stand level surveys to describe these assemblages and quantify their ability to affect endemic MPB populations in pine habitats across Alberta. We found that wood-boring beetles (Cerambycidae and Buprestidae) dominated subcortical insect communities in jack pine stands and were rare or absent on lodgepole pine stands. Similarly, we found that sub-cortical insect-infested trees in jack pine stands frequently attracted woodpeckers. This was a rare occurrence in lodgepole pine stands. However, the probability of a woodborer-infested tree being disturbed by a woodpecker was elevated across stand types. Data suggest that, because of increased niche overlap between endemic MPB and wood-boring beetles, woodpeckers may play a relatively more important role in the regulation of sub-outbreak MPB populations in jack pine habitats.

The Light at the End of the Tunnel: Photosensitivity in Developing Mountain Pine Beetle

Debra Wertman[1 (current); 2,3 (former)], Katherine Bleiker[3] and Steve Perlman[2]

[1]Department of Forest and Conservation Sciences, University of British Columbia, [2]Department of Biology, University of Victoria, and [3] Pacific Forestry Centre, Canadian Forest Service

The role of light in the biology of insects living within subcortical tree tissues is under-investigated, presumably due to a belief that the microhabitats of cryptic organisms are aphotic. In this study, we investigated the capacity for extraocular photoreception in immature mountain pine beetle (*Dendroctonus ponderosae*, MPB), which is well-adapted for development beneath the bark of pine trees and is eyeless in the larval stage. We identified light-mediated behavior and opsin gene expression in MPB larvae, as well as an effect of light on the onset of pupation. The larvae displayed negative phototactic behavior, as a greater number of insects selected dark over light microhabitats in phototaxis assays. Long-wavelength opsin transcription was identified in all life stages, including eggs and larvae, indicating that MPB is likely photosensitive throughout its life cycle. Additionally, we detected an effect of light on timing of pupation when MPB were reared under treatment conditions from the egg stage. Our results suggest that photosensitivity contributes to the survival, and potentially the phenology, of immature MPB.

Dispersal of the Emerald Ash Borer Parasitoid *Tetrastichus planipennisi* (Hymenoptera: Eulophidae) Along an Ash Corridor in Western New York

Michael I. Jones[1], Juli R. Gould[2], Melissa L. Warden[2] and Melissa K. Fierke[1]

[1]SUNY, College of Environmental Science and Forestry, and [2]Plant Protection and Quarantine Science and Technology, USDA Animal and Plant Health Inspection Service

Emerald ash borer (*Agrilus planipennis*, EAB) is a highly destructive forest pest and biological control offers a long-term and sustainable management option for controlling this insect. Three larval parasitoids, *Spathius agrili* Yang (Hymenopter: Braconidae), *Tetrastichus planipennisi*

Yang (Eulophidae), and *S. galinae* Belokobylskij and Strazanac, and 1 egg parasitoid, *Oobius agrili* Zhang and Huang (Encrytidae), have been introduced to North America from EAB's native east Asian range. While *T. planipennisi* and *O. agrili* appear to be establishing well and persisting, *S. agrili* has failed to establish in the Northeast. Climate matching suggests the more recently discovered *S. galinae* should be better adapted to northern climates. We established 3 long-term studies to explore the ecology and management of EAB and its introduced parasitoids in the Northeast.

The first study we conducted was to determine dispersal capabilities of the parasitoids. In 2013 and 2014, we released *S. agrili*, *T. planipennisi*, and *O. agrili* on an ash (*Fraxinus* spp.) corridor along which EAB was still dispersing. From 2013 to 2017, we deployed yellow pan traps to detect dispersal along the corridor and collected ash health data at each trap location. In 2016, additional traps were established parallel to the study area to detect dispersal away from the corridor. EAB was recovered in traps each year of the study and severity of ash decline aligned with EAB trap detections to indicate progression of the infestation. *Tetrastichus planipennisi* was first recovered in 2014 and trap catches increased each subsequent year of the study. The other parasitoid species were not recovered. In 2016, *T. planipennisi* was detected ~10 km from release points, had caught up to EAB populations at the leading edge of the infestation, and was detected in traps ~3.9 km away from the corridor. By 2017, *T. planipennisi* was well established across the entire study area.

The second study was established to document phenology of the larval parasitoids in the Northeast to determine if asynchrony between parasitoids and EAB development or climate could have an impact on establishment and persistence. We established phenology studies at 3 scales in Syracuse, NY (growth chambers, an open-air insectary, and caged trees in the field) for 3 years. Insectary and growth chamber studies indicated *S. galinae* and *T. planipennisi* were well-adapted as both species started emerging before EAB, suggesting they can take advantage of EAB developing with 2-year life cycles, and they completed multiple generations in 1 season. Field studies also suggested both species are well adapted to fall temperatures in the Northeast and could reach overwintering stages even when eggs were oviposited later in the fall as temperatures began to decrease. On the other hand, *S. agrili*, emerged after EAB, partially completed only 1 generation each season, and had difficulty overwintering. This parasitoid is from a more southern range of China compared to *T. planipennisi* and *S. galiane*, and appears to be asynchronous with both EAB development and climate in the Northeast.

The final study incorporated the principles of integrated pest management to determine if biological control parasitoids could replace the use of insecticides to protect high-value ash trees in the urban environment once EAB populations began to collapse. In 2015, 2 plots were established in the city of Syracuse urban forest, where high-value ash trees had been treated with insecticides since 2013. Two plots were established within the area where trees were being treated. In a natural infested area of 1 plot, *T. planipennisi* and *O. agrili* were released and in 2015 and 2016, and *S. galinae* was released in 2017. Yellow pan traps were deployed and branch samples were collected from each plot to monitor for dispersal and establishment of parasitoids. Ash health data were collected on a set of treated and untreated trees. To date, treated trees have remained relatively healthy, while untreated trees are becoming increasingly more infested. Additionally, *T. planipennisi* has dispersed and established in both plots. The next step of the study will be to stop treatment of a subset of trees within each plot to determine if established parasitoids can protect vulnerable high-value trees from EAB.

Results from these studies suggest the introduced parasitoids, in particular *T. planipennisi* and the recently discovered *S. galinae*, are highly capable of establishing and persisting in the Northeast. Once established, they quickly disperse. These studies also suggest these parasitoids will be important biological control agents of EAB in northern North American climates.

CONCURRENT SESSION 1

SPRUCE BEETLE IMPACTS ON HIGH ELEVATION FORESTS

Seth Davis
Colorado State University

Recent Advances in Spruce Beetle Semiochemical Repellents

E. Matthew Hansen

Rocky Mountain Research Station, USDA Forest Service

MCH and multiple novel semiochemicals have been recently tested as spruce beetle (*Dendroctonus rufipennis*, SB) repellents in trapping bioassays and as protectants in single tree and area trials. MCH has long been known as a SB repellent but has failed in most tree protection trials. A new release device has about twice the active load and release rate compared to the industry standard. Meanwhile, novel semiochemical repellents were identified in trapping bioassays and later tested with MCH to protect live spruce from SB attack. The most successful of these was a combination of MCH and AKB (Acer kairomone blend). Over 2 years of testing, 4/52 MCH+AKB treated, baited trees were mass-attacked compared to 42/52 bait-only trees. In area protection trials, MCH alone reduced the probability of SB attack by about 50% while MCH+AKB reduced the probability of infestation by almost 75%. Testing will continue in 2018 focusing on dose and the addition of sulcatone, which was previously identified as a repellent in trapping bioassays.

Carbon Biomass as Metric for Assessing the Impacts of Spruce Beetle across Spatial and Temporal Scales

Jesse L. Morris

Department of Geography, Weber State University

Long-term vegetation and disturbance histories, such as those produced from lake sediment cores, are useful for characterizing recent events in the context of longer term dynamics. Paleoenvironmental data from 6 lake sediment cores collected in southern Utah are discussed here. The pollen records from 2 lakes located on the Wasatch Plateau, Emerald Lake and Blue Lake, are integrated with forest demographic data and historical records to better understand the dynamics and potential interactions of natural (beetles, wildfire) and anthropogenic (logging) disturbances. These reconstructions of environmental change are discussed over the last 10,000 years, with emphasis on the post-settle era (1850 CE to present). The Emerald and Blue Lake records together show that during the last 10,000 years, the subalpine forests of southern Utah have been compositionally dominated by Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*), along with common understory taxa, such as sagebrush (*Artemisia* spp.) and grass

(Poaceae), that are broadly similar to modern subalpine vegetation communities in the region. Beginning in mid-1800s CE, the Emerald Lake and Blue Lake records show that ecosystem modification occurred from anthropogenic activities, including logging and grazing. The resulting forest structure and compositional homogeneity appear to be unprecedented elsewhere in the 10,000-year record. To what degree the legacy of the 1850 CE logging event influenced the landscape-level susceptibility to a severe spruce beetle (*Dendroctonus rufipennis*) outbreak during the 1980–90s CE is an important question in Utah, as well as in other locations throughout western North America that were settled during the 19th century and have also experienced severe bark beetle outbreaks in recent decades.

What is Happening to the Engelmann Spruce-Subalpine Fir Type?

Danielle Malesky and Liz Hebertson

Forest Health Protection, USDA Forest Service

Presenters offered background information on current status, trends and management case studies in the Engelmann spruce-subalpine fir type in Region 4. Regional Forest Inventory and Analysis (FIA) data evaluations illustrated number of growing stock trees by ownership (FIADB 2016, Miles 2016). National Forest System lands in Region 4 hold the most amount of this type, with the majority of true fir represented in older and denser stands (FIADB 2016, Miles 2016). In order to demonstrate current status of the type, we complied aerial detection survey data spanning the past 15 years to display major agents impacting this forest type. Presenters developed a cumulative mortality map showing spruce beetle (*Dendroctonus rufipennis*) impacts from 1990–2015 (Egan et al. 2018). Agents such as balsam woolly adelgid (*Adelges piceae*), spruce beetle, and subalpine fir mortality complex continue to threaten Engelmann spruce-subalpine fir forests in Region 4. Presenters shared management case studies that showcased difficulties and worthwhile considerations when developing management strategies for this forest type.

**Due to discussion, Sarah Hart and Seth Davis did not share their formal presentations.*

INVASIVE FOREST INSECTS

Jordan Burke and **Stan Pokorny**
University of British Columbia

The Walnut Twig Beetle: An Endemic Invader in North America and a Threat to Global Walnut Resources

Jackson P. Audley[1], Richard M. Bostock[2] and Steven J. Seybold[3]

[1]Department of Entomology and Nematology, University of California, Davis, [2]Department of Plant Pathology, University of California, Davis, and [3]Pacific Southwest Research Station, USDA Forest Service

This presentation gave an overview of the walnut twig beetle (WTB), *Pityophthorus juglandis* Blackman, and its role in the insect-pathogen complex known as thousand cankers disease (TCD). As WTB adults enter the phloem of host walnut, *Juglans* spp., or wingnut, *Pterocarya* spp., the spores of a pathogenic fungus, *Geosmithia morbida*, are introduced to the phloem tissue, causing a localized necrotic zone surrounding the WTB gallery system. Multiple necrotic lesions cause a relatively slow, progressive crown decline of host trees. Both organisms are native to the southwestern U.S., associated with Arizona walnut, *Juglans major*; however, in recent decades, the beetle and pathogen have been introduced into new sites and new hosts throughout the U.S., likely *via* the movement of infested wood. WTB has been collected from 128 counties across 16 states. The beetle and pathogen are also recently established in northern Italy, marking the first international occurrence of this invasive complex. As a result of the recently expanded range, WTB and TCD currently threaten North America's walnut resources. The edible nut industry in California, the black walnut timber industry in the eastern U.S., local municipalities and private land owners with walnut landscaping trees, and native stands of riparian forests are all likely to incur significant damage and losses as a result of TCD. Global walnut resources are also threatened by potential introductions of the beetle and pathogen to new sites beyond the U.S. and Italy. Management options for WTB/TCD are limited to monitoring for the beetle with a pheromone lure and phytosanitation of infested trees. We believe there is potential for successful implementation of semiochemical interruption of WTB host searching/selection behavior to protect walnut trees from attack.

Native Invasives? Southern Pine Beetle Moves Northward

Carissa Aoki[1], Jeffrey Lombardo[2], Kevin Dodds[3], Lynn Fleming[4] and Matt Ayres[1]

[1]Dartmouth College, [2]St. Mary's College of Maryland, 3Forest Health Protection, USDA Forest Service, and [4]New Jersey State Forestry Service

No abstract received

Host Mediated Invasion Dynamics of Beech Scale (*Cryptococcus fagisuga*) in American Beech

Devin Goodsman[1] and Jonathan Cale[2]

[1]Los Alamos National Laboratory, and [2]Department of Renewable Resources, University of Alberta

Beech scale (*Cryptoccocus fagisuga* Lindinger) is an invasive insect that serves as a predisposing factor for beech bark disease, resulting in widespread mortality of American beech trees where the insect has invaded in eastern North America. The *C. fagisuga* invasion front has advanced at a rate of approximately 15 km per year after its introduction in Nova Scotia, Canada in the late 19th century. This is a surprisingly rapid rate of spread given that all stages of the *C. fagisuga* life cycle are wingless. Prior research has suggested that beech scale dispersal is driven by wind and updrafts or turbulence that pull a small proportion of individuals above the forest canopy where wind speeds are much higher than below the canopy. We will present a simple model to demonstrate that under this type of dispersal, with realistic, physics-based parameters, a small subset of individuals could disperse >15 km from a heavily infested tree. Although this is a first requirement to explain the rapid invasion rate of this species, a full explanation requires incorporation of the prolific rate of reproduction of this species to produce enough individuals such that some are able to travel long-distances in spite of the low probabilities of long distance dispersal.

CONCURRENT SESSION 2

NEW TOOLS AND APPROACHES FOR LARGE-SCALE INSECT AND DISEASE ASSESSMENTS

Robbie Flowers and **Andy Graves**
Forest Health Protection, USDA Forest Service

Using Landscape-Scale Susceptibility Data to Support Mountain Pine Beetle Risk Assessments

Joel M Egan[1], John Withrow[2] and Jose Negrón[3]

[1]Forest Health Protection, USDA Forest Service, [2]Forest Health Applied Science & Technology Team, USDA Forest Service, and [3]Rocky Mountain Research Station, USDA Forest Service

Definitions of hazard and risk related to bark beetle-attack in the field of forest entomology are often used synonymously. For this work, hazard refers to the level of susceptibility or resistance to beetle-attack and indicates the potential for various severities of tree mortality. Risk refers to the probability of outbreak occurrence multiplied by the degree of hazard. Risk assessments are valuable tools to prioritize management treatments to reduce forest susceptibility to bark beetle-attack. Past assessments typically use the proximity to known beetle source populations to determine the probability of outbreak occurrence. Our work investigated whether the abundance of susceptibility pine host could be used as a proxy for beetle populations to determine landscape-level risk to mountain pine beetles (*Dendroctonus ponderosae*, MPB) within the Northern Region during a period of beneficial climate. Specifically, our objectives were to: 1) validate a landscape-scale MPB hazard rating product for further use as a proxy for beetle pressure; and 2) model the risk of a severe MPB outbreak occurring within subwatersheds (HUC-12) across the Northern Region.

First, MPB susceptibility data estimated by the National Insect and Disease Forest Risk Assessment (2002-vintage) were used to predict response of cumulative aerial detection survey data for MPB (1999–2015) within Northern Region subwatersheds. Data were scaled to respective susceptibility-weighted and severity-weighted area totals. Results from simple regression modeling identified a significant positive, linear relationship between variables ($r^2 = 0.43$). Spatial autocorrelation was identified with a 53 km distance to independence. Geographically weighted regression modeling adjusted for spatial covariance and identified significant association between variables across 89% of the Northern Region's subwatersheds. Thus, National Insect and Disease Forest Risk Assessment susceptibility data for MPB pine hosts in the Northern Region were validated. A logistic regression model was then built to identify the risk of a severe MPB outbreak (defined as $\geq$1000 severity-weighted acres) based on each subwatershed's susceptibility-weighted area. Data were portioned into a training (75%) and testing datasets (25%) which facilitated model cross-validation that yielded a correct classification accuracy of 84%. A similar model with percent of subwatershed containing susceptible host as predictor indicated severe outbreak is when $\geq$26% of the subwatershed had highly susceptible host.

Landscape-Level Forest Insect and Disease Assessments Using Aerial Detection Surveys and State-and-Transition Models

Andrew D. Graves[1], Daniel E. Ryerson[1], Priya C. Shahani[2] and Tom W. Coleman[1]

[1]Forest Health Protection, USDA Forest Service, and [2]Ecosystem Management Coordination Staff, USDA Forest Service

Current land management goals in frequent-fire forests in the Southwest include restoring the landscape to historical or reference conditions. The objective of ecologically-based restoration is to reestablish and retain biodiversity, ecosystem health and productivity, ecological function, and resiliency. Forest land managers are asking for landscape-level approaches for analyzing the effects of insects and disease under different management scenarios. Data are available to give insight to managers from aerial detection survey, growth and yield models, and knowledge of how forests can change states under different scenarios. In the Southwestern Region, 20 years of aerial detection survey data were used to determine the frequency of state changes that might be expected over various time scales. We applied the state-and-transition models to current conditions and desired conditions (as defined by the Forest) for the ponderosa pine forest and dry mixed-conifer types for a specific project area on the Lincoln National Forest in southeastern New Mexico. The goal of the treatment project is to restore forest health on an approximately 140,000 acre planning area in the southern Sacramento Mountains. The project is designed to meet restoration objectives at a landscape-scale, primarily in mixed-conifer and ponderosa pine forest. Prominent forest insects throughout this area include these bark beetle species: western pine beetle (*Dendroctonus brevicomis)*, roundheaded pine beetle (*D. adjunctus*), pine engravers (*Ips* spp.), Douglas-fir beetle (*D. pseudotsugae*); and these defoliator species: western spruce budworm (*Choristoneura occidentalis*), Douglas-fir tussock moth (*Orgyia pseudotsugata*), and at least 2 species of geometrid moths, or loopers. In addition, dwarf mistletoe infection in ponderosa pine is common throughout the project area with an estimated 70% of the ponderosa pine type infected.

From this modeling we wanted to know a) how insects and disease drove forest change, b) the frequency and scale of disturbance, c) the likelihood of insect and disease disturbance, d) and resulting changes. Tentatively, we found that using historical aerial detection survey in combination with knowledge of specific insect and disease effects can better inform landscape level analyses. In the ponderosa pine type under both a no management scenario and the proposed scenario, the models predicted a state change frequency of 1.1%. In the dry mixed-conifer type under a no management scenario the models predicted a state change frequency of 0.88%. Under the proposed scenario, the state change frequency in the dry mixed-conifer decreased slightly to 0.82%. While the acres of state change were quite similar between no management and the proposed actions, the states that were affected and how they changed were different. One area that needs to be further investigated is ensuring probabilities derived through aerial detection survey data and within the state change classifications are complimentary and not over-reducing the probabilities. Additionally, initial efforts focused on mortality agents within the aerial survey data set.

New Tools and Landscape Insect and Disease Assessments: Examples from California

Sheri Smith, Danny Cluck, Meghan Woods, and Andrea Hefty

Forest Health Protection, USDA Forest Service

Priority Stand Treat Analysis (D. Cluck and M. Woods): The recent drought-induced tree mortality event as well as the increase in high-severity fire in California have highlighted declining forest health conditions and reinforced the urgency for conducting preventive landscape level tree density and fuels reduction treatments. At the same time, limited resources are reducing the ability of land managers to address most at-risk acres. Land managers must be able to prioritize areas of highest risk that are also conducive to project implementation. Projects must address forest health issues but also be cost-effective, which generally means ground-based mechanical thinning treatments that produce forest products such as sawlogs and biomass. To address the need for identifying priority areas, Forest Health Protection analyzed existing GIS data to highlight acres that met specific criteria. This analysis was developed to assist National Forests in identifying areas considered most at risk to high levels of bark beetle-caused tree mortality, are accessible, and appropriate for thinning. The analysis used a variety of readily available corporate data sets, as well as data sets specific to Forests. Outputs included a series of maps and datasets. Priority locations for thinning were identified using existing GIS data including USDA-FS Region 5 Existing Vegetation, stand density index, size class (generally a large tree component), historic vegetation, tree mortality, fire history, land ownership, plantations, areas (commercial and/or pre-commercial) thinned since 1995, average annual precipitation, slope, protected activity centers (spotted owl habitat) and wilderness, wild and scenic and roadless areas. Results were summarized into analysis groups by high risk vegetation type and annual precipitation amount. Products are being used by National Forests to develop 5-year plans of work to meet restoration and resiliency goals, and to identify cross-boundary opportunities to increase acres treated.

Risk of Invasive Shot Hole Borers to National Forest Lands in Southern CA (A. Hefty):
The polyphagous (PSHB) and Kuroshio (KSHB) shot hole borers, *Euwallacea* nr. *fornicatus* spp., and fungal species of *Fusarium*, *Graphium*, and *Paracremonium* spp., are insect-disease complexes in southern California. The closely-related beetles are now referred to collectively as invasive shot hole borers (ISHB), but are considered to be genetically distinct with independent invasions into the Los Angeles Basin in 2003 and San Diego County in 2012. These invasive beetles have caused widespread mortality of urban landscape trees, both in parks and on roadsides, and in riparian forests in natural areas.

A forest-wide risk assessment was completed for the Cleveland National Forest (CNF) to help determine areas most at risk to invasion by ISHB using arrival potential, potential to establish, and spread potential as the factors examined in detail. One of the objectives of the assessment is to target survey and detection work to areas most at risk as funding and forest personnel are limited. Initially, a forest-wide GIS exercise was conducted to determine where the riparian areas were located which had ISHB host species. Additional analyses were conducted to determine host density and distribution (continuous vs. patchy), and distance to the closest known infested area. Through these analyses it was determined that there were 67 intersecting vegetation types in riparian areas, 12 of these included ISHB host species. Of these 12 riparian areas, 8 were <10 miles from a known infestation (priority area for monitoring given high likelihood of introduction and establishment). In total, 6,000 acres of riparian forest were determined to be at risk of ISHB infestation. Forest Health Protection is working with Forest/District staff to develop and implement a survey and detection program and incorporate other important information into the risk assessment such as identifying high-value wildlife habitat areas (some riparian areas on the CNF are critical habitat for migratory songbirds) and determining other ecological, social and economic impacts associated with the anticipated invasion.

California Climate Investments (CCI) (S. Smith): The Global Warming Solutions Act of 2006, or Assembly Bill 32, grants the California Air Resources Board (CARB) the authority to regulate and reduce CA greenhouse gas emissions. One of the measures within AB-32 is the Cap–and-Trade Program, which allows CARB to cap the emissions from power generators, large industrial facilities, and distributors of transportation, natural gas, and other fuels. Within each sector's cap, a certain number of allowances are given to the industry for free, and a certain number sold, with revenues going back to the State. With the renewal of Cap-and-Trade in 2017, this program and these revenues will be a significant recurring funding source through 2030. These funds present an enormous opportunity to increase pace and scale of forest restoration treatments across all lands in California.

CALFIRE administers the Forest Health program and associated CCI funding. Eligible activities under pest management must address pest control, related forest health improvement, reducing pest-related tree mortality, improving tree growth, stabilizing carbon retained in trees, and increasing forest resilience. Activities may include forest thinning, and/or brush removal. Forest thinning activities should result in changing stand structure to increase carbon storage in more widely-spaced trees that are more resistant to wildfire, drought, and insect attacks. Harvesting activities need to focus on removing dead, diseased, stagnant or slow-growing trees for the purpose of promoting carbon storage in remaining trees and must be compatible with achieving resilient forests with stable carbon storage and co-benefits such as fish and wildlife habitat, increased biodiversity and wildlife adaptation to climate change.

The Forest Service can apply directly for these funds – salary and NEPA costs can be included. In 2017, the Forest Service directly or indirectly (through partners) submitted 7 forest health concept proposals, with 5 being invited to submit full applications, and 3 ultimately being awarded (maps of analyses and treatment areas were shown during the presentation), for about $11m total. The 2018–2019 spending plan includes $160 million for forest improvement, fire prevention, and fuel reduction projects. Projects can also have a research component. Fifteen projects (by NFS or with NFS partners) were submitted as concept proposals totaling $145 million. Final election of 2018/2019 projects is ongoing.

New Landscape Departure Assessments to Support Insect and Disease Analyses

Mike Simpson

Forest Health Protection, USDA Forest Service

Landscape Ecology is the study of landscape patterns, interactions among the elements of these patterns (species composition, size/structure of the vegetation, density, disturbance regime, and site productivity), pattern and interaction change through time, and the effect of spatial heterogeneity on the element interactions. Typical landscape assessments in the Pacific Northwest are stratified by potential vegetation type to account for differences in stockability, development rates, and disturbance regimes. They compare current vegetation conditions to reference vegetative conditions and highlight conditions that are more abundant and less abundant in the current landscape than in the reference landscape. Insect and Disease risk analyses derived from landscape assessments usually focus on which Insect and Disease vectors are important agents of change in over-abundant conditions in the current landscape. The Insect and Disease species that have the ability to change seral/structural stages in vegetation classes that are over-abundant on the landscape are highlighted, because they can have impacts that are more extensive and with greater mortality than in the historic conditions.

Landscape assessments for effective Insect and Disease analyses require species composition, size class/structure, density (BA, SDI and cover), and productivity (PVT, BPS) elements to assess insect and disease mortality risk by agent. Disturbance frequency and severity are needed to help frame the HRV or NRV ranges for each vegetation class. The minimum assessment area to compare current conditions to historic reference conditions is 5–10 times the average stand replacement disturbance. For mixed and stand replacement disturbance regimes this often means an area of 50,000–100,000 acres and could be much larger in areas with infrequent large scale disturbances. If the assessment area is smaller than the typical replacement disturbance size, any state class could be 0–100% and the comparison to historic conditions is not informative.

Data sources for input layers needed for the assessments including potential vegetation, reference/historic vegetation conditions, and current vegetation conditions useful at the landscape scale were discussed. Although there are ground based sampling methods that could be utilized to create current vegetation, the scale of the landscape assessments and the diverse ownership patterns in the landscapes usually make a complete ground based sample unfeasible due to time and funding constraints. This reality leaves some method of remote sensing as the only practical solution to populate the current vegetation classes on the landscape of interest. I highlighted 2 different types of remote sensing widely available in Oregon and Washington; Gradient Nearest Neighbor Imputation and Lidar. I introduced plot based and individual tree based Lidar derived datasets including snag delineation and crown heath ratings. Example assessments from Thomas Creek on the Fremont-Winema National Forest and Walton Lake on the Ochoco National Forest, which utilized Lidar derived current vegetation layers, were presented.

POLLINATORS ACROSS FORESTED LANDSCAPES

Lisa Mason
Colorado State University and Colorado State Forest Service

Influences of Douglas-fir Beetle (*Dendroctonus pseudotsugae*) and Habitat Structure on Bee Communities Within Douglas-fir (*Pseudotsuga menziesii*) Forests of Idaho

Gabriel G. Foote[1], Christopher J. Fettig[2], Justin B. Runyon[3], Darrell W. Ross[1], Tom W. Coleman[4], Monica L. Gaylord[4], Andrew D. Graves[4], Laura L. Lowrey[4], Joel D. McMillin[4], Leif A. Mortenson[2] and Agenor Mafra-Neto[5]

[1]Oregon State University, [2]Pacific Southwest Research Station, USDA Forest Service, [3]Rocky Mountain Research Station, USDA Forest Service, [4]Forest Health Protection, USDA Forest Service, and [5]ISCA Technologies Inc.

Douglas-fir beetle (*Dendroctonus pseudotsugae*, DFB) is the most damaging pest of Douglas-fir throughout North America. DFB infestations are managed successfully using the beetle's anti-aggregation pheromone, 3-methylcyclohex-2-en-1-one (MCH), in commercial formulations to protect thousands of hectares of trees annually. Despite its widespread use, the potential non-target effects of MCH on other forest-dwelling insect groups, including bees, remain unknown. Wild bees provide essential pollination services to the majority of forb and shrub species in forests throughout North America. However, certain methylcyclohexanones have been shown to repel bees. In the summer of 2016 we collected bees using blue vane and yellow bowl traps from plots in a Douglas-fir forest near Boise, Idaho to address the following research questions: first, does MCH exhibit a repellent effect towards forest-associated bees? And second, how does habitat structure affect bee community composition in Douglas-fir forests? Analysis of variance tests and multiple logistic regression models indicated that 1) trap collections within MCH-treated plots did not differ in overall bee abundance, richness, or diversity compared to untreated control plots; 2) across the study site, bees were more abundant and diverse in areas with lower basal area and higher flower abundance; and 3) variation in bee abundance and species richness within individual bee families was related to additional habitat variables; bees in Andrenidae, Apidae, and Megachilidae were more abundant and diverse in areas with reduced canopy closure, needle litter depth, soil organic matter content, and increased flower species richness. Our results suggest that MCH exhibits no repellency effect toward bees in areas treated for DFB. Furthermore, our findings are consistent with other studies showing bees to be more abundant and diverse in forests with reduced canopies and more abundant floral resources. However, these other studies are generally limited to forests in the eastern U.S. and have focused primarily on the effects of forest management practices (i.e., thinning and harvesting) and do not account for landscape-altering natural disturbance events (e.g., drought, wildfire, pathogen and pest outbreak), which are occurring with higher frequency and increasing severity throughout much of western North America. Future efforts aimed at determining the outcomes of natural disturbance events on forest pollinators could have important implications for predicting changes in their community compositions and associated ecosystem services.

Effects of Fire and Vegetation on Population Dynamics of Pawnee Montane Skippers (*Hesperia leonardus montana*)

John Sovell

Colorado Natural Heritage Program, Colorado State University

The Pawnee montane skipper (*Hesperia leonardus montana*) is a butterfly within the *leonardus* complex consisting of three subspecies distributed from the east coast of the U.S., north of the Carolina's, to the Rocky Mountain Front. Distribution of the Pawnee montane skipper subspecies is limited to an area of approximately 40 square miles in the ponderosa pine-dominated foothills of the South Platte River Valley near Deckers, Colorado. The Pawnee montane skipper occurs with its congener, the Western branded skipper (*Hesperia colorado*) and within close proximity to populations of its sister species, the Pawnee skipper (*Hesperia leonardus pawnee*). Recent genetic analysis has identified that the Pawnee montane and Western branded skippers are distinct species while genetic analysis of the Pawnee montane and Pawnee skippers is currently ongoing. Currently there are 10,000 to 60,000 Pawnee montane skippers estimated within their distribution while estimates were as low as 1,000 individuals as recently as 2002, when severe drought and Colorado's Hayman Fire dramatically affected the butterfly's habitat in the South Platte River Valley. The effects of the Hayman fire and three previous fires dating to 1996 have burned approximately 50% of the butterfly's habitat, dramatically influencing population dynamics of the butterfly. Our research has identified that populations of the flower dotted gayfeather (*Liatris punctata*), the butterflies primary nectar resource that is closely correlated with growing season precipitation; tree density; and burn status are important determinants of Pawnee montane skipper density. Areas that have suffered catastrophic wildfire are no longer suitable habitat for the butterfly as also are areas of ponderosa pine forest within the valley that have become unnaturally dense after 100 years or more of fire suppression. To support populations of the butterfly, forest thinning to protect against fire within the butterfly's distribution should create a heterogeneous tree distribution with small openings (0.1–0.25 acres in size) in the overstory canopy and an age class distribution including both smaller and larger trees. Tree basal area should average <60 feet^2/acre with an average canopy cover of <35%.

Urban Bee Diversity and Abundance Monitoring Using Citizen Science

Lisa Mason

Colorado State University and Colorado State Forest Service

This study determined the efficacy of citizen science protocols for monitoring of bee diversity, and compared bee diversity in public gardens located in the inner-city and in natural areas in the City of Fort Collins, Colorado. Citizen science provides a variety of benefits including reduced research costs, increased efficiency of personnel and resource use, and increased opportunities to connect people to nature, facilitating habitat protection and pollinator conservation. In 2016, 22 citizen scientists were recruited and trained to identify bees in three gardens, working closely with trained researchers to ensure accuracy. They also collected plant names and tallied floral resources while monitoring. Researchers replicated the citizen scientists' activities on different days, creating two different data sets. In 2017, the same study was repeated with 25 citizen scientists. Returning volunteers improved their bee identification skills and helped new volunteers monitor. Researchers repeated the same methods. Including citizen science volunteers proved to be an effective method to collect data as indicated by the congruency of the citizen science and researcher data sets. Both 2016 and 2017 had high correlation rates between the citizen science and researcher data sets. We conclude that investing sufficient time training volunteers ensures accuracy of data collected by citizen scientists.

CONCURRENT SESSION 3

DEFOLIATORS ON THE MOVE: CHANGES IN DISTRIBUTION, HOST AND CONTROL METHODS

Caroline Whitehouse[1] and **Samuel Farhrner**[2]
[1]Alberta Agriculture and Forestry and [2]University of Montana

In the Pursuit of Synchrony: Northward Shifts in Western Spruce Budworm Outbreaks in a Warming Environment

Allan L. Carroll and Amberly R. Marciniak

Department of Forest and Conservation Sciences, University of British Columbia

We analyzed the distribution of western spruce budworm (*Choristoneura freeman*, WSB) infestation centers in British Columbia from 1967 to 2011 to assess the observation that outbreaks were occurring further north than in the past. There was a significant shift in infestations towards higher latitudes and elevations. We then tested the prediction that this shift was a result of a climate change-induced change in optimal synchrony between springtime larval emergence and Douglas-fir budburst since WSB is dependent upon access to newly flushed foliage. We simulated the dates of first larval emergence and budburst annually from 1901 to 2011 using phenology models and long-term weather data. The mean difference in dates at higher latitudes and elevations has converged towards optimal synchrony over the last century, while lower latitudes show divergence from optimal synchrony.

Evaluating Gypsy Moth Larval Movement Potential and Effective Barriers Limiting Their Movement

Jake T. Wittman[1], P.H. Chaloux[2], S.W. Myers[3] and Brian H. Aukema[1]

[1]Department of Entomology, University of Minnesota, [2]USDA – APHIS, Riverdale, MD, and [3]USDA – APHIS, Buzzards Bay, MA

Gypsy moths (*Lymantria dispar*, GM) are an invasive forest pest in North America, first introduced in the 1860s. Since the introduction of the moth in Massachusetts, it has spread west to Minnesota, north into Canada, and south into Virginia. GM is an irruptive forest pest that can feed on over 300 species of plants and cause extensive defoliation during outbreaks. To slow the spread of the GM, federal and state quarantines exist that limit the movement of regulated products, as much of the spread of GM is due to human-assisted movement of their egg masses. Industries that stage regulated products outside are required to sign compliance agreements, which require them to stage their products in a 100-foot buffer zone free of any surrounding vegetation. We studied the movement behavior and capabilities of late instar GM larvae in the buffer zone environment to evaluate the effectiveness of this practice in preventing larvae from pupating, emerging, and

laying eggs on these products. Our field data was used to parametrize a Monte Carlo simulation model to explore how changing the size of the buffer zone affected its efficacy.

Characterization of Western Spruce Budworm Outbreaks in Interior British Columbia - An Ecological Shift

Lorraine Maclauchlan[1] and Lori Daniels[2]

[1]B.C. Forests, Lands, Natural Resource Operations and Rural Development, and [2]Department of Forest and Conservation Sciences, University of British Columbia

The western spruce budworm (*Choristoneura freeman*, WSB) shapes Douglas-fir forests throughout western North America with periodic, severe landscape-level defoliation events. The largest and most continuous recorded defoliation in B.C. occurred in the 2000s, largely centered in the Williams Lake and 100 Mile House WSB Outbreak Regions, peaking in 2007 at 847,000 hectares defoliated. Unique WSB Outbreak Regions in southcentral B.C. are described using biogeoclimatic ecosystem classification, geography, 106 years of documented defoliation, and 46 stand-level Douglas-fir host tree-ring chronologies. Since the 1980s, recorded defoliation in B.C. has shifted from coastal ecosystems and become a dominant disturbance in drier, colder, Interior Douglas-fir ecosystems. Defoliation records demarcate 4 outbreaks from 1950–2012 and up to 3 growth suppression events from 1937–2012. Outbreak duration was shorter in the north and far south of B.C. with recovery periods (no trees showing growth suppression) shorter over all WSB Outbreak Regions in the 2000s, suggesting trees may be increasingly susceptible to each successive defoliation event. Tree ring records show outbreaks have occurred in northern Douglas-fir forests for hundreds of years yet until the most recent outbreak there are few mapped aerial survey records. It may be that until the 2000s budflush phenology of overstory trees was not synchronized with larval emergence and only minimal defoliation would result in canopy trees. Budflush of understory or mid-canopy trees budflush occurs 2 or more weeks earlier than overstory trees so may be more synchronized with early larval emergence and feeding. With changing climate in the past few decades budflush has become more synchronous with larval emergence and could, in part, account for aerial surveys being unable to detect these defoliation events until recently.

Developing a Mycoinsecticide to Control Spruce Aphids

Amanda Grady[1], **Clifford Bradley[2],** and Richard Hofstetter[3]

[1]Forest Health Protection, USDA Forest Service, [2]Montana BioAgriculture Inc., and [3]School of Forestry, Northern Arizona University

No abstract received

Estimating the Potential for Larch Casebearer to Establish on Alpine Larch

Samuel Fahrner and Brian Aukema

Department of Entomology, University of Minnesota

No abstract received

SOCIAL ASPECTS OF BARK BEETLE RESEARCH

Stu Cottrell
Colorado State University

Ally Gran (Colorado State University) led with an excellent discussion highlighting her experiences working as an honors student on outreach and other socio-ecological aspects of bark beetle outbreaks in Colorado.

Bark Beetle Impacts to Social-ecological Systems: What Have We Learned and Where Do We Go From Here?

Jesse L. Morris[1], Stuart Cottrell[2], Christopher J. Fettig[3], Winslow D. Hansen[4], Rosemary L. Sherriff[5], Vachel A. Carter[6], Jennifer L. Clear[7], Jessica Western[8], R. Justin DeRose[9], Jeffrey A. Hicke[10], Philip E. Higuera[11], Katherine M. Mattor[2], Alistair W. R. Seddon[12], Heikki T. Seppa[13], John D. Stednick[14] and Steven J. Seybold[3]

[1]Department of Geography, University of Utah, [2]Department of Human Dimensions of Natural Resources, Colorado State University, [3]Pacific Southwest Research Station, USDA Forest Service, [4]Department of Zoology, University of Wisconsin, [5]Department of Geography, Humboldt State University, [6]Department of Botany, Charles University, [7]Department of Geography, Liverpool Hope University, [8]Ruckelshaus Institute of Environment and Natural Resources, University of Wyoming, [9]Rocky Mountain Research Station, USDA Forest Service, [10]Department of Geography, University of Idaho, [11]Department of Ecosystem and Conservation Sciences, University of Montana, [12]Department of Biology, University of Bergen, Norway, [13]Department of Geosciences and Geography, University of Helsinki, and [14]Department of Forest and Rangeland Stewardship, Colorado State University

Outbreaks of native bark beetles in forest ecosystems have caused substantial changes to landscape structure and function worldwide. As a result, adjacent human populations have realized alterations to ecosystem services. To advance our understanding of bark beetle impacts on society, we assembled a team of ecologists, land managers and social scientists to participate in a research prioritization workshop. We identified 25 key questions by using an established methodology to identify priorities for research into the impacts of bark beetles. Our efforts emphasize the need to improve outbreak monitoring and detection, educate the public on the ecological role of bark beetles, and develop integrated metrics that facilitate comparison of ecosystem services across sites.

The effects of bark beetle outbreaks are often detrimental to the provision of ecosystem services, including degraded landscape aesthetics and diminished air and water quality. There have been instances where bark beetle outbreaks have benefited communities by, for example, improving habitat for grazing animals and enhancing real-estate values. As a consequence of the interaction of a warming climate and susceptible forest stand conditions, the frequency, severity, and extent of bark beetle outbreaks are expected to increase and therefore will continue to challenge many social-ecological systems. We synthesize experiences from recent outbreaks to encourage knowledge transfer from previously impacted communities to potentially vulnerable locations that may be at risk from future bark beetle epidemics.

Public Perceptions of Bark Beetle Disturbance: Implications for Human Dimensions of Natural Resources, Recreation and Tourism

Stuart Cottrell[1], Jana Raadik Cottrell[2], Michael Czaja[1], Arne Arnberger[3], Martin Ebenberger[3], Ingrid Schneider[4], Alexander Schlueter[4], Rob Venette[4,6], Eick von Ruschkowski[5], Stephanie Snyder[6], Paul Gobster[6] and Pavlina McGrady[7]

[1]Human Dimensions of Natural Resources, Colorado State University, [2]Kuressaare College, University of Technology, Estonia, [3]University of Natural Resources and Life Sciences, Vienna, Austria, [4]University of Minnesota, [5]Alfred Toepfer Academy for Nature Conservation, Schneverdingen, Germany, [6]Northern Research Station, USDA Forest Service, and [7]Southern Oregon University

Bark beetle outbreaks have been identified as one of the top threats to forests in the U.S. and internationally. Whether native or introduced, forest insect outbreaks can have damaging effects on tree mortality and forest health, and their impacts are predicted to spread and intensify under current climate change scenarios for the first half of the 21st century. Perceived effects of beetle disturbances, such as mountain pine beetle (*Dendroctonus ponderosae*, MPB), are in the eye of the beholder with bark beetle disturbance as an inevitable social-ecological reality. Throughout the western U.S. and Europe, interactions between people and natural disturbances, specifically bark beetle outbreaks are increasing and inevitable. As climate changes, disturbance events occur more frequently, and concurrently, people have increasingly chosen to live in, recreate and explore natural landscapes where bark beetle outbreaks occur. Thus, it’s difficult to understand the ecological aspects without examining the social implications. The ways in which people perceive and respond to disturbance and the associated myths influence how we manage subsequent disturbance and the visitor experience and the extent to which disturbance is allowed to play its integral ecological role. As a National Science Foundation-funded research collaborative to examine public perceptions of bark beetle infestation effects on water quality and resource management in the Rocky Mountain West, a communication gap exists across scientists, land use managers, policymakers, and the public. Implications of these findings for the human dimensions of natural resources, recreation and tourism were discussed with an overview of social science approaches (i.e., values-attitudes-beliefs, landscape preference scenarios) used to understand visitor perceptions of bark beetle landscape disturbances from a socio-ecological systems perspective.

Communicating the Effects of Mountain Pine Beetle to Drinking Water in the Interior West

Kathie Mattor[1], Stuart Cottrell[2], Mike Czaja[2], John D. Stednick[1], Eric Dickinson[3] and Alan Bright[2]

[1]Department of Forest and Rangeland Stewardship, Colorado State University, [2]Department of Human Dimensions of Natural Resources, Colorado State University, and [3]Department of Civil and Environmental Engineering, Colorado School of Mines

Widespread changes to forested watersheds affected by the mountain pine beetle (*Dendroctonus ponderosae*, MPB) epidemic across western North America have raised concerns about the effects of this climate-induced disturbance on drinking water resources. Effective communication and knowledge exchange across scientists and stakeholders is essential for constructively responding to such disturbances, providing improved adaptive capacity through knowledge transfer. An assessment of drinking water stakeholder knowledge levels, information needs, primary concerns, and suggested communication strategies were conducted through expert elicitation and quantitative surveys, as well as Beetle Café workshops. A majority of participants reported little to no knowledge of the effects of MPB on drinking water quality and quantity, thereby indicating limited knowledge exchange between scientists and drinking water stakeholders. Increased accessibility and dissemination of scientific research findings pertinent to the MPB epidemic's effects on drinking water quality and quantity is necessary. Recommendations for improving communication among scientists and drinking water stakeholders include dispersal of non-academic research summaries, exchange of information through existing media and community resources, demonstration projects, and information clearinghouses. This information provides an opportunity for scientists to better understand the challenges, concerns, and first-hand experience of stakeholders and apply this knowledge to the formation and focus of their research. Study findings have aided in the development of placed-based outreach programs to share knowledge between drinking water providers and consultants, community watershed groups, primary and secondary education students, and the general public.

**Due to discussion, Stu Cottrell did not share his formal presentation on adaptive capacity frameworks.*

CONCURRENT SESSION 4

MANAGEMENT OF BARK BEETLES WITH SEMIOCHEMICALS

Chris Fettig
Pacific Southwest Research Station, USDA Forest Service

Management of Western Bark Beetles with Semiochemicals: A Review

Steve Seybold[1], Barbara Bentz[2], Chris Fettig[1], John Lundquist[3], Rob Progar[4] and Nancy Gillette[1]

[1]Pacific Southwest Research Station, USDA Forest Service, [2]Rocky Mountain Research Station, USDA Forest Service, [3]Pacific Northwest Research Station and Forest Health Protection, USDA Forest Service, and [4]Pacific Northwest Research Station, USDA Forest Service

This presentation provided an overview of a recent review paper on semiochemicals and management of bark beetles prepared by the Western Bark Beetle Research Group (WBBRG). The conifer forests of western North America have a long history of profound impacts by phloem-feeding bark beetles, and species such as mountain pine beetle (*Dendroctonus ponderosae*) and spruce beetle (*D. rufipennis*) have recently undergone epic outbreaks linked to changing climate. There is more urgency than ever before to develop integrated pest management (IPM)-compatible techniques for attenuating the impact of these pests and an ensemble of other damaging species. In the presentation, the nomenclature of chemical ecology and types of semiochemicals relevant to bark beetles were introduced. Historical examples of the isolation, identification, and bioactivity of bark beetle behavioral chemicals were covered. Furthermore, examples of semiochemical-based management strategies used for bark beetles were described. These included: 1) Monitoring and detection with baited plastic traps/baited trees; 2) Treatments to achieve population suppression through trap out with plastic traps or standing or felled trap trees; 3) Treatments to protect hosts through application of semiochemicals to or near the host tree (based on interruption or inhibition of aggregation or host location, which causes dispersal away from the protected trees); and 4) Treatments that push bark beetles away from protected trees and pull them into traps or trap trees at the periphery (push-pull). Research on tree protection techniques with semiochemicals was illustrated briefly for a hardwood system (walnut twig beetle and English walnut in California) and a conifer system (the northern spruce engraver and Lutz spruce in Alaska).

Seybold, S.J., Bentz, B.J., Fettig, C.J., Lundquist, J.E., Progar, R.A., and Gillette, N.E. 2018. Management of western North American bark beetles with semiochemicals. *Ann. Rev. Entomol.* 63: 407–432. https://doi.org/10.1146/annurev-ento-020117-043339.

Searching for New Semiochemicals: Selections from the Vault

Dave Wakarchuk[1], Brian Sullivan[2], Will Shepherd[2], Jorge Macias-Samano[3] and Evert Wakarchuk[1]

[1]Synergy Semiochemicals, [2]Southern Research Station, USDA Forest Service, and [3]Consultant

No abstract received

Effective Management of Bark Beetles with Semiochemical Tools and Solutions

Agenor Mafra-Neto[1], Chris Fettig[2], Steve Munson[3], Jesse Sarroli[1], Carmem Bernardi[1], Rodrigo Silva[1], Joey Palomera[1], Rob Progar[4], Brytten Steed[3] and William Urrutia[1]

[1]ISCA Technologies Inc., [2]Pacific Southwest Research Station, USDA Forest Service, [3]Forest Health Protection, USDA Forest Service, and [4]Pacific Northwest Research Station, USDA Forest Service

We synthesized information related to the management of bark beetles in western coniferous forests, and highlight recent research focused on development of novel semiochemical-based tools and tactics for management. In 2015, Fettig et al. (2015) developed a novel formulation of (–)-verbenone (SPLAT® Verb, ISCA Technologies Inc., Riverside, CA, USA; EPA Reg. No. 80286−20; 10.0% a.i.) that rather than a single release device is a flowable emulsion that allows the user to adjust the size of each release point (dollop) according to desired rates and distributions. SPLAT® Verb applied at 7.0 g of (−)-verbenone/tree to the tree bole is effective for protecting lodgepole pine, but not ponderosa pine, from mortality attributed to mountain pine beetle (*Dendroctonus ponderosae*). In sugar pine, 4.0, 7.0, and 10.0 g of (−)-verbenone/tree were effective. Rates as low as 250 g of (−)-verbenone/0.4 ha are effective for protecting stands of lodgepole pine. SPLAT® Verb was registered by the U.S. Environmental Protection Agency for use on pines in 2013, and has been used operationally since 2014. We discuss the implications of these and other results to the management of bark beetles, and share recent efforts concerning the development of SPLAT® MCH for management of Douglas-fir beetle (*D. pseudotsugae*).

Thirty-Six Years of Semiochemical Use in the Northern Rockies: The Good, the Bad, and the Ugly

Ken Gibson and Sandy Kegley

Forest Health Protection, USDA Forest Service

Beginning at our first involvement with bark beetle semiochemicals, a pilot project to evaluate the effectiveness of aerially-applied MCH-impregnated polymer beads in 1982, we described early testing and the eventual operational use of semiochemicals from that time to the present. Through a series of “fits and starts” - some “good,” some “bad,” and some “ugly” - semiochemical use ultimately came to significantly affect the management of coniferous host stands through the beneficial manipulation of bark beetle behavior.

Describing the early use of mountain pine beetle (*Dendroctonus ponderosae*) attractants, we noted they were originally more effective than we were prepared to deal with! And early first tests of

verbenone were in doses too small to be meaningful. Later testing and operational use of MCH bubble capsules almost always provided desirable results. Throughout the next 20 years, testing of verbenone pouches and aggregative pheromones useful as trap lures and tree baits, for several bark beetle species, brought early failures but eventual successes. Approaching the second decade of the 21st century, bark beetle semiochemicals have become valuable tools useful in reducing bark beetle-caused tree mortality. Today, resource managers are at a pretty good place relative to the successful use of bark beetle semiochemicals. Getting to this point has been an interesting venture, one not always as accommodating as we might have liked. As the saying goes, “the trip was long and arduous, and not all the roads were paved!”

THE ROAD TO RESTORATION: PAVED WITH GOLD OR YELLOW BRICKS?

Liz Heberston
Forest Health Protection, USDA Forest Service

In response to extreme wildfire events, outbreaks of native bark beetles and threats from invasive species, restoration has become a forest management priority in the western regions of the U.S. and Canada. Several models have been developed that address various forest restoration goals. In practice, however, land management policies, unclear direction, and reduced capacity and capability of land management agencies can constrain achieving forest restoration goals. In this session, presentations given by Roy[1] and Lorraine[2] covered restoration concepts, policies, and practices in the U.S. and Canada, respectively.

Roy indicated that the road to restoration in the western U.S. began in the early the 2000s with improved planning and the enactment of ‘common sense legislation’. The National Fire Plan (2001) provided measures for managing the impact of wildfires on communities and the environment including increased budgets for fire operations, rural fire assistance, emphasis on burned area rehabilitation and restoration and hazardous fuels treatments, and an increase in fire-focused research.

Federal laws, such as the Healthy Forest Restoration Act (HFRA 2003), increased the capacity for active management by expediting environmental analysis, providing direction on collaborative process, supporting biomass opportunities, promoting projects to reduce departures from historic fire regimes, and addressing forest insect and disease activity. The Southwest Forest Health and Wildfire Prevention Act of 2004 established 3 university-based Forest Restoration Institutes in the Southwest (AZ, CO and NM), and further defined terms like adaptive (ecosystem) management. The 2014 Agriculture Act (= “Farm Bill”) amended HFRA to improve insect and disease and hazard tree management based on the results of annual surveys, reauthorized State Forest Action Plans, provided a permanent Good Neighbor Authority for all states and Puerto Rico, gave States authority to administer wood energy grants, provided appropriation Authority for International Programs through 2018, and gave permanent authority for Stewardship Contracting.
Special programs, including the Collaborative Forest Landscape Restoration Program (CFLRP) established by Congress in 2009, provided funding for projects that emphasized on “All Lands” approach to restoration at landscape scales with specific direction on collaboration and monitoring. Joint Chiefs’ Landscape Restoration Partnership (USDA Forest Service and Natural Resource

Conservation Service) in 2014 provided for innovative silvicultural and implementation methods with a focus on increasing forest heterogeneity to achieve restoration goals.

Lorraine indicated that B.C. Forests, Lands, Natural Resource Operations and Rural Development have defined ecosystem restoration as the "process of assisting with the recovery of ecosystems that have been degraded, damaged, or destroyed by re-establishing structural characteristics, species composition and ecological processes". Forest restoration programs include Forests for Tomorrow (FFT) that was established in 2005 in response to catastrophic wildfires that occurred in the southern and central interior of the Province and to the recent mountain pine beetle (*Dendroctonus ponderosae*) epidemic. The aim of FFT is to improve the sustainability of future timber supplies and mitigate the impacts of fire and bark beetle disturbances on other forest values. FFT has recently expanded in response to 2017 wildfires, and spruce beetle (*D. rufipennis*) and Douglas-fir beetle (*D. pseudotsugae*) outbreaks.

In B.C., practices including conventional harvests, slash spacing techniques, and prescribed fire have all been used to treat stands. The method used has depended on specific restoration goals. Although these treatments have primarily served to meet timber supply goals, they have also contributed to the maintenance of ecosystem resilience, fuel management, range productivity, wildlife habitat, water quality, and carbon sequestration goals. Implementing active management in B.C. still necessitates overcoming some challenges, and thus, treatments have actually occurred on relatively few acres.

The aim of reforestation programs is the re-establishment of young forests on land that would otherwise remain under-productive. These programs have an increased emphasis on surveying, site preparation and tree planting, and timber supply analyses. Areas receiving priority for treatment have included those most impacted by catastrophic disturbances, and where activities can increase the short-, mid-, or long-term timber supply.

Definitions of restoration may vary and some goals may not be achievable, but new polices and legislation in both the U.S. and Canada have done much to help land managers address forest restoration. Climate change, the magnitude and complexity of the landscapes, limited resources, unfunded mandates, and conflicting goals will likely continue to challenge restoration efforts. Session participants, however, felt that publics have responded more favorably to 'Action' vs. 'No Action' policies. Finally, meeting restoration goals into the future will likely rely on strengthening partnerships and collaborative efforts, and continued advances in science and technology.

Roy Mask[1] and Lorraine Maclauchlan[2]
[1]Forest Health Protection, USDA Forest Service, and [2] B.C. Forests, Lands, Natural Resource Operations and Rural Development

CONCURRENT SESSION 5

BALSAM WOOLLY ADELGID IS CREEPING ACROSS THE WEST: CAN WE DO ANYTHING TO MANAGE IT?

Rob Progar
Pacific Northwest Research Station

Determining the Distribution of Balsam Woolly Adelgid (*Adelges piceae*) in Montana

Amy Gannon

Montana Department of Natural Resources and Conservation

Balsam woolly adelgid (*Adelges piceae*, BWA) was first confirmed in Montana from a USDA Forest Service Forest Inventory and Analysis survey in 2017. Previous to this detection, the presence and distribution of BWA had be unknown in the state. The State of Montana Department of Natural Resources and Conservation along with the USDA Forest Service conducted a delimitation survey to identify the extent of the non-native invasive insect. A roadside survey that was developed and implemented by the State of Idaho was used to ensure consistency across state and jurisdictional boundaries. Non-permanent survey plots were installed at 2-mile intervals in contiguous subalpine fir and at 1-mile intervals for discontinuous subalpine fir. Trees were examined at eye level for indication of BWA (gouting or wool) and determination of presence or absence was made after 5 minutes. GPS coordinates were recorded but no permanent markers installed. Samples were taken in each drainage surveyed and sent to Dr. Nathan Havill (Northern Research Station, USDA Forest Service) for confirmation. BWA was confirmed in the following counties in Montana: Broadwater**,** Flathead, Gallatin, Granite, Lewis and Clark, Lincoln, Mineral, Missoula, Ravalli, Sanders.

Balsam Woolly Adelgid, *Adelges piceae* (Hemiptera: Adelgidae), in Utah

Danielle Malesky

Forest Health Protection, USDA Forest Service

Balsam woolly adelgid (*Adelges piceae*, BWA) is causing widespread mortality of subalpine fir in Utah. Limited species diversity and BWA-caused damage, which negatively impacts all size classes and capacity for natural regeneration, exacerbates these concerns. In addition, spruce beetle (*Dendroctonus rufipennis*)-caused mortality of Engelmann spruce has influenced stand conditions in the Engelmann spruce/subalpine fir type, leaving this type more susceptible to BWA. Given current true fir stand conditions in R4 (older and more dense stands), availability of host type and weather trends, the ecological sustainability of subalpine fir and other true fir host types is a primary concern. In 2018, entomologists will establish (72) Evaluation Monitoring plots, continue delimitation and ADS verification, and collect BWA for county verifications. Furthermore, we will collaboratively develop proposals for examining BWA phenology in the central Rockies, and for developing effective chemical and silviculutral control methods.

Reflecting and Futuring after 35 Years of Balsam Woolly Adelgid in Idaho

Gina Davis

Forest Health Protection, USDA Forest Service

Balsam woolly adelgid (*Adelges piceae*, BWA) was first detected in Idaho in 1983. Since its introduction, the Idaho Department of Lands (IDL) and Forest Health Protection have cooperated for ground and aerial detection surveys, monitoring the damage BWA has caused to fir forests, and educating land managers and the public. Ground detection surveys were conducted along roadways after BWA was first detected, through 1998 and again from 2006 through 2011. BWA was detected in most counties, except those along the southern border and southeastern corner. Observers started to map damage caused by BWA during aerial detection surveys north of the Salmon River in 1989. Starting in 2000, aerial observers mapped BWA signatures throughout the state. Intensity of BWA damage was quantified through ground observations at 4 sites that were mapped during an aerial detection survey. Subalpine fir mortality ranged from 10–49%.

Effects of BWA on subalpine fir forests were monitored at 9 locations near the origin of the first BWA detections in Idaho between 1987 and 2004. By 2004, only 16% of the trees survived. Additional evaluation monitoring for the effects of BWA to subalpine and grand fir forests at 26 locations across the state began in 2008–2009, were monitored in 2013–2014 and monitoring will continue in 2018 with additional locations in Montana and Utah. Ongoing monitoring will evaluate how other biotic damage agents and environmental factors may effect fir tree survival in the presences of BWA. Detection and monitoring protocols for this pest have been well developed and recently transferred to Survey123 for ArcGIS (ESRI) for ease of data colleting and sharing methodology broadly.

Previous Attempts to Manage Balsam Woolly Adelgid

Rob Progar

Pacific Northwest Research Station, USDA Forest Service

Balsam woolly adelgid (*Adelges piceae*, BWA) was introduced to the U.S. around 1900 and is considered a severe pest of native true firs. In western North America, BWA was discovered in California in the 1930s on grand fir (*A. grandis*), noble fir (*A. procera*) and European silver fir (*A. alba*). During the 1950s and 1960s infestations were observed in Oregon, Washington and British Columbia on grand fir, Pacific silver fir (*A. amabalis*) and subalpine fir (*A. lasiocarpa*). Today the insect continues to disperse eastward across Idaho, northward into western Montana and British Columbia and southward into Utah. Salivary injections of feeding BWA inhibit normal growth and cause anatomical, structural and physiological changes in host tissue. BWA causes degradation in tree quality due to swelling of nodes, branch dieback, and cessation in terminal growth, and frequently kills trees. In managed settings such as Christmas tree farms insecticides continue to be the only successful way of controlling BWA. Silvicultural controls have been attempted but few measures are effective. In wildland forests, biological control has been employed with mixed success.

DIRECT CONTROL OF BARK BEETLES

Darren Blackford
Forest Health Protection, USDA Forest Service

Bole Sprays: A Review and Alternative Timing of Carbaryl Treatments in Ponderosa and Lodgepole Pines

Chris Fettig[1], Steve Munson[2], Ken Gibson[2], Darren Blackford[2], Laura Lowrey[2], Leif Mortenson[2] and Joel McMillin[2]

[1]Pacific Southwest Research Station, USDA Forest Service, and [2]Forest Health Protection, USDA Forest Service

Protection of individual conifers from mortality attributed to bark beetles often involves applications of liquid formulations of contact insecticides to the tree bole using ground-based sprayers. Treatments should be applied to all bole surfaces from the root collar to mid-crown up to about 15 m in height. For engraver beetles, treatment of branches >5 cm in diameter is also recommended. Residual activity varies by active ingredient (e.g., bifenthrin, carbaryl, and permethrin), formulation, bark beetle species, tree species and associated climatic conditions (Fettig et al. 2013). We synthesized information on the efficacy, residual activity, and environmental safety of contact insecticides commonly used to protect conifers from mortality attributed to bark beetles, and shared novel research findings concerning alternative timing of treatments. In lodgepole pine, both spring (immediately prior to mountain pine beetle (*Dendroctonus ponderosae*, MPB) flight for that year) and fall (after flight had ceased for that year, and months prior to MPB flight the following year) treatments of 2.0% a.i. carbaryl (Sevin® SL) were efficacious for 2 field seasons, while results from a third field season were inconclusive. In ponderosa pine, both spring and fall treatments of 2.0% a.i. carbaryl (Sevin® SL) were efficacious for 1 field season.

Systemic Injections for Management of Bark Beetles and Associated Fungi

Don Grosman[1], Chris Fettig[2], Darren Blackford[3] and Steve Munson[3]

[1]Arborject Inc., [2]Pacific Southwest Research Station, USDA Forest Service, and [3]Forest Health Protection, USDA Forest Service

In recent years we have demonstrated the efficacy of phloem-mobile systemic insecticides, injected with pressurized systems into the tree bole, for protecting conifers from mortality attributed to mountain pine beetle (*Dendroctonus ponderosae*, MPB*)*, spruce beetle (*D. rufipennis*, SB), and western pine beetle (*D. brevicomis*). These systems push adequate volumes of product (i.e., generally less than several hundred ml for even large trees) into the small vesicles of the sapwood. Following injection, the product is transported throughout the tree to the phloem. In general, injections can be applied at any time of year when trees are actively translocating, but time is needed to allow for full distribution of the active ingredient within the tree prior to being challenged by bark beetles (i.e., ranging from wks in low-elevation systems to months in high-elevation systems). In this presentation, we focus on recent research evaluating the efficacy of combining insecticides with fungicides for protecting lodgepole pine from MPB and Engelmann spruce from SB. These and other species of bark beetles carry symbiotic fungi (e.g., *Ophiostoma montium and Grosmannia clavigera*) that are inoculated into the tree upon colonization by the beetle, which may also be deleterious to tree health. By combining emamectin benzoate (TREE-äge®) with propiconazole (a systemic fungicide) higher levels of tree protection were observed in both the MPB and SB system (Fettig et al. 2014, 2017). In the future, we expect that systemic injections will be more commonly used for direct control of bark beetles in the western U.S., especially in areas where bole sprays are impractical.

Variability in Stand Characteristics Can Influence the Distribution of Tree Mortality Caused by the Mountain Pine Beetle in Ponderosa Pine: Implications for Restoration

Jose Negrón and Laurie Huckaby

Rocky Mountain Research Station, USDA Forest Service

Over the last few decades there has been an increase in the number and intensity of wildfires across the western U.S. Cessation of fires over the past century has resulted in dense forests, particularly at lower elevations, that can facilitate the development of large fires. Forest restoration projects in ponderosa pine forests in the Colorado Front Range are frequently implemented with the primary objective of reducing the risk of large and intense fires. Restoration strategies vary among locations but often the objective is to create low-density stands with clumps of larger-diameter trees by removing trees of all sizes while creating openings and a forest structure more similar to historical conditions. The mountain pine beetle (*Dendroctonus ponderosae*, MPB) is a bark beetle that attacks and kills ponderosa pine particularly in dense stands comprised of large trees. We examined the spatial distribution of basal area pre- and post- a MPB outbreak and observed increased mortality in the denser parts of the stand. Restoration projects will reduce the risk of large fires and as a collateral benefit may reduce overall susceptibility to MPB by creating lower density stands. However, when MPB populations increase, infestations may develop in the clumps of large trees created during restoration efforts. Managers should be cognizant that restoration projects could create conditions where MPB is likely to infest and expand populations.

Acoustic Tools for Detection and Management of Bark Beetles

Richard Hofstetter[1], David Dunn[2] and Carol Bedoya[3]

[1]Northern Arizona University, [2]Music Department, University of California, Santa Cruz, and [3]University of Canterbury

Bark and ambrosia beetles are one of the most significant biotic disturbance agents in forest ecosystems, and when introduced into new habitats typically lead to extensive economic losses, transitions of forest communities, and negative impacts on local recreation and food production. These beetles have well developed chemical communication systems that allow for mass aggregations on host trees, which is often exploited in control strategies and management. However, these beetles also use acoustic signals to communicate at the tree surface and within tree tissues. These acoustic signals can be complex and provide a context for species recognition, premating interactions, pair formation, mate selection, intra-species aggression, territoriality and predator deterrence. Acoustic communication provides an avenue for species detection in wood materials and also strategy for beetle management and tree protection. We discuss technical and applied applications of acoustic tools for management of wood-infesting insects and fungi.

CONCURRENT SESSION 6

LINKING BARK BEETLE SPATIAL DYNAMICS TO APPLIED FOREST ECOLOGY

Jeff Hicke[1] and Joel Egan[2]
[1]University of Idaho, and [2]Forest Health Protection, USDA Forest Service

Something Wicked This Way Comes: The Invasive Dynamics of Mountain Pine Beetle in the Boreal Forest

Barry Cooke

Canadian Forest Service

"Something wicked this way comes" was a 1962 Ray Bradbury novel. After the seminal work of Réné Thom (1963) on catastrophe theory, Horst and Rittel (1973) formally defined "wicked" problems as that class of social planning problems that are difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize. Moreover, because of complex interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems. "Confusis" is the collective state of confused thinking and action that occurs when we must plan around compound nonlinear fast-slow stochastic dynamic disturbance processes. This talk clarifies what happens when an eruptive invasive species outbreaks, using the recent model of Cooke and Carroll (2017). This model, developed for the southcentral interior of British Columbia, includes nonlinearity, stochasticity, non-stationarity, uncertainty, and process inter-dependency, which are central to all wicked problems. We show how combinations of small perturbations associated with climate warming are likely to lead to a cascading "perfect storm" outcome in any compound nonlinear system. The implications for leading-edge spread dynamics are profound. For 3 years running, MPB in the jack pine region of eastern Alberta has been stationary in space, and performing poorly. There are indications that beetles are even starting to switch to endemic host-searching behavior because the epidemic mode of attack is not succeeding. What happens over the next decade is unclear because we do not know how long before beetles consolidate in the numbers required to re-erupt. This largely depends on how much control effort the provinces continue to invest in containment, and on weather.

Spatial Dynamics and Forest Density Drives Jeffrey Pine Beetle-Attack During the Epidemic Phase of an Outbreak

Joel M. Egan[1], Omid Khormali[2], Ekaterina Smirnova[2], David Patterson[2] and Jon Graham[2]

[1]Forest Health Protection, USDA Forest Service, and [2]University of Montana

Bark beetle outbreaks have impacted yellow pine forests throughout the western U.S. in recent years in conjunction with protracted drought events. The fine-scale spatial dynamics of erupting bark beetles in yellow pine systems is an important topic that has received little scientific investigation to-date. Our study evaluated the influence of Jeffrey pine beetle (*Dendroctonus jeffreyi*, JPB) spatial dynamics and forest characteristics on likelihood of successful beetle-attack with spatiotemporal census data. Data included JPB-attack status monitored annually across 10,722 trees over a 24-ha study area from 1991–1996 near Lake Tahoe, Nevada. Specific objectives were to: 1) create best-fit multivariate logistic regression model to predict JPB-attack in 1993; 2) verify best-fit model predictors and assess neighborhood size of important with autologistic spatial term controlling spatial correlation; and 3) validate non-spatial 1993 model with 1994 JPB-attack data. Modeling indicated JPB-attacks were influenced by spillover and correlated with nearby attacked trees (50 m distance to independence), linear distance to the nearest brood tree and stand density index. The forest density neighborhood size with greatest association with JPB-attacks was the finest scale tested at .02-ha. Trees within .02 ha neighborhoods that had the equivalent of ≤100 SDI had minimal rates of mortality (0–3%) in both 1993 and 1994 despite being challenged by high beetle pressure. Validation of the non-spatial, best-fit model with 1994 JPB-attack data indicated 79.3% classification accuracy. Overall, JPB-attacks were driven by spatially layered ecological dynamics including spatial covariance or spillover within 50 m of attacked trees, proximity to brood trees, and forest density within a local, .02-ha neighborhood.

Development and Evaluation of the Mechanistic Model of Outbreaking Bark Beetles-Mountain Pine Beetle (MMOBB-MPB)

Jeffrey A. Hicke[1], Polly C. Buotte[2] and Kenneth F. Raffa[3]

[1]University of Idaho, [2]Oregon State University, and [3]University of Wisconsin

Bark beetles have killed billions of trees in western North America in recent decades. Climate has influenced these outbreaks through warming and drought, and future climate change is expected to continue to be favorable for these insects in the future. Here we describe a prognostic model of mountain pine beetle (*Dendroctonus ponderosae*) outbreaks in lodgepole pine forests designed for use across the western U.S. and over centuries. The model tracks beetle populations from eggs through egg-laying adults, and includes the major mechanisms affecting outbreaks, including climate, stand structure and dispersal. The model is designed for simulations at the scale of an individual forest stand, in this case, a 1-km grid cell. We have developed the model and evaluated dynamics using a simplified stand growth model together with observed and synthetic climate time series. Simulations result in the expected responses of beetle populations and forest carbon to climate and stand conditions based on theory. Regionally, recent climate change has created conditions that lead to substantially more outbreaks than for runs without warming. In this talk we describe the modeling structure, stand-level simulations, and regional simulations that include the effects of climate change.

OPEN SESSION

Monica Gaylord
Forest Health Protection, USDA Forest Service

Opportunities to Collaborate With (or Receive Funding From) the Western Integrated Pest Management Center

Amanda Crump, Matthew Baur and Steve Elliott

Western Integrated Pest Management Center

The Western Integrated Pest Management Center is 1 of 4 regional centers funded by the USDA National Institute of Food and Agriculture to promote integrated pest management. We serve as the hub of a multi-state partnership and communication network linking researchers, growers, extension educators, commodity organizations, environmental groups, pest control professionals, government agencies and others. From our office in Davis, California, we serve 17 western states and Pacific Island Territories. The Western IPM Center promotes IPM development, adoption and evaluation to solve pest problems in agriculture, natural settings and communities across the West. We encourage a science-based approach to pest management to reduce risks to people and the environment by using pest biology, environmental information and all available technology to reduce pest damage to acceptable levels by the most economical means. Our goal is to bring the right people together with the necessary resources to solve the West's important pest problems. We support those doing IPM through various ways. We have a grant program that opens every October. We also work on invasive species on a continual basis. Our communications work highlights IPM throughout the West – illustrating how IPM can lead to a healthier West with fewer pests. Find us at westernipm.org.

Severe Drought and Fire Alter Oleoresin Composition and Volatile Emissions of Ecology Significant Terpenoids in Jeffrey pine, *Pinus jeffreyi*

Jason Maxfield[1], Lori Nelson[2], Andy Graves[3], Steve Seybold[2], and Nancy Grulke[4]

[1]Portland State University, [2]Pacific Southwest Research Station, USDA Forest Service, [3]Forest Health Protection, USDA Forest Service, and [4]Western Wildland Environmental Threat Assessment Center, USDA Forest Service

No abstract received

Endemic Jeffrey Pine Beetle Fungal Transmission and Their Interaction with a Common Yeast

Javier E. Mercado[1], Beatriz Ortiz-Santana[2], Danielle Francis[3] and Eddyliz P. Rosado-Camacho[4]

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Research explores symbiotic mechanisms that may help explain changes in western U.S. *Dendroctonus* bark beetle populations. Preliminary results of what we defined as an endemic population sample of *D. jeffreyi* from northern California identified the known fungal associate *Grosmannia clavigera* and the new associate *Ophiostoma minus* both occurring in similar abundance in the population sample. *O. minus* has not been reported before from this beetle. But in *D. frontalis,* it interacts with the symbiosis antagonistically by outcompeting beetle mutualistic fungi and reducing the beetle's population. Growth essays at 5 °C intervals (0–34 °C) showed that *O. minus* outperformed *G. clavigera* at most temperatures tested. When we tested the interactions of the most common yeast associated with the beetle, *Kuraishia capsulata*, the growth pattern was inverted causing *G. clavigera* to outperform *O. minus* at temperatures 0–30 °C. *K. capsulata* may increase the chances of *G. clavigera* dissemination by *D. jeffreyi* when potentially antagonistic *O. minus* is present in the population, and it may represent a direct mutualist to that fungus that indirectly improves *D. jeffreyi* performance in its pine host. It is probable that as in the *D. frontalis* symbiosis, fungal interactions with *O. minus* and other fungi of similar ecology may occasionally prevent *D. jeffreyi* populations from becoming epidemic.

A Short History of Spruce Beetle in Alaska

John E. Lundquist

Forest Health Protection and Pacific Northwest Research Station, USDA Forest Service

The first report of a spruce beetle (*Dendroctonus rufipennis*, SB) outbreak in Alaska was written in 1922 by a mining engineer enquiring to A.D. Hopkins about dying trees near McCarthy. Since then, what we know about the distribution and impacts of this bark beetle has been limited by the vast areal expanse of this state and by the limited number of insect-knowledgeable people that have worked here. Five eras are characterized: Pre-McCambridge (1922–1952), McCambridge (1952–1960), Post-McCambridge (1961–1976), Werner/Holsten (1977–2004) and the Post Werner/McCambridge (2004–2015). Most early work focused on the western blackheaded budworm in Southeast Alaska, as until the early 1960s little attention was paid to SB. With the rising human settlement of the Kenai Peninsula beginning in the early 1970s, SB became increasingly noticeable. By the late 1980s, it had become catastrophic and the need to know more about this species became urgent. The Werner/Holsten era saw some of the most active research ever done on SB. Ed Holsten and Skeeter Werner, along with their many collaborators, especially John Hard and Ken Zogas, became well-known for their contributions to our knowledge of the biology, ecology, and management of SBs and their impacts in Alaskan forests.

Efficacy of Emamectin Benzoate and Propiconazole for Protection of California Sycamore Against Polyphagous Shot Hole Borer and Its Associated Fungi

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[1]Arborjet Inc., and [2]Department of Plant Pathology and Microbiology, University of California, Riverside

The polyphagous shot hole borer (*Euwallacea* sp., PSHB), an exotic and destructive beetle, was recently found attacking a number of tree species in Los Angeles and Orange Counties in southern California. Their colonization and subsequent inoculation of a suite of symbiotic fungi that cause Fusarium Dieback, has resulted in extensive mortality of some tree species, including, California sycamore (*Platanus racemose* Nutt.). There is no known sustainable control option for PSHB other than maintaining tree vigor and removing severely-infested branches and trees. Recently, an injected systemic insecticide containing emamectin benzoate (EB) has shown some promise for improving the health of PSHB-attacked trees. In the first of 2 trials, the effectiveness of EB alone or combined with a systemic fungicide, propiconazole (P), was evaluated over a 4-year period for maintaining the health of individual sycamore trees infested by PSHB. All treatments containing EB reduced levels of PSHB colonization and associated sap flow (bleeding) compared to untreated controls. In addition, tree mortality (40%) was reduced to 22% with EB alone and 10% with EB + P. A second trial evaluated efficacy of EB and P alone or combined to protect individual sycamore from colonization by PSHB. After 45 months post-treatment, all treatments had significantly reduced PSHB attack levels and successful attacks compared to untreated controls (EB + P > EB alone > P alone). We concluded that EB alone or combined with P were acceptable therapeutic and preventative treatments for management of California sycamore in southern California.

POSTER PRESENTATIONS

Assessing the Landing Behavior of Pioneer Walnut Twig Beetles, *Pityophthorus juglandis*, in Response to Host and Non-host Volatiles in a Northern California Riparian Forest

Jackson P. Audley[1], Crystal S. Homicz[1], Richard M. Bostock[2] and Steven J. Seybold[3]

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The walnut twig beetle (WTB), *Pityophthorus juglandis*, is an invasive bark beetle that vectors the fungal pathogen *Geosmithia morbida*. Together, these 2 organisms comprise thousand cankers disease (TCD), the progressive, often fatal disease of walnut, *Juglans* spp. WTB and TCD threaten North American walnut resources and potentially threaten walnut resources on a global scale. This study investigated host searching behavior by pioneer WTB in a native riparian forest in northern California. We established host/non-host branch pairings whereby a *J. hindsii* branch was paired with a non-host hardwood branch. Ten host/non-host pairs were established for each of 6 non-host angiosperms: boxelder, *Acer negundo*; eucalyptus, *Eucalyptus* sp.; Oregon ash, *Fraxinus latifolia;* Fremont's cottonwood, *Populus fremontii*; willow, *Salix* spp.; and valley oak, *Quercus lobata* (only 9 pairs for cottonwood). Two sticky sheet traps were wrapped around each branch proximally and distally to the stem (N = 236). Traps were deployed from 6 June–2 Aug. 2017 on trees at the UC Davis Putah Creek Riparian Reserve in Davis, CA. WTB landing rates on host/non-host pairs were compared by using GLM in R statistical software. Factors tested in the models included trap placement (proximal vs. distal), quarter section on the trap, and tree species. Data from only 2 of the 6 non-host species have been recorded thus far, so only results for *Eucalyptus* sp. and boxelder are presented here. During the trapping period, 389 WTB were recovered from traps on host branches, whereas only 23 were recovered from those on the 2 non-host tree species. In 4 instances (2 on a *Eucalyptus* pair and 2 on a boxelder pair), pronounced landing rates on *J. hindsii* in the pair suggested that volunteer attacks by WTB had led to incipient aggregation and likely production of aggregation pheromones. These 4 branch pairs (Pairs 2 and 9 for eucalyptus; 2 and 5 for boxelder) were removed for the analyses of WTB counts, but were retained for the analyses of presence vs. absence of WTB. There was a greater likelihood of presence of WTB on the host (10/10) versus eucalyptus (2/10); however, there was no difference in proportion of branches with WTB on the host (5/10) versus boxelder (3/10). The nb.GLM (log link) model for *Eucalyptus* sp. pairs indicated that tree species had a significant effect on WTB landing rate ($z = -3.706$, $P < 0.001$). However, proximal versus distal trap location ($z = 1.63$, $P = 0.103$) and WTB sex ($z = 1.737$, $P = 0.082$) were not significant in the model for *Eucalyptus* sp. Two of the trap aspects, top and right were significant ($P = 0.015$ and 0.026, respectively); however, a post-hoc comparison (Dunn's test with Bonferroni method) revealed that the aspects were not different (all $P > 0.63$). The nb.GLM (log link) model for boxelder pairs indicated that none of the variables were significant in the model (all $P > 0.097$). Therefore, all data were pooled at the branch level, and male and female trap catches were combined for data presentation. WTB trap catches on host traps exceeded those on non-host traps in 63% (10/16) of the pairings. Mean landing rate of WTB on *J. hindsii* (3.75) was significantly greater than that on *Eucalyptus* sp. (0.375) ($N = 8$). Mean landing rate on *J. hindsii* (0.5) was not different from that on boxelder (0.375) ($N = 8$). Based on these preliminary analyses, it appears that WTB is capable of distinguishing between host and non-host branches for certain, but perhaps not all, non-host angiosperms while in flight, likely in response to the volatile profiles of the individual trees.

Geographic Distribution and Environmental Factors Contributing to Genetic Variation in Mountain Pine Beetle Populations in Western North America

Marianne E. Davenport, Edwina J. Dowle and Gregory J. Ragland

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In North America, millions of forest acres have been impacted by mountain pine beetle (*Dendroctonus ponderosae*, MPB), which normally exists at low population sizes and serves a beneficial role in forest health. MPB tends to target old, weak trees and by killing them helps future forest regeneration. However, favorable environmental conditions can lead to exponential population growth, resulting in potential epidemic population outbreaks.

Here, we use GIS data to 1) test the effects of host availability on genetic connectivity among populations, and 2) apply a correlational analysis to identify genetic markers associated with environmental differences across the geographic distribution of MPB. The goal is to understand populations connectivity, and to identify genetic markers that may predict important population metrics such as phenology and growth rate.

Previously, Dowle et al. (2017) used 19,904 genetic loci (ddRADseq) to identify 3 distinct genetic clusters (Y chromosome haplogroups) that correspond with post-glacial expansion from 3 distinct refugia. There is restricted autosomal gene flow among Y haplogroups, suggesting partial reproductive isolation, and that different loci may be associated with adaptation to the same environmental factors in different geographic regions.

Drought Management Recommendations for California

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The state of California is an important example of society's vulnerability to drought. As the 6th largest economy in the world, California is home to nearly 39.3 million people and an agricultural and forestry sector of national and international significance. Droughts have had an important influence on California for millennia, for example, in forests droughts have contributed to widespread bark beetle outbreaks, extensive tree mortality, and increased wildfire risks and hazards, which in turn impact biogeochemical cycling and hydrologic processes. In rangelands, droughts have limited production, altered nutrient cycling, increased wildfire risks and hazards, and increased susceptibility to invasive plants. The most recent drought (2012–2016) in California was characterized by large precipitation deficits and abnormally high temperatures during both the wet and dry seasons. While consecutive years of drought and associated stress on vegetation are not uncommon, this event was the most severe in 1,200 years and may foreshadow future impacts of drought within the state. We consider the impacts of drought on several major ecotypes in California, and highlight management options to minimize impacts and to facilitate recovery.

Evaluations of Emamectin Benzoate and Propiconazole for Protecting Individual Trees from Mortality Attributed to Colonization by Bark Beetles and Associated Fungi

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Protection of conifers from bark beetles often involves applications of liquid formulations of contact insecticides to the tree bole. Researchers attempting to find safer, more portable and longer-lasting alternatives to bole sprays have evaluated the effectiveness of injecting systemic insecticides directly into the lower bole of trees. Several active ingredients, including acephate, azadirachtin (neem), dinotefuran, fipronil, and oxydemeton methyl, have been demonstrated to be ineffective. We evaluated the efficacy of bole injections (Arborjet Tree IV™; Arborjet Inc., Woburn, MA) of emamectin benzoate (TREE- äge®; Arborjet Inc.) alone and combined with the

fungicide propiconazole (Alamo®; Syngenta Crop Protection Inc., Wilmington, DE) for protecting individual lodgepole pine and Engelmann spruce from colonization by bark beetles and associated blue stain fungi. We observed no symptoms of phytotoxicity associated with either treatment. In lodgepole pine, emamectin benzoate injected in late summer or early fall provided adequate levels of tree protection the following summer, and by combining emamectin benzoate with propiconazole tree protection was afforded the year that injections were implemented. In Engelmann spruce, injections of emamectin benzoate were effective when injected 1 year prior to treatments being challenged by beetles.

Efficacy of a Novel Formulation of the Anti-aggregation Pheromone 3-methylcyclohex-2-en-1-one (MCH) for Managing Douglas-fir beetle (*Dendroctonus pseudotsugae*) in High Risk Stands

Gabriel Foote[1], Christopher J. Fettig[2], Darrell W. Ross[1], Justin B. Runyon[3], Tom W. Coleman[4], Monica L. Gaylord[4], Andrew Graves[4], Laura Lowrey[4], Joel D. McMillin[4], Leif A. Mortenson[2] and Agenor Mafra-Neto[5]

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Douglas-fir beetle (*Dendroctonus pseudotsugae*, DFB) is among the most damaging agents of Douglas-fir in western North America. Infestations can be managed using the beetle's anti-aggregation pheromone 3-methylcyclohex-2-en-1-one (MCH). Various formulations of MCH exist, including bubble capsules and a prototype biodegradable, controlled-released emulsion (SPLAT® MCH, ISCA Technologies Inc., Riverside, CA). To determine the efficacy of SPLAT® MCH for preventing tree mortality we conducted experiments near Socorro, NM (Exp. 1) and Boise, ID (Exp. 1 and 2). Experiment 1 utilized a completely-randomized design with 6 replicates (0.4-ha square plots) and 3 treatments including: (1) untreated control, (2) MCH bubble capsules (30 units/plot), and (3) SPLAT® MCH (12 g AI/plot). For Experiment 2, a total of 30 individual trees were randomly administered 1 of 3 treatments (10 replicates each), including: (1) untreated control, (2) MCH bubble capsules (2 or 4/tree depending on tree DBH), and (3) SPLAT® MCH (2 or 4 10-g dollops/tree depending on tree DBH). SPLAT® MCH significantly reduced ($\alpha = 0.05$) tree infestation (by 72.5%) and mortality (by 50.7%) by DFB compared to untreated plots at the NM site. These levels of reduction did not differ significantly from plots treated with MCH bubble capsules. Neither MCH treatment significantly reduced DFB infestation compared to the untreated control at the ID site. Every untreated control tree in Experiment 2 was infested by DFB by mid-summer, while only 1 tree (10%) per each MCH treatment group (bubble capsules and SPLAT® MCH) was infested; chi- square analyses indicated these levels of infestation significantly differed ($\alpha = 0.05$) from the untreated control. Overall, these results indicate SPLAT® MCH is as effective in preventing tree mortality attributed to DFB as MCH bubble capsules.

Blended Beetles vs Beetle Bodies: A Comparison of Two Methods for Processing EDRR Samples

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Early Detection and Rapid Response (EDRR) program goals are to quickly detect, delimit and monitor newly introduced non-native bark beetles, ambrosia beetles and wood borers. One aspect that the program severely lacks is the ability to quickly assess the trap catches. Biomonitoring using metabarcoding is advocated for arthropods because these methods have the potential to be much faster and cheaper than identifications obtained by morphological identifications or Sanger sequencing. Thirty samples were sent to RTL Genomics (http://rtlgenomics.com/) for Next-Generation Sequencing (NGS). From the 26 samples in the main study design 26 unique identifications were obtained using morphological methods and 32 unique identifications were made using NGS. From these a total of 30 were species identifications: 7 using morphological methods and 24 using NGS. Only 1 species, *Plectrura spinicauda*, was identified by both methods. In general, NGS yielded better identifications than morphological methods, but NGS methods often missed target species.

Landing Behavior of the Walnut Twig Beetle on Host and Non-host Hardwood Trees under the Influence of Aggregation Pheromone in a Northern California Riparian Forest

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The walnut twig beetle (WTB), *Pityophthorus juglandis* Blackman (Coleoptera: Scolytidae), vectors the pathogenic fungus, *Geosmithia morbida*, to the phloem of walnut and wingnut trees. Together the 2 organisms cause thousand cankers disease (TCD). To better understand the host colonization behavior of WTB, a trapping experiment was conducted in a riparian forest at the Putah Creek Riparian Reserve in Davis, CA. Landing rate of the beetle was monitored with acetate sticky sheet traps baited with 3-methyl-2-buten-1-ol (1.2 mg/d), the male-produced WTB aggregation pheromone, and placed on paired branches of host (*Juglans hindsii*) and non-host hardwood trees (*N*=10 hosts/non-hosts for each pair). The assay was conducted over 2 periods, 22–29 May 2017 (7 days) and 29 May–26 June 2017 (28 days). There were 6 non-host species included in the study: boxelder, *Acer negundo*; eucalyptus, *Eucalyptus* sp.; Oregon ash, *Fraxinus latifolia*; Fremont's cottonwood, *Populus fremontii*; willow, *Salix* sp.; and valley oak, *Quercus lobata*. We are reporting results from the first assay period for *A. negundo* and *Eucalyptus* sp., which are the 2 non-hosts that have been processed so far. Landing rates were also monitored spatially on 4 sections (aspects) on the sticky sheets (top, right, bottom, and left). Host and non-host landing rates by WTB were compared by GLM with R software. We predicted that WTB uses long-range volatile cues as a primary method to discriminate between host and non-host trees prior to landing. Conversely, WTB likely does not use short range cues alone, such as gustatory and olfactory signals, to discriminate host from non-host. We were curious about the strength of the attraction/repellency of the host/non-host cues relative to the aggregation pheromone of the WTB. Analysis of WTB landing rate data on *J. hindsii/A. negundo* during the first deployment period revealed a total of 738/582 WTB, respectively, on traps from 9 pairs of trees (one trap pair was lost in the field). Similarly, during this period, a total of 185/39 WTB landed on traps on branches of 8 pairs of *J. hindsii*/*Eucalyptus* sp. trees (2 trap pairs were lost in the field). In the context of its pheromone, WTB had a higher landing rate on *J. hindsii* in 12 of 17 instances across both pairings. Female landing rate generally exceeded male landing rate, which underscores the influence of the male-produced synthetic pheromone in this system. Grubbs' test (outliers package) was used to find any outliers in either data set. As a consequence, Pairs 9 and 10 (*A. negundo* pairs) and Pair 1 (*Eucalyptus* sp. pairs) were removed as outliers from the nb.GLM (log link) analyses (*A. negundo*, $N = 7$, *Eucalyptus* sp., $N = 7$). There was no significant difference in landing rates by aspect on the traps for *J. hindsii/A. negundo* (all aspects, $P \geq 0.294$) or for *J. hindsii/Eucalyptus* sp. (all aspects, $P \geq 0.84$), so landing rate data were pooled across aspects in both data sets. There was no significant difference in landing rates of male ($z = 0.494$, $P = 0.623$); female ($z = -0.76$, $P = 0.860$); or the combined sexes ($z = 0.065$, $P = 0.948$) of WTB on *J. hindsii* vs. *A. negundo*. Thus, preliminary results indicate that in the context of the aggregation pheromone, volatiles from *A. negundo* do not repel WTB. However, WTB landing rates of both sexes combined on the *Eucalyptus* sp. pairings were a significant factor in the model ($z = 2.415$, $P = 0.016$). Furthermore, post hoc Kruskal-Wallis (Bonferroni method) comparisons of WTB landing rates between *J. hindsii* and *Eucalyptus* sp. indicated significance for females ($z = -2.28$, $P = 0.022$) and the combined sexes ($z = -2.36$, $P = 0.019$), but not for males ($z = -1.511$, $P = 0.131$). Thus, preliminary results indicate that in the context of the aggregation pheromone, volatiles from *Eucalyptus* sp. may repel the arriving, but not the colonizing sex of WTB.

Synchrony and Phenology of Emerald Ash Borer and Its Introduced Larval Parasitoids in the Northeast

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Three larval parasitoids (Hymenoptera) have been introduced to the U.S. for biological control of emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae). One species, *Tetrastichus planipennisi* Yang (Eulophidae) appears to be establishing well, while another, *Spathius agrili* Yang (Braconidae) does not appear to be establishing in northern states. Climate matching suggests a recently discovered species, *S. galinae* Belokobylskij and Strazanac, may be better suited for northern climates than *S. agrili*. We conducted phenology studies at 3 scales in Syracuse, NY (growth chambers, an open-air insectary, and caged trees in the field) to document phenology of the larval parasitoids in the northeast to determine if asynchrony between parasitoid and host development or climate could have an impact on establishment. Insectary and growth chamber studies indicated *S. galinae* and *T. planipennisi* were well-adapted to the northeast as both species started emerging before EAB, suggesting they can take advantage of EAB developing with 2-year life cycles, and they completed multiple generations in 1 season. Field studies also suggested both species are well adapted to fall temperatures in the northeast and could reach overwintering stages even when eggs were oviposited later in the fall as temperatures began to decrease. On the other hand, *S. agrili*, emerged after EAB, partially completed only 1 generation, and had difficulty overwintering. This parasitoid is from a more southern climate in China and appears to be asynchronous with both EAB development and climate in the northeastern US. The results from this study suggest *T. planipennisi* and the recently discovered *S. galinae* will be important biological control agents of EAB in northern North American climates.

Integrating Insecticide Treatments and Biological Control for Controlling Emerald Ash Borer in Urban Environments

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Emerald ash borer (EAB), *Agrilus planipennis*, parasitoids are establishing in many states, parasitism rates are increasing and the density of EAB is declining. This is generally good news, except that in these forest environments most of the large ash trees have died due to EAB damage in spite of parasitoid releases. By the time populations of EAB are discovered there are millions of EAB against which we are releasing thousands of parasitoids. Treatment of large ash trees is not economically feasible in most forest settings, but in urban environments city managers often choose to protect a portion of the trees from damage due to EAB by injecting systemic insecticides. This research centers on the effectiveness of the combination of the insecticide plus biocontrol treatments with the hypothesis that chemical treatment will protect the ash long enough for the parasitoid populations to increase sufficiently in the environment to continue protecting the ash (particularly larger ash trees). Three species of EAB parasitoids were released in each of 3 U.S. cities: Syracuse, NY; Naperville, IL; and Boulder, CO. At each location we released 2 larval parasitoids, *Spathius galinae* (~2,000 females released) and *Tetrastichus planipennisi* (~5,000 females released), and 1 parasitoid that attacks EAB eggs, *Oobius agrili* (~2,200 females released) in 2015 and 2016 (*S. galinae* was also released in 2017). Fifty trees in 3 categories (treated indefinitely, treated once, and not treated) were established in each of the release and control locations. To document the dispersal of parasitoids, 30 yellow pan traps were placed on infested but living ash trees on a grid throughout both the release and control plots. Health of each tree as it pertained to infestation by EAB (crown class, bark splits, epicormic shoots, d-shaped exit holes) and in the first 2 years 2 branches from a sub-set of the trees were collected to record EAB density and levels of parasitism). *Tetrastichus planipennisi* has shown a remarkable ability to establish and spread throughout urban environments. We have had less success capturing *S. galinae* and *O. agrili* in the yellow pan traps, but branch sampling will pick up the larval parasitoids, and in 2018 we will scrape ash bark to recover EAB eggs to determine levels of parasitism. In the next year or 2 we will determine if we think *T. planipennisi* is sufficiently established and we will start withholding insecticide treatment from half of the treated trees. We will then continue to monitor ash health and EAB density and parasitism to determine the validity of our hypothesis.

Landing Rate of the Walnut Twig Beetle, *Pityophthorus juglandis*, on Two Western North American Walnut Species, *Juglans californica* and *J. major*

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The walnut twig beetle (WTB), *Pityophthorus juglandis*, vectors a phytopathogenic fungus, *Geosmithia morbida*, which causes Thousand Cankers Disease (TCD) in walnut trees, *Juglans*. We are investigating the susceptibility of 2 walnut species native to the western U.S. (*Juglans californica* and *J. major*) by comparing WTB flight and landing responses to small diameter branch sections. Twenty unbaited branch sections (10 each of *J. californica* and *J. major*) were presented in a completely randomized design to populations of WTB at the USDA ARS National Clonal Germplasm Repository *Juglans* collection located at Wolfskill Experimental Orchards (Winters, California) and at the Agricultural Teaching and Research Center (ATRC) in Chico, California. Stickem-coated acetate sheets were placed around the branch sections and exchanged weekly. Three assays were completed at Wolfskill (Assays 1–3), and 1 assay was completed at ATRC (Assay 4). Landing rates on these traps were compared between *J. californica* and *J. major*. An additional assay (Assay 5) was completed at Wolfskill to compare responses to *J. californica* and to a similarly sized cardboard tube (negative control). A statistical analysis that pooled results from Assays 1–3 showed a preference by WTB for *J. californica*. However, in Assays 4 and 5 WTB showed no preferences between treatments, perhaps due to the low population densities of WTB flying during the assays. The fruit-tree pinhole borer (an ambrosia beetle), *Xyleborinus saxeseni*, showed relatively higher flight responses during all assays, which suggests a higher population density or a greater sensitivity to host volatiles. The flight responses of WTB recorded in some of the assays during this study indicate that host preference by this pest may be determined by long-range olfactory cues.

Highlights of Alaskan Forest Entomology History

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Some highlights of the growth and development of forest entomology in Alaska are presented as a timeline of history. These were gleaned from written published and unpublished reports and correspondence, mostly by USDA Forest Service scientists working in the state. A complete bibliography was compiled by Ken Zogas, long-time, now retired, technician to the Forest Health Protection group in South-central Alaska. Over 600 events are documented in Ken's bibliography, and many of these are considered significant to the growth and development of forest entomology in Alaska. The sequence of these events is divided into 6 eras based largely on the dominant scientists and insect pests active in Alaska at the time: Pre-

recorded (Pre-1922), Pre-McCambridge (1922–1952), McCambridge/Downing (1952–1960), Crosley (1961–1976), Werner/Holsten (1977–2004), and current (2004–present). Undoubtedly, more reports will yet be found from other sources. One intention of this work is to present a framework to which these and future reports can be added when they are found.

Western Forest Insect Work Conference Founder's Award: An Amazing Legacy

Founder's Award Committee

Western Forest Insect Work Conference

The Founder's Award is bestowed to an individual who has significantly advanced forest entomology in western North America. The award recognizes contributions in the areas of pest management, extension-consultation, research and teaching. We highlight the amazing legacy of the award and include pictures of prior recipients. From 1991 to 2018, there have been 25 recipients who embody the evolution of western forest entomology. For more information concerning Founder's Award recipients and how to submit a nomination please visit the WFIWC website (http://www.wfiwc.org/awards/founders-award). We acknowledge and appreciate the assistance of the Technology Committee in recording and uploading recent Founder's Award presentations.

Spatial and Temporal Analysis of Mortality Factors in Washington and Oregon Forests, 2007–2017

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Increased tree mortality has been observed across the western U.S. over the last 40 years. Some areas seem to be conducive to persistent large-scale biotic disturbance events (i.e., hotspots), while others seem resistant to these events (i.e., coldspots). It is unclear how these phenomena are spatially and temporally distributed throughout the western U.S. and what mechanisms underlie these distributions. We used aerial detection survey, the National Land Cover Database 2011, and PRISM climate group data to link biotic disturbance, forest cover, summer precipitation, and January minimum temperature within 10 × 10 km-grid cells across Washington and Oregon from 2007–2017. The upper 20th damage percentile (hotspot) and lower 20th damage percentile (coldspot) were spatially autocorrelated but negatively spatially cross-correlated. Expectations were that increased summer precipitation would reduce biotic disturbance, while increased forest cover and January minimum temperatures would increase biotic disturbance. Generalized linear model estimates (fitted for each year) showed that forest cover was the only covariate that consistently and significantly explained increased biotic disturbance. January minimum temperature had a significant negative effect on biotic disturbance for all years, while summer precipitation had a significant negative effect in some years. Results reveal expected and

unexpected patterns in biotic disturbance, illustrating the need for further large scale, long-term spatiotemporal analyses of disturbance in the iconic forests of western North America.

Survival of Jeffrey Pine (*Pinus jeffreyi*) and Coulter Pine (*Pinus coulteri*) Following Prescribed Fire, Wildfire, and Bark Beetle (Scolytinae) Attacks in Southern California

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Bark beetles commonly exploit trees with reduced host defenses, including overmature pines and pines injured by fire. Wildfires are a common disturbance agent and prescribed burns are common forest management techniques in the western U.S. In January 2014, we tagged and evaluated 191 Coulter pines with various levels of crown scorch in the 2013 Mountain Wildfire on the San Bernardino National Forest (SBNF/BDF). In May 2015, we tagged and evaluated 354 Jeffrey pines within 2 prescribed burns conducted in 2015 in the Wooded Hills area of the Cleveland National Forest (CNF). For each tree in the wildfire area, we measured the DBH, percent crown scorch, height, and bark beetle activity observed. The same measurements were collected for the tagged trees in the prescribed burn in addition to tree and base crown height and bole scorch height. We reevaluated the status of all tagged trees in June 2015, October 2015, November 2016, and October 2017. The objective of this research was to determine the survival of Coulter and Jeffrey pines following wildfire and prescribed fire and subsequent bark beetle (*Dendroctonus valens*, *Ips paraconfusus*, and *Dendroctonus brevicomis*) attack in southern California. Of the 191 Coulter pines, 56% died within the first 2 years after the wildfire. The majority of the dead trees were attacked by *Dendroctonus brevicomis* and *D. valens*. Of the 354 Jeffrey pines, 37 died across both sites (10%). *Ips paraconfusus* attacks on Jeffrey pine were greater in smaller-diameter trees (25.4–76.2 cm). *Dendroctonus valens* attacked 75 Jeffrey pines (21%) with attacks occurring in trees <50.8 cm and greater than 101.6 cm DBH. The findings from this study can inform forest management activities such as removal of hazardous trees and salvage logging.

Protecting Whitebark Pine from Mountain Pine Beetle with SPLAT® Verb

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Verbenone is the most effective anti-aggregation pheromone for protecting pines from mortality attributed to mountain pine beetle (*Dendroctonus ponderosae*, MPB) infestation. Verbenone applied in 7 or 7.5-g pouches has been used for many years to protect high-value whitebark pine.

SPLAT® Verb, a new formulation of (–)-verbenone (Fettig et al. 2015), has been consistently successful in protecting lodgepole pine from MPB. We examined the efficacy of SPLAT® Verb for protecting whitebark pine in MT, OR and CA, 2015–2017. Different doses of SPLAT® Verb along with 7-g pouches were tested on individual trees baited with a MPB attractant at Branham Lakes, MT. No verbenone-treated trees were mass attacked by MPB compared to 90% mortality of baited-control trees. Verbenone treatments were not significantly different from each other. Pouches and SPLAT® Verb with the same amount of active ingredient were also tested on 0.41-ha plots on Strawberry Mtn., OR and Ball Mtn., CA. SPLAT® Verb was applied with a caulking gun with 1 dollop placed on 4 sides of each tree. One pouch was stapled to the north side of trees. The center of each plot was baited with a MPB attractant except in OR where high beetle populations occurred in the surrounding area. The percentage of mass-attacked trees was greater in control plots than verbenone-treated plots. However, the percentage of mass-attacked trees was <10% in the control in both CA and OR.

Drosophila suzukii in the Grande Ronde Valley

Marisa E. Mode and Robert A. Progar

Pacific Northwest Research Station, USDA Forest Service

Drosophila suzukii, known as the spotted wing drosophila is a species native to Japan. *D. suzukii* made its first appearance in the U.S. in the 1980s in Hawaii. In 2008, *D. suzukii* was first found in the Continental U.S. in raspberry and strawberry fields in California. Since then it has progressively invaded many parts of the U.S., as well as other countries. *D. suzukii* is not limited to agricultural crops. Homeowners in the Grande Ronde Valley of eastern Oregon have been noting larvae in small fruits grown on their property. There is concern of *D. suzukii* infesting wild fruits such as huckleberries, currants, snowberries, choke cherries, elderberries, etc. that are harvested by local peoples. We placed 20 Pherocon SWD traps consisting of 2 broad spectrum lures within 4 different transects (containing 5 traps each) at different elevations near wild and native fruit. These transects were placed NE, NW, SE, and SW of La Grande, Oregon. Each week the traps were collected and then taken to the lab, in order to evaluate the samples, and record the presence of *D. suzukii*, other fruit flies as well as other insects. The samples were collected for 8 weeks and the baits were replaced 3 times. We found *D. suzukii* at each transect, however the largest population occurred along the transect SE of La Grande.

The Commercial and Entomological Impact of Bundling in Thinning Operations

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Thinning is a common practice in northern Arizona, where whole trees of various sizes are felled and piled in "bundles" by a feller buncher. Based on current contractual policies, loggers are required to remove felled wood materials from the forest within 60 days. Although thinning is vital to restore the long-term sustainability of forests in Arizona, a proper analysis on the impact of bundling and 60 day removal process upon wood-infesting organisms has not been conducted in this region. We are studying 1) the impact of bundling on wood-infesting organisms, particularly bark beetles, ambrosia beetles, and wood borers, along with their natural enemies, and 2) the impact of bundling on the wood drying process to determine the optimal time for removal. We monitored 5 bundles at 3 different sites between the end of June 2017 and the present and documented insect activity and wood drying rates. Our preliminary results indicate that wood-infesting beetles tend to prefer bundles based on location along the tree stem, presence of branches, and seasonal conditions such as temperature, humidity, and precipitation. Wood drying depends on the same seasonal factors but the presence/absence of branches has little impact on drying rates of tree materials. Initially, our measurements displayed around 45% moisture content (wet basis) which decreased to around 35% by the third week after site set-up, same week when we recorded bark beetle attacks for the first time. We hope our results provide information to help contractual policies promote forest health while supporting sustainable and profitable practices among the local timber industry.

Delayed Tree Mortality, Bark Beetle Activity, and Regeneration Dynamics Influence Resiliency and Recovery Following the Wallow Fire, Arizona, U.S.

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Warm/dry mixed-conifer forests have undergone changes in disturbance regimes, forest structure, species composition, and surface fuel accumulation which have led to increased susceptibility to large, uncharacteristically severe fires and pathogenic outbreaks. Fuel reduction treatments are often placed adjacent to high-value areas, such as communities and infrastructure and can be effective at reducing fire severity and allow for safe suppression activities. We revisited warm/dry mixed-conifer stands treated prior to the 2011 Wallow Fire and paired untreated sites 5 years following the fire. Our objective was to evaluate ecosystem resiliency in terms of forest structure, bark beetle activity, and tree regeneration. We hypothesized that treated units would have higher mid-term post-fire resiliency compared to untreated units. Twice as many trees were attacked by bark beetles in treated versus untreated units suggesting treatments may have reduced post-fire beetle activity. Following wildfire, conifer regeneration decreased and hardwood regeneration increased with higher burn severity; conifer regeneration was nearly 3 times higher in treated units. Areas that were treated prior to the 2011 Wallow Fire remained more resilient by 2016 compared to untreated units in terms of forest structure, bark beetle activity, and regeneration. This study suggests that pre-fire fuel reduction treatments maintained mid-term ecosystem resiliency following the Wallow Fire, thus adding resiliency to future uncharacteristic wildfire, insect outbreaks, and potential climate change impacts.

Does Radial Thinning Enhance Large Sugar Pine? Survival, Growth, and Regeneration at 5, 9 and 16 Years Post-treatment

Don Goheen (retired), Bill Schaupp, Ellen Goheen and Bob Schroeter

Forest Health Protection, USDA Forest Service

The Wolfpine Thinning Evaluation was initiated in 1997 in 10 forest stands in the Little River Adaptive Management Area on the Roseburg District Bureau of Land Management and North Umpqua Ranger District, Umpqua National Forest. Dense mixed conifer/hardwood forests composed of Douglas-fir, white fir, western hemlock, incense cedar, western red cedar, sugar pine, ponderosa pine, Pacific dogwood, bigleaf maple, Pacific madrone, canyon live oak, and golden chinquapin occur in the area. As elsewhere in Southwest Oregon, the sugar pine components of these forests have exhibited substantial mortality in recent decades. Infestation by mountain pine beetle (*Dendroctonus ponderosae*, MPB) has been the direct cause of most mortality of mature sugar pines. The Wolfpine thinning study was established to test how changes in tree density around large sugar pines might influence their vitality and hence susceptibility to MPB infestations or the impacts of other mortality agents over time. The study consisted of 4 treatments with individual large sugar pines serving as treatment foci:

Treatment 1–Control: no clearing under the focal sugar pine’s crown or within 25 feet of its drip-line

Treatment 2–Compressed-Radius Clearing: complete removal of trees and shrubs under the focal sugar pine’s crown and within 10 feet of its drip-line

Treatment 3–Extended-Radius Clearing: complete removal of all trees and shrubs under the focal sugar pine’s crown and within 25 feet of its drip-line

Treatment 4–Extended-Radius Clearing with Large Trees Retained: as in (3) above but retaining all trees of any species 25 inches or greater dbh within the otherwise cleared area around the focal sugar pine

Between pre-treatment data collection in 1997 and when all treatments were finished in 2001, there were 229 sample sugar pines remaining. After 5 and 9 years, it appeared that thinning around large sugar pines contributes to increased growth, decreases likelihood of bark beetle infestation, and promotes sugar pine regeneration. The extended radius clearing with reserve trees retained continues to show evidence of being the best for the objective of retaining large, old sugar pines in mixed stands and at the same time promoting adequate new sugar pine regeneration. However, at 16 years, substantial MPB-caused tree mortality has occurred in treatments 2 and 3 and may be associated with recent severe, warm droughts.

Tree Mortality Following the Pine Butterfly (*Neophasia menapia*) (Lepidoptera: Pieridae) Outbreak in the Malheur National Forest, Oregon

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Pine butterfly (*Neophasia menapia* C. Felder and R. Felder) (Lepidoptera: Pieridae) can be a serious defoliator of ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) in western North America. From 2008 to 2012, the Malheur National Forest was subject to an outbreak of pine butterfly in ponderosa pine, peaking at ~100,000 ha of forest visibly defoliated in 2011. Whether or not trees die following such outbreaks has been a subject of debate for decades, and so far no consensus has emerged. We monitored 441 sample trees from 15 randomly-located plots for mortality from 2012 until 2016, post outbreak. Within this population, 35 trees died giving an annual mortality rate of 2.05% - a relatively low number indicating that the outbreak did not cause massive tree mortality in the short term. However, then a drought intensified and western pine beetle (*Dendroctonus brevicomis*, WPB) caused significant tree mortality. The highest levels of WPB-caused tree mortality occurred in areas with the most years of defoliation. From this single case study, we conclude that weather following a defoliation event is an important variable that may influence whether tree mortality will occur, but defoliation severity and number of years of defoliation also matter.

WEDNESDAY'S FIELD TRIP

Denver Parks and Recreation (Forestry) and Denver Museum of Nature and Science

GROUP PHOTOGRAPHS

Back: David Shaw, Jeff Hicke, Derek Uhey, Marcos Thiquiline, Greg Zausen, Steve Munson
Front: Samuel Ward, Jacob Wittman, Bill Riel, Joel McMillin, Monica Gaylord, Liz Graham

Back: Andy Graves, Don Grosman, Tom Valentine, Robbie Flowers, Lorraine Maclauchlan, Darren Blackford
Front: Cindy Snyder, Jim Kruse, Joel Egan, Chris Fettig, Karen Ripley, Beverly Bulaon

Back: Alek Pane, Bob Cain, Sheri Smith, Bill Schaupp, Steve McKelvey, Stanley Pokorny
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