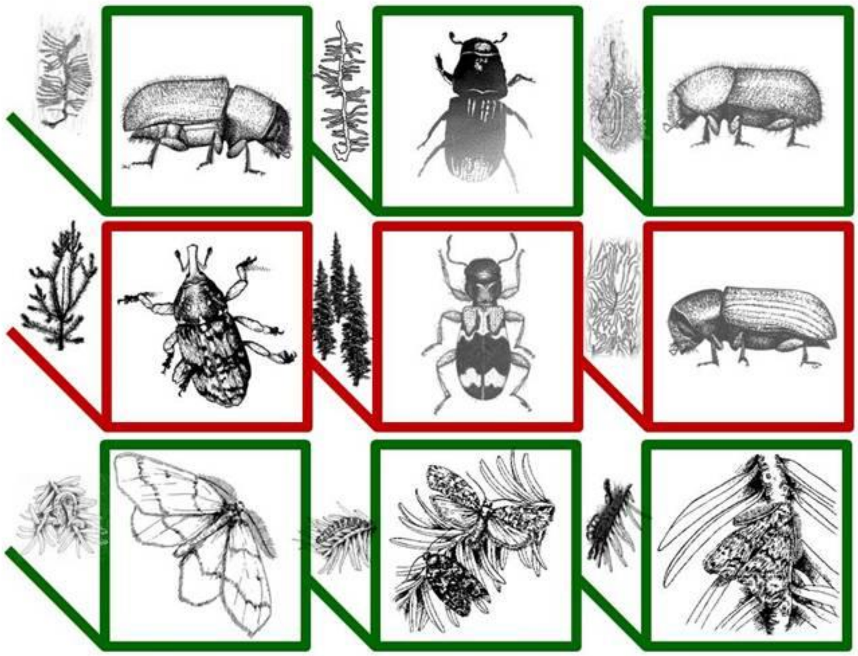
CUMULATIVE EFFECTS OF INSECT OUTBREAKS



63rd Western Forest Insect Work Conference
Penticton, British Columbia
March 26-29, 2012

Disclaimer

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Western Forest Insect Work Conference Executive

Chair	Rich Hofstetter
Past Chair	Kathy Sheehan (2010)
Secretary	Darci Carlson
Treasurer	Glenn Kohler (for Karen Ripley)
Councillor	Steve Cook
Councillor	David Jack
Councillor	Jennifer Burleigh

Penticton Conference

Local Arrangements	Lorraine Maclauchlan, Joan Westfall
Program Committee	Kathy Bleiker Jennifer Burleigh Tim Ebata Erin Havard Robert Hodgkinson Lorraine Maclauchlan Lisa Poirier Art Stock Ward Strong Joan Westfall Ken White

Registration desk WFIWC 2012

Table of Contents

Conference Program

Date	Time	Title	Moderator
March 26	13:30 – 20:00	Registration	
	16:00 - 18:00	Executive Committee Meeting	Richard Hofstetter
	18:00 – 20:00	Welcome Reception	
March 27	8:00 – 8:15	Opening Address	Richard Hofstetter
	8:15 – 10:15	Plenary Session I:	
		Cumulative Effects and Impacts	Ken White
	10:45 – 11:15	Memorial Scholarship Presentation	Christopher O'Connor
	11:15 – 12:00	Initial Business Meeting	Richard Hofstetter
	13:30 – 15:00	Graduate Student Presentations	Jennifer Burleigh
	15:30 – 17:00	Workshops I:	
		Forest Health Conditions Report	Tim Ebata
		High Elevation/High Latitude Insects in the West	Andy Eglitis
		"Crock pot" of Forest Entomology	Chris Fettig
	18:30 – 20:30	Silent Auction	Valent BioSciences
March 28	8:00 = 9:30	Workshops II:	
		Cone and Seed Pests	Ward Strong
		Defoliator Outbreaks in Western Conifers: Past, Present and Future	Rob Flowers
		Spatial Dynamics of Outbreaking Bark Beetles	Joel Egan
	10:00 – 12:00	Plenary Session II	
		Evidence of Changing Climate Influencing Outbreaks and Impacts	Chris Fettig & Mary Reid
	13:30 – 17:00	Tours	
		Pacific Agri-Food Research Centre Tour	
		Naramata Bench Winery Tour	
	18:00 – 21:00	Banquet and Founders Award	Ed Holsten & Richard Werner
March 29	8:00 - 9:30	Workshops III	
		Genetics of Tree/Pest Interactions	Ward Strong
		Sawflies: The Other Defoliators	Kathy Sheehan
		"Catching up with Bark Beetles (or not)"	Iral Ragenovich
	10:00 – 11:30	Workshops IV	
		Bark Beetle Range Expansions and Risk Assessments	Glenn Kohler
		Aerial Surveys: Comparison across all Borders	William Ciesla & Janice Hodge
		Poster Session	Kathy Bleiker
	11:30 – 12:00	Final Business Meeting	Richard Hofstetter
		Adjourn	

General Meetings

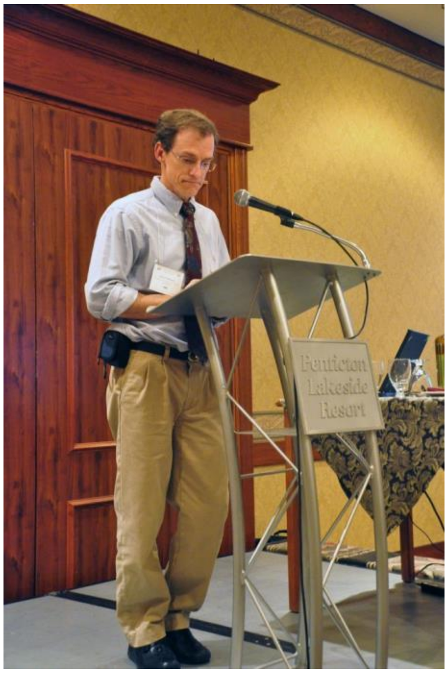
Executive Committee Meeting

26 March 2012

Rich Hofstetter called the meeting to order at 4:05 pm.

Present:

Rich Hofstetter: WFIWC 2012 Chair



Bill Ciesla: Common Names Committee
Glenn Kohler: Treasurer (for Karen Ripley)
Lorraine Maclauchlan: Local Committee Report
Darrell Ross: Memorial Scholarship Committee
Steve Cook: Memorial Scholarship Committee (for Barb Bentz)
Sandy Kegley: History Committee
Joel Egan: Ad hoc
Darci Carlson: Secretary
Jennifer Burleigh: Councillor
David Jack: Councillor

Darci Carlson read 2010 Final Business notes – accepted by Rich Hofstetter, seconded by Darrell Ross.

Lorraine Maclauchlan (Local Committee)

Lorraine reported on this 2012 meeting. 100 attendees (approx.) – Close to break-even due to travel restrictions - Final numbers will be forthcoming.

No field trips due to weather and road conditions. However, two tours are offered: one to the Pacific Agri-Food Research Centre (Summerland Research Station) and the other a winery tour of the Naramata Bench.

Members who have passed on – (Last 2 years)
William Barr, Ken Graham, Scott Tunnock, Sheryl Costello, Peter De Groot, Gary Grant, and Edwin Donaubauer.

Recent Retirements (Last 2 years) – Leo Rankin, Bruce Hostetler, Don Goheen, Ed Holsten, Fred Hain, Mark Shultz, Jan Volney

Darrell Ross (Memorial Scholarship Committee)
5 applications were reviewed in 2011. The committee selected Christopher O' Connor (PhD Student at University of Arizona) for 2011 Scholarship.
4 applicants for 2012 – Ryan Bracewell – University of Montana was selected.

Bill Ciesla (Common Names Committee)
– 5 species of sawflies were submitted for common names.

- *Neodiprion edulicolis Ross* – pinyon sawfly
- *N. autumnalis* Smith – autumn ponderosa pine sawfly
- *N. annulus contortae* Ross – northwestern pine sawfly
- *Zapdiprion rohweri* (Middleton) – Rohwer's pinyon sawfly
- *Z. townsendi* (Cockerell) – bull pine sawfly

During March 2009-2010, five common names were submitted and approved:

Agrilus coxalis Waterhouse – gold spotted oak borer
Dasychira grisefacta (Dyar) - western pine tussock moth
Ips hunter Swaine – blue spruce engraver
Ips pertubatus (Eichoff) – northern spruce engraver
Lophocampa ingens (Hy. Edwards) - southwestern pine tiger moth

Sandy Kegley (History Committee)

Professor Garth Reese, University of Idaho, head of Special Collections Library, visited Mal Furniss to become acquainted with the historical forest entomology material that Mal has accumulated. Mal provided Garth with his publications on the development of forest entomology in America, including the creation of a forest insect field station at Coeur d' Alene in 1919 by J.C. Evenden. Mal plans to encourage the library to create an online catalog with links to the WFIWC website.
A photo of James A. Beal (1933) climbing a pine tree to sample western pine beetle was seen on the Photo/History link on the WFIWC website and requested for use in a YouTube video. A fee for use of the photo will benefit the Scholarship fund.

Sandy Kegley & Mal Furniss are preparing a presentation highlighting the history of the Coeur d'Alene Field Station established by Evenden, and the early days of Forest Entomology. The house where Evenden lived still exists and will be a short walk from the 2013 conference venue.

Mal published an oral history of Ralph C Hall – A pdf copy is available at www.foresthistory.org/Research/Hall_Ralph_C_ohi.pdf

"Beginnings of Forest Entomology in Alaska" was published in eMagazine, Sour Dough Notes. The story concerns a spruce beetle outbreak, which was investigated by Robert L. Furniss and which led to Bill McCambridge, the first forest entomologist being stationed in Juneau, Alaska in 1952. Kathy Sheehan set up a vignettes link to the WFIWC web page, including initial articles by Mal Furniss on the recollections of Mr. McCambridge.

Glenn Kohler (for Karen Ripley) (Treasurer's Report)
Balances for Jan. 1, 2012 are as follows:
2012 – Checking - $8,062.62 Savings – $95,904.20 CD's - $11,992.03 Total = $115,271.00
Glenn gave the Councillors the banking records to review with Rich Hofstetter before the end of the 2012 meeting.

Issues/Events
NAFIWC earned $14,440 and $400 in Charity revenue (NAFIWC)
Options as to what to do with revenue
Option A – Divide among conferences
Option B – Hold until NAFWIC in 2016
Option C – Divide only charity now
Sheryl Costello Memorial Donations - $2050
Other Donations for Gary Daterman, Dave Schultz, & Dick Mason
Mal Furniss - Sold the rights to use a photo (James Beal WFIWC archives) - $50

Steve Cook (for Barbara Bentz) (Memorial Scholarship Committee)
73 items were donated to silent auction-highest bid Tohono Odham basket
Steve will collect items for this silent auction & memorial scholarship donations

Rich Hofstetter (Founders Award Report)
Skeeter Werner and Ed Holsten – will present at the 2012.
Ken Gibson will receive the Founders Award in March 2013.
It was determined that a Founders Award will no longer be awarded on a year before NAFIWC.

New plaques for the Founders Award were made this year due to the old one being full – Cost was $904.20 for three plaques, which are displayed at this meeting.

***To be discussed** – One night lodging given to Founders Award recipients as has been done in the past.

Joel Egan (Ad Hoc)

Joel submitted a request to digitize special presentations. The Ad Hoc Committee sent out a "Survey Monkey" survey and a vote was taken by the WFIWC members. Approximately 35% of WFIWC members responded, or 70 people. It was decided that this year's Founders Award speech (2012) would be digitized. The Committee did not recommend broadcasting the WFIWC Proceedings. Instead, a strategic recording of the Founders Award and possibly special Plenary Sessions was recommended.

The survey report questions were discussed.

Travel restrictions may affect attendance. More people may want to see portions of the WFIWC remotely, using technology used by the Ad Hoc Committee. Most WFIWC members were interested in the Founders Award, Plenary Sessions and Concurrent Sessions being digitized. There is concern that further recording will result in less attendance. However, studies show that face-to-face contact is the preferred medium for technology transfer.

These results will be reviewed.

Some of the Equipment used at the current WFIWC to record the Founder's Award was bought by Region 5, to use for both WFIWC 2012 and 2013. It was asked: "what is the availability of this equipment? What is cost of equipment rental? Should we buy it for WFIWC meetings?" Cost benefit report available from Ad Hoc Committee. (notes)

Ad Hoc Committee Discussion:

(Darrell Ross) Who will record future meetings? What will cost be? How will it be paid for?
(Bill Ciesla) It may be hard to pull off, but we should try it out.
(Lorraine Maclauchlan) – The hard part will be archiving these recordings.
(Jennifer Burleigh) Could this draw in more people, more viewing during travel restrictions?
(Bill Ciesla)– If you don't need to go to meeting –and you can watch the recording, managers may not let people attend, which Glenn Kohler confirmed, saying that if there is another way to view a conference, then the state folks cannot attend.
(Rich Hofstetter) So, should we pursue recording the Founders Award Speech, but use caution with recording other parts of WFIWC?

Joel will track how much time it takes to splice and dice the recording, and will post results on the WFIWC website with Kathy Sheehan.

New Business –

(Darrell Ross) Concerning the NAFIWC funds, Karen's report lists only one feasible option (Option B), because NAFIWC is not a big WFIWC. It is separate.
This is the 62nd WFIWC. NAFIWC does not count as a WFIWC…WFIWC has different constitution and rules from NAFIWC.
We have the opportunity to pass forward money made to the next NAFIWC – which has not been done in the past – speaker costs, etc. WFIWC should not decide how to use NAFIWC funds.

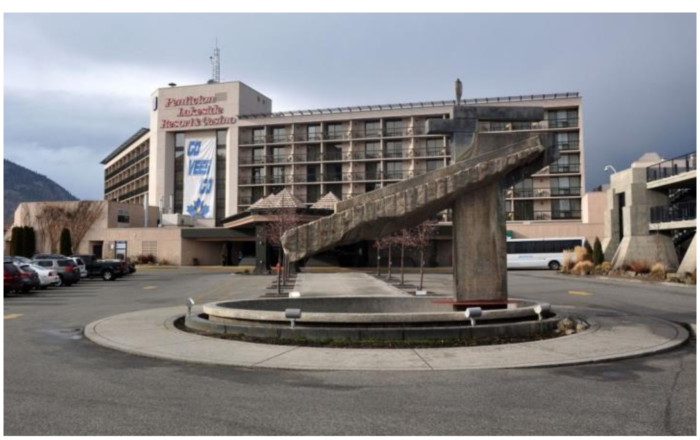
1) Motion put forward by Bill Ciesla - WFIWC should hold money until next NAFIWC in a separate account as seed money for NAFIWC (including $400.00 donation made during NAFIWC) – Seconded by Sandy Kegley.

2) More discussion needed – Motion put forward by Jennifer Burleigh (seconded – Bill Ciesla).

Audit issues (Steve Cook) – should be separate account for NAFIWC.
Are we going to be the banker for NAFIWC ? (Jennifer)
Non-profit status?

3) Recommend there to be ***No Founders Award*** prior to NAFIWC – They are separate. Barbara Bentz brought up Jennifer Burleigh seconded – discussion.
4) Free night for Founders? – Up to the discretion of organizers
5) Replace Councillor (Sheryl Costello) – interim Steve Cook (Rich H. appointed)
6) Jennifer Burleigh should be replaced, as Councillor for 3 meetings
7) Darci Carlson should be replaced as Secretary for 2 meetings
8) Next year in Coeur d' Alene – what about 2014?

Bill Ciesla, motioned to adjourn. David Jack seconded (5:45 PM).



Initial Business Meeting

March 27, 2012

Rich Hofstetter called the meeting to order at 11:35 a.m.

WFIWC Members who have retired in the last 2 years are as follows - Leo Rankin, Bruce Hostetler, Don Goheen, Ed Holsten, Fred Hain, Mark Shultz, and Jan Volney.

WFIWC Members who have passed on in the last 2 years include - Sheryl Costello, William Barr, Ken Graham, Scott Tunnock, Peter De Groot, Gary Grant, Edwin Donaubauer, and Tom Leurent - a moment of silence was observed for these members.

Darrell Ross - Read the Scholarship Committee Report.

> He announced that Ryan Bracewell (PhD student at University of Montana) was the 2012 recipient and will have the opportunity to present at the 2013 WFIWC meeting.

Sandy Kegley –Read the History Committee Report.

Bill Ciesla –Read the Common Names Committee Report.

Barbara Bentz –Read the Founders Award Committee Report.

> She announced Ken Gibson as the 2012 Founders Award Recipient. He will have the opportunity to speak at the 2013 WFIWC meeting.

Steve Cooke – Read the Memorial Scholarship Report.

Announced Silent Auction’s proceeds from this year will to the Sheryl Costello Memorial Fund

Glenn Kohler – Read Treasurer’s Report

Joel Egan – Read Ad Hoc Report.

Lorraine Maclauchlan - Read the Local Committee Report.

These reports will be available online on the WFIWC website.

No Old Business to report.

New Business

Steve Cook will act as interim Councillor for Sheryl’s last year (appointed by Rich Hofstetter, President WFIWC)

Need a new Councillor to replace Jennifer Burleigh for a 3-year term – Volunteers Welcome.

Need a new Secretary to replace Darci Carlson for a 2-year term – Volunteers Welcome.

March 4-8 2013 WFIWC Meeting will be in Coeur d’ Alene, ID

Again, welcome new WFIWC Members!

Motion to adjourn Rich Hofstetter, Seconded by Joel Egan - Closed at 11:54 a.m.

Final Business Meeting

29 March 2012

Rich Hofstetter called the meeting to order at 11: 36 a.m.
Rich suggested we thank the Local Arrangements Committee – all Members applauded.

Lorraine Maclauchlan

Beautiful Penticton, BC

Joan Westfall

Rich suggested that WFIWC Members thank the hotel staff - all Members applauded.
Darci Carlson, WFIWC Secretary, read the Initial Business Meeting notes.

The Local Arrangements Committee reported that $1600 was raised during this year's WFIWC meeting. As well, $500 was raised for the Memorial Fund and $800 was raised at the Silent Auction, which will be donated to the Memorial Scholarship in Sheryl Costello's name for 2012.

The silent auction and delicious food sponsored by Valent BioSciences

Abstracts and submissions to be given to Lorraine Maclauchlan. Lorraine will send a reminder.

New Business

Next WFIWC Meeting will be held in Coeur d'Alene in 2013.

Sandy Kegley reported on upcoming events for the 2013 WFIWC Meeting. There will be a photo contest at the 2013 WFIWC Meeting. Suggestions for the 2013 Meeting are welcome.

Rich summarized the 2011 NAFIWC Meeting. The question was raised as to what should be done with money earned at NAFIWC.

It was determined that a Founders Award will not be awarded the year before a NAFIWC. However, a Student Award will be given every year, so there may be two student speakers on a year after a NAFIWC Meeting.

Rich Hofstetter asked WFIWC Members for any further **New Business**:

Kathy Sheehan asked "who will host the 2014 WFIWC Meeting?" Kathy suggested that Region 5 should be the host. Kathy Sheehan motioned to accept that Region 5 be the 2014 host of WFIWC, and Iral Ragenovich seconded the motion. The Executive Committee will contact Region 5 to confirm that they will host the 2014 Meeting.

Amy Gannon put forth a motion to name the Annual Fun Run the "Sheryl Costello Fun Run". Kathy Sheehan seconded the motion.

Jennifer Burleigh put forth a motion to nominate Glenn Kohler as Councillor for a three-year period. Steve Cook seconded the motion. Glenn Kohler accepted the nomination.

Darci Carlson put forth a motion to nominate Laura Lazarus as WFIWC secretary for a two-year term. Steve Cook seconded the motion. Laura Lazarus accepted the nomination.

Rich Hofstetter asked for any other new items. No WFIWC Members responded. The Local Committee was again thanked for a great 2012 WFIWC.

Kathy Sheehan motioned to end the 2012 WFIWC Meeting. Andy Graves seconded the motion.

The Meeting ended at 11:53 a.m.

Scholarship Presentation

Christopher D. O'Connor, PhD Candidate, School of Natural Resources and the Environment, University of Arizona, Tucson, AZ.

Dynamics of a spruce-fir island: interactions among spruce beetle, fire, climate, and logging in the upper elevation forests of the Pinaleño Mountains

Christopher D. O'Connor[1,2] , Ann M. Lynch[2,3], Donald A. Falk[1], and Thomas W. Swetnam[2]
[1]University of Arizona School of Natural Resources and the Environment, Tucson, AZ.
[2]University of Arizona Laboratory of Tree-Ring Research, Tucson, AZ.
[3]USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO.

The Pinaleño Mountains of southeastern Arizona contain the southernmost spruce-fir forest in North America. This geographically isolated forest system is a remnant of the Wisconsin Glaciation some 10,000 years before present. The contemporary spruce-fir forest established after a stand-replacing fire in 1685. Spruce beetle activity is documented from two twentieth century outbreaks, an early 1950s event resulting in less than 30% mortality and a late 1990s outbreak preceded by two other insect outbreaks that led to more than 85% mortality of the mature Engelmann spruce. Shortly after the collapse of the second spruce beetle outbreak, a high-severity fire in 2004 consumed 29,000 hectares of the high elevation ecosystem, resulting in the most severe contraction of the spruce-fir forest since the 1685 fire. Using dendrochronology, we reconstructed the disturbance events and stand dynamics that followed the 1685 fire, and examined relationships among stand composition, climate, fire and insect outbreaks during the spruce-fir forest expansion period leading up to the past two decades of severe insect outbreaks and fire. The 1685 fire event occurred in the most severe west-wide drought of the last 500 years. The 2004 fire took place under moderate drought

conditions, suggesting that additional factors may have contributed to the spread of fire from lower elevations.

While the recovery of the spruce-fir forest following the 1685 fire is one model for the next several hundred years of spruce-fir dynamics in the Pinaleño Mountains, recent changes to climate and disturbance regimes coupled with a century of human-mediated modification of forest structure suggest an alternative possibility. If fire or insect mediated disturbances become more frequent or severe in the 21st century, the mixed conifer forest type common at lower elevations may encroach on the spruce-fir forest, resulting in a long-term shift from a bark beetle mediated to a fire mediated system.

Founders Award Address

The 2012 Founders Award Addresses by Skeeter Werner and Ed Holsten are available on the WFIWC website at http://www.fsl.orst.edu/wfiwc/awards/speeches.htm . There are also videos of both presentations.

Steve Seybold, Skeeter Werner, Ed Holsten and Andy Graves at the Founder's Award Banquet

Standing ovation for the Founder's Award recipients at 2012 WFIWC

Plenary Session I – Cumulative Effects and Impacts

Moderator- Ken White: BC Ministry of Forests Lands and Natural Resource Operations

Presenters:

1) Ken Raffa, Entomologist, University of Wisconsin, Madison, WI.
2) Marvin Eng, Manager Special Investigations, BC Forest Practices Board, Victoria, BC.
3) Rita Winkler, Forest Hydrologist, Research and Forest Health, Thompson Okanagan Region, Kamloops, BC.

Compound effects of root herbivory: a bottom-up look at how habitat alterations at the site and landscape scales can come back to bite us.

Ken Raffa, Department of Entomology, University of Wisconsin, Madison, WI

Cumulative Effects: From Assessment Towards Management

Marvin Eng, Forest Practices Board, Victoria, BC

The Forest Practices Board has growing concerns about the cumulative effects of resource use on the land base. In our work examining forest and range practices, it is often apparent that other activities are impacting the land and water; activities not regulated under the *Forest and Range Practices Act*.

The Board undertook a cumulative effect assessment case study, in the Kiskatinaw River watershed near Dawson Creek, looking at effects of all resource development on drinking water, soil and caribou habitat. At the same time, the Board reviewed a project-specific cumulative effects assessment as part of the investigation of a public complaint about an independent power project.[i] A summary report from these separate but related processes concluded that:

- Cumulative effects assessments are often required, to obtain approval for 'major' projects, but there are significant structural impediments that limit the utility of those assessments. These include problems collecting baseline information, limited external guidance about the significance of effects and the incremental nature of decision making about individual project approvals.
- There is no requirement to assess the cumulative effects of the myriad of 'minor' activities that are continually authorized on the land. The result is that cumulative effects of the natural resource development remain largely unknown and unmanaged. A commonly proposed solution to this problem is to conduct broad scale assessments (e.g., regional strategic environmental assessments). These solutions meet with limited success because there are no institutional mechanisms to use the results of the assessments – that is, there is no one to tell.

[i] http://www.fpb.gov.bc.ca/IRC175_Forest_Resources_and_the_Toba_Montrose_Creek_Hydroelectric_Project.pdf.

- Cumulative effects assessment methods have some inherent difficulties, in large part because there is a need to consider human values in the assessment. Deciding what people value is a social, or political, process; while determining how those values are affected by human activities should be a scientific process. For a variety of reasons, this distinction is difficult to make. Once made, the assessment can be problematic because we can rarely, if ever, directly examine the effects of activities on human values so we choose indicators that represent those values. In order for those indicators to be useful we need specific and measurable objectives for them. Those objectives must include the notion of limits. Methods exist for resolving these issues.
- A fundamental requirement for cumulative effects assessment is a solid base of information about the real world. Unfortunately our information base is relatively poor and is deteriorating in some cases.

The issues with cumulative effects assessment are not primarily about the methods of assessment; they are about the need for a comprehensive land management framework in which those methods could be used. It is clear to many that "making marginal improvements in a seriously flawed cumulative effects assessment system is unwarranted."[ii]

The Forest Practices Board believes that progress can be made if cumulative effects assessment methods are appropriately embedded in a land management framework that is designed to meet the objectives society has for values on the land. Such a framework requires the following elements:[iii]

1. Government has an ongoing process for developing and articulating broad strategic direction about society's values for the land and natural resources.
2. Structures exist to ensure that decisions are made, at appropriate spatial and temporal scales, about the kinds and amounts of human activities that should take place on the land. At a minimum this requires mechanisms for setting specific and measurable objectives for the values articulated by government.
3. Private rights (and responsibilities) are issued to public land and resources within the limits imposed by objectives. This is meant to ensure that values held by society, for example cultural rights and duty to future generations, are respected.
4. Some proposed activities may be assessed to ensure that they will have the minimum negative effect and maximum positive effect on values. This function also serves as a check on whether objectives will be met.
5. Regular monitoring of actual activities and effects is done to ensure that objectives are being met. Feedback, both positive and negative, would be provided. This monitoring includes the need to continuously improve inventories of natural resources.

[ii] Duinker P. and Greig L. 2006. The impotence of cumulative effects assessment in Canada: ailments and ideas for redeployment. Environmental Management. 37(2):153–61.

[iii] This proposed framework is not particularly novel. It is similar to the "decision making continuum" described in Kennett, S. 2006 [Integrated landscape management in Canada: Getting from here to there. CIRL Occasional Paper #17] and many of the concepts in the framework are similar to those in the "Land-Based Management Statement" of the Association of BC Forest Professionals available at: http://www.abcfp.ca/publications_forms/publications/documents/Pat_Bell_LBM.pdf.

Forest Defoliation and Water Supplies

R. Winkler[1], S. Boon[2]; B. Zimonick[3], and D. Spittlehouse[1]
[1] Ministry of Forests, Lands and Natural Resource Operations, Kamloops and Victoria
[2] Department of Geography, University of Lethbridge, Lethbridge
[3] Zimonick Enterprises, Kamloops

In BC, many communities rely on water derived from mid to upper elevation snowpacks in forested watersheds. Forest cover influences water yield through its direct effect on the interception of rain and snow, evaporation, transpiration, snow melt and soil moisture. Forest defoliation following insect attack, or complete loss of cover through fire and logging, alters the amount of water accumulating as snow over winter and the rate of snow melt in spring. Extensive changes in snow accumulation and melt can affect the volume and timing of water yield downslope and downstream. Much of the current water resource research in BC, and elsewhere, is focused on quantifying the magnitude and timing of these changes, as well as the incremental effects of climate change. In the southern interior of BC, long-term field studies at Mayson Lake and Upper Penticton Creek measure hydrologic response to insect infestation and harvesting at the stand and headwater basin scales, respectively.

At Mayson Lake, research is primarily focused on quantifying changes in snow accumulation and ablation associated with forest defoliation following attack by mountain pine beetle. Surveys began in 2006, the year following attack. Attacked trees turned from green in 2006 to red in 2007 to grey in 2011. By spring 2011, 96% of the trees in the main canopy of an attacked lodgepole pine stand had lost their needles and canopy transmittance had increased from 27% to 49%. Snow accumulation and ablation in the pine stand varied from 3-23% higher than that in the mixed Engelmann spruce, subalpine fir and pine stand until early 2010, the winter following the year of greatest annual needle loss. In subsequent years, differences in snow accumulation between the attacked and mixed stand increased to 36%. A similar delay in snow response was observed in a burned stand near Mayson Lake where increases in snow accumulation were not measured until year three due to retention of red needles and fine canopy material for several years after the fire. Differences in ablation rates between the pine and mixed stands did not change significantly in the two years after needle loss and averaged 1.4 times higher in the pine stand. In a mixed stand, attacked pine comprised 53% of the main canopy. However, because of the spruce and subalpine fir retained in the main canopy and a dense intermediate layer, canopy transmittance to the snow surface remained at 19% and snow was not significantly affected. Post-pine beetle salvage logging resulted in a 40-128% increase in peak snow accumulation relative to the mixed stand, with the largest increases over the six-year survey period observed during the lowest snow year. Snow ablation rates were 1.5 to 2.3 times higher in the open than mixed stand, depending on the year. Weather had the greatest effect on both snow accumulation and ablation, with the greatest differences between both forested stands and the clearcut occurring in the year of lowest SWE. In high snow years, the forest canopy had a smaller effect on snow accumulation.

Stand-scale changes in snow accumulation and ablation with logging over a small portion of the study watersheds at Upper Penticton Creek were overwhelmed by inter-annual weather variability and did not significantly affect water yield. As logging extent increased to 50% of total watershed area, daily flow variability increased dramatically, increases in streamflow occurred earlier in spring and both maximum daily flow and annual water yield increased by up to 23% in the logged watershed. Similar changes in streamflow have been observed by other researchers following fire. The results of local stand and watershed scale research, combined with the results of other studies, highlight the complex interactions between ecohydrologic processes and the potential for significant changes in water yield with forest defoliation.

Plenary Session II - Evidence of Changing Climate Influencing Outbreaks and Impacts

Moderators – Chris Fettig: USDA Forest Service, Pacific Southwest Research Station, Davis, CA
Mary Reid: Dept. of Biological Sciences, University of Calgary, Calgary, AB

Presenters:

1) Dave Spittlehouse, BC Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC
2) Tongli Wang, University of British Columbia, Vancouver, BC
3) Sanna Sevanto, Los Alamos National Laboratory
4) Barry Cooke, Canadian Forest Service,
5) Barbara Bentz, USDA Forest Service

Observed and projected changes in climate in Western North America

Dave Spittlehouse
Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC

Over the last 60 years, average annual temperatures have increased by about 2°C in the northern part of western Canada and by about 1°C in the western US. Temperature increases were greater in the winter than in summer and the increase was mainly in the minimum (nighttime low) temperature. Temperature changes in western North America are consistent with world-wide trends. Precipitation trends are more variable than temperature with some areas showing small increases and others decreases in the last 60 years. The warming winter and spring temperatures have affected the amount of precipitation that falls as snow, length of the fire season and insect infestations.

All scenarios for the future (combinations of global climate model plus emissions profile) project a warming of western North America. For the mid-21st century, the projected increase in mean annual temperature for British Columbia ranges from 1 to 3°C (change referenced to 1961-90 normals). The equivalent numbers for the western US are 1.5 to 3.5°C. By the end of this century the projected values are 2 to 5°C and 2 to 6°C, respectively. By the middle of this century, the winter precipitation is projected to increase by up to 20% in western Canada and the northern part of the western US, and decrease by up to 20% in the southern part of the western US. In the summer, precipitation is projected to increase by up to 10% in the northern part of western Canada and to decrease by 10 to 30% in southern western Canada and the western US. These changes in climate will further decrease the winter snow pack, produce earlier snowmelt, and increase the risk of weather-related forest disturbance.

Changes in extreme conditions will accompany the changes in the mean. By the mid-century, what is currently a 1 in 20 year extreme warm temperature event will becomes 1 in 5 year event and extreme cold events will be less frequent than now. Extreme precipitation events show similar changes with 1 in 20 year events becoming 1 in 10 or lower. Dry periods during the summer in southern Canada and the US will likely become more intense.

Changing climate, changing forests

Tongli Wang and Sally Aitken
Centre for Forest Conservation Genetics, Department of Forest and Conservation Sciences, UBC

Forest tree species are adapted to a range of climatic conditions (i.e., often referred to as their "climatic niche"), thus climate is the primary factor regulating their geographic distributions. Climate change will cause shifts in the geographical distribution of the climatic niche. For long-lived tree species, because of their slow rates of migration, climate change will likely result in a mismatch between the climate that trees are currently adapted to and the climate that trees will experience in the future. Individuals or populations exposed to climate conditions outside their climatic niches will likely be maladapted, resulting in compromised productivity and increased vulnerability to disturbances. Niche-based bioclimate envelope models have been widely used to project future geographic distributions of ecosystem climate niches. However, challenges arising from model accuracy and the uncertainty of future climates make it difficult to apply the model projections with confidence in developing adaptive strategies in natural resource management. We addressed these challenges through an integral approach based on a framework developed at our center during the past years. The framework has the following four major components: 1) high-resolution climate models (ClimateBC/WNA) to downscale and integrate historical and future climate data; 2) bioclimate envelope models to model the realized climate niches of forest ecosystems, tree species and populations, and to project their shifts in future climates; 3) forest adaption strategies developed based on the output of bioclimate envelope models; 4) a web-based platform for data visualization and data access.

The bioclimatic envelope models built with Random Forest and high-resolution climate variables generated by our climate models can accurately predict the distributions of current ecosystems and tree species in British Columbia (BC). Based on our predictions, climate envelopes of some BC ecosystems have already shifted to climate envelopes of different ecosystems. To cope with the uncertainty arising from uncertain future climate, we used consensus projections based on projections using 20 climate change scenarios. Projected shifts in BC ecosystem climates are substantial under climate change and may impose serious challenges to land managers and policymakers. However, expansions of climate niches for several productive ecosystems, such as Interior Cedar-Hemlock and Interior Douglas-fir ecosystems, may provide an opportunity to increase forest productivity and carbon sequestration capacity in BC if appropriate species and populations are matched for future climates. The consensus projections could also be used as a basis to develop species selection and seed transfer guidelines. To consider the variation in response to climate change among populations within a species, we have developed growth response functions, genecology functions and a universal response function for Lodgepole pine. A large amount of spatial data has been generated and accumulated from various components of our framework in recent years. A Google Map based tool ClimateBC Map recently developed at the center allows users to visualize and access these data, and will help the information flow from the researchers to policy makers and practitioners.

Tree defenses under changing climate

Sanna Sevanto, Los Alamos National Laboratory, NM

Climate-related, continental scale forest mortality events have been observed throughout the earth during the past 20 years, and many of them are related to insect outbreaks. Climatic stress such as drought, freezing or wintertime warm spells seem to make plants more susceptible to insect attacks, but we still know little about how plant defenses react to stress and how the insects know which plants are weaker than others. In this talk, I will review our knowledge of plant physiological changes under climatic stress and discuss how these changes affect plant defences.

Climate change and the emergence and spread of boreal forest insect 'super species'

B.J. Cooke, Laurentian Forestry Centre, Canadian Forest Service, Ste. Foy, QC

Modern day climate and insect disturbance regimes share important similarities with those of the hyspithermal, some 5000-9000 years ago. Across the Holocene, forest insects seem to do most of their damage while exhibiting transient, non-equilibrium dynamical behaviour, associated with temporary release by (1) pulses of climate warming embedded within an overall warming trend, and (2) a relative absence of predatory and parasitic natural enemies. These forest pest systems are hypothesized to converge on a moving equilibrium that is paced by ice sheet dynamics, with spatial colonization of successive trophic levels leading to gradual equilibration over super-decadal/sub-secular time scales, and constant re-equilibration over longer time scales. Post-glacial range expansions are thus hypothesized to occur via punctuated explosions, where range-expanding outbreaks are fuelled by non-equilibrium transients that produce large numbers of long-range dispersing migrants that serve as early colonists.

Temperature, life-history traits and mountain pine beetle population success: What have we learned?

Barbara Bentz, USFS, Rocky Mountain Research Station, Logan, UT

The significant correlation between temperature and insect development time is well studied and expected to be an important factor in insect response to climate change. Mountain pine beetle (*Dendroctonus ponderosae,* Hopkins) is one of the most important forest disturbances in western North America, causing tree mortality at landscape scales that can influence numerous ecosystem properties, impact economic and societal values, and result in a disruption of ecosystem services. Mountain pine beetle has been well studied, and the influence of temperature on population success is believed to be a major factor driving range expansion and population success as climate warms. Multiple temperature dependent life-history traits play a role in this success including sister broods initiated by parents that re-emerge after laying an initial cohort of eggs to start additional cohorts, cold tolerance, and summer survival as a function of developmental timing. Over the past 20+ years we have been generating data to develop a mechanistic model that describes the influence of daily temperature on mountain pine beetle phenology and population success. We also have developed a model that uses daily temperature data to predict the influence of temperature on mountain pine beetle survival as a function of cold tolerance. Combining the immense biological information gathered by many over the past century with data-driven models that describe biological processes provide important tools for understanding how this insect will respond to continued climate change.

Workshops

Concurrent Workshops I

1.1 Forest Health Conditions Reports

Moderated by Tim Ebata (Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC)

This workshop is held annually to highlight forest pest conditions throughout Western North America. Presentations were given by representatives from Regions 1, 2, 3, 4, 5, 6 and 10, and BC, with a handout provided by AB. The following are some of the highlights:

Region 1 – presented by Joel Egan, USDA Forest Service, Forest Health Protection, Missoula, MT. Mountain pine beetle activity declined in lodgepole pine mainly due to host depletion but increased substantially in Ponderosa pine. Defoliation by western spruce budworm, hemlock looper, Douglas-fir tussock moth, and pine butterfly increased in 2011. Balsam woolly adelgid was previously detected in northern Idaho and along the Montana-Idaho border and was detected in additional areas in western and central Montana in 2011. More information can be found at: http://www.fs.usda.gov/goto/414-FHPmain

Region 2 – Presented by Sky Stephens, Colorado State Forest Service. The last 15 years of aerial surveys have shown that every forested acre in Colorado has been impacted by insects and diseases. Mountain pine beetle attacked 752,000 acres bringing the cumulative attack to 3.3 M acres. The current infestation is decreasing. Spruce beetle attack increased to 262,000 acres with a cumulative of 742,000 acres affected. Subalpine fir decline attributed to a complex of western balsam bark beetle and diseases has decreased with 180,000 acres mapped in 2011. There was 25,000 acres of Douglas-fir beetle attack mapped bringing the cumulative total to 321,000 acres. Western spruce budworm defoliation decreased to 90,000 acres. More information can be found at: www.csfs.colostate.edu .

Region 3 – Andy Graves provided a verbal description of conditions in Arizona and New Mexico. Spruce beetle was observed heavily damaging a single clone. Arizona was damaged by large fires last year. Freezing damage was recorded on alligator juniper and fir regeneration. Chronic western spruce budworm affected 2 to 400 acres/year on the tops of "sky islands". These stands also suffer from severe dwarf mistletoe infection. Douglas-fir is being killed by the flat-headed fir borer.

Region 4 – Danielle Reboletti, Forest Health Protection, Odgen Field Office. In 2011, about 35,000 acres were aerially surveyed. MPB infestations increased in the northern half of the region while they declined in the southern portion and overall, area infested decreased to 834,179 acres, mainly attributed to a cold snap at high elevations. Douglas-fir beetle attack appears to be increasing with 83,056 acres of damage mapped in 2011. Spruce beetle and fir engraver beetle continued to decline but Jeffrey pine beetle increased considerably in 2011. Blowdown in 2010 is predicted to increase spruce beetle populations. The largest single damage agent recorded in Nevada was pinion pine scale and pine sawfly defoliation that covered over 640,000 acres. The area identified as subalpine fir mortality complex declined. Pine and pinion engraver are still low at 1,888 acres mapped last year from a high of over 904,000 ha mapped in 2004 post-mountain pine beetle but there are localized increases. WSBW increased considerably all across Idaho.

More information is available at: http://www.fs.fed.us/r1-r4/spf/fhp/aerial/index.html

Region 6 – Presented by Rob Flowers for Oregon and Washington. MPB attack decreased by about 50% from 2010 (270,000 acres in Oregon, 120,000 acres in Washington). Ponderosa pine "legacy trees" have been lost due to western pine beetle. Damage reported in recently thinned 20 year old Ponderosa pine plantations causing about $6-7 M of damage in 6-7" diameter stems. Scattered spruce beetle attack recorded (15,000 acres) but there are not many large spruce stands remaining. Fir engraver was at endemic levels. Flat-headed fir borer has been acting like a bark beetle by attacking and killing live hosts. Douglas-fir beetle populations are growing on marginal habitat (~13,000 acres damaged). Western spruce budworm damage reached 500,000 acres. Pine butterfly attacked 250,000 acres of ponderosa pine in Oregon. About 125,000 acres of subalpine fir decline was mapped. Western hemlock looper was reported in the North Cascades. Outbreaks of fall webworm were mapped in SW Oregon on arbutus. Gypsy moth trapping resulted in 16 males caught in Washington but none in Oregon (17,000 and 13,000 traps, respectively).

Region 10 – A short report was provided by Roger Burnside who provided a handout with the summary from their "Forest Health Condition in Alaska – 2011 Annual Report".

British Columbia

Mountain Pine Beetle – Declined to 4.6 M ha, from 6.2 M ha last year. Main activity is in the northern and southern edges of the outbreak. Now 80 km from the Yukon border but not doing well. To date, the estimated cumulative mortality is over 600 M cubic meters and is expected to kill 61 % of the total provincial pine volume by the time the outbreak ends.

Douglas-fir Beetle – Area attacked dropped to 15,789 hectares, but is expected to increase this year due to wildfires in the Central Interior.

Spruce Beetle – also declined to 19,346 ha but expected to increase in 2012 due to wind and flooding damage last year.

Western Spruce Budworm – 616,512 ha of defoliation mapped in 2011 – a 19% increase from 2010. Most increases occurred in the Cariboo region. Increases were also noted in the Kootenay/Boundary Region. About 49,000 ha were treated with B.t.k. and a larger program is planned for this year.

Douglas-fir Tussock Moth – 16,801 ha mapped put intensity of damage decreased following the expected decline in the outbreak. B.t.k. was used to treat 7,154 ha.

Western Hemlock Looper (*Lambdina fiscellaria lugubrosa*) – defoliation increased this year to 7,051 ha mostly in the Cariboo region. Populations are expected to increase based on pheromone trap catch trends. A B.t.k. treatment of about 15,000 ha is planned for the Cariboo and Thompson/Okanagan Regions.

2 year cycle Budworm (*C. biennis*) - host is mainly subalpine fir. Defoliation rose to 178,205 ha mainly in the two northern regions. The cycles are different between the northern and southern regions. The Cariboo had no defoliation because it was "off cycle" but damage is expected this year. A 1,000 ha spray trial is being planned near Quesnel to determine optimal spray timing of B.t.k. treatments.

Blackheaded Budworm (*Acleris gloverana*) – a coastal defoliator of mainly hemlock. Outbreaks usually last 2-4 years and occur about every 8 yrs. This one is on its third year and is mainly affecting stands on Haida Gwaii and on northern Vancouver Island. In 2011, 41,142 ha of defoliation were mapped. No treatments are planned; only damage monitoring to determine impacts of repeated outbreaks.

Deciduous Defoliators:

Aspen (Serpentine) Leaf Miner *(Phyllocnitsis populiella)* – first mapped in 2006 and increases were recorded each year. It now is damaging 669,550 ha of aspen throughout the interior, particularly in the northeast.

Forest Tent Caterpillar (*Malacosoma disstria*) – 453,137 ha of defoliation was mapped; most in the Omineca Region.

Full report available on line at: www.for.gov.bc.ca/hfp/health/overview/2011.htm

AB – Sunil Ranasinghe, Alberta Sustainable Resource Development – provided a handout that summarized their conditions recorded during 2011. For more information, refer to:

See: http://srd.alberta.ca/LandsForests/ForestHealth/ForestHealthAnnualReports.aspx

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1.2 High Elevation/High Latitude Insects in the West

Organized by Lia Spiegel, moderated by Andy Eglitis (Forest Health Protection, Pacific Northwest Region)

Although much attention has recently been focused on whitebark and other five-needle pines, there are forest health issues with other high-elevation tree species as well. In this workshop, we address subalpine fir and some of its issues, both present and future, as climatic conditions continue to change and present additional problems. The impetus for this workshop came from work Lia Spiegel did with the balsam woolly adelgid (BWA) in Oregon and Washington over the past 5 years. Damage from BWA on subalpine fir mapped during aerial surveys from 1999-2008 was high and this led to detailed investigation of the relationships of the insect and its host in the Pacific Northwest. In other western states, concerns for high-elevation species have increased with the greater awareness of the effects of changing climate.

Influence of climate on the distribution and spread of sub-alpine fir decline in Colorado

S. Sky Stephens, Colorado State Forest Service, Fort Collins, Colorado

Today, our high elevation forests face a multitude of forest health issues, but none more prominent than the western balsam bark beetle and fungi complex, also collectively known as sub-alpine fir decline (SFD). SFD has been active on Colorado's landscape for over a decade and has affected more acres than almost any other pest disturbance. From 1996-2011, SFD has cumulatively affected 2.303 million acres in Colorado; this is second only to mountain pine beetle. The spruce-fir forest cover type is highly valued due to its contribution to wildlife habitat, watershed health and water supply, recreation, and wood products. Due to its value to the state, there is a desire to keep these forests healthy. A 2011 publication by CSFS ranked Colorado forest types by insect and disease mitigation potential; spruce-fir ranked highest in both the high and very high categories for mitigation and management potential. More research within this forest cover type is needed to improve management strategies to benefit forest health.

Improved estimates and predictions of the distribution of sub-alpine fir decline resulting in improved management techniques. We expect to develop spatial models through the integration of aerial surveys and ground checking that will have an adequate level of statistical accuracy and will contribute reliable information to entities that would use the information. Models developed will also help to predict the impact of climate on host distribution and insect and disease activity in sub-alpine fir forest type. These models could also be used to predict future levels of loss in the sub-alpine fir forest type due to range shifts and insect and disease activity. From these models we expect to illustrate the impacts of potential loss on watersheds, water quality, economics of winter recreation and hunting, wildlife habitat loss/change. We expect results of this study to be used directly to establish best management practices for sub-alpine fir stands.

Balsam woolly adelgid: An emerging architect of high elevation/high latitude forests in the West

Andris Eglitis, Forest Health Protection, Bend, Oregon
(prepared by Lia Spiegel, Forest Health Protection, LaGrande, Oregon)

Balsam woolly adelgid (BWA) is a very small, non-native insect that feeds only on true firs in North America. Since the adelgid was found east of the Cascades in the 1970s, it has spread throughout most of the subalpine fir in Oregon, Idaho, and southern Washington, causing widespread mortality to mature trees. In many areas, all of the mature subalpine firs have been killed by BWA. Grand fir and Pacific silver fir are susceptible at lower elevations west of the Cascades, while damage to grand fir east of the Cascades and at higher elevations is currently very minor. Long-term studies done by Russ Mitchell have revealed that west of the Cascades infestation and damage is most severe on the best sites and lowest elevations. With the additional mortality of whitebark pine in many areas from blister rust and mountain pine beetles, many high elevation stands are now mostly dead. It isn't clear what the species mixture, density, and size distribution of these forests will be in the future.

When BWA became well-known west of the Cascades, there was little concern for its spread east. It was believed to be ineffective at dispersal and the climate of the interior forests was believed inhospitable. However, warmer than average summers and successful dispersal have produced increased damage at high interior elevations throughout Oregon and parts of Washington. Expansion into new habitats is likely.

In the Cascades, BWA was first detected in central west Oregon in 1930. Extensive mortality occurred in the 1950's and 1960's and led to a biological control program where several predators of BWA were established. However, this insect appears to be controlled by weather and climate rather than predators. Now in the Cascades, the mortality is low-level and chronic.

In 1970 in the west, BWA was restricted to the west coast. In 1974 BWA was found in southeastern Washington near Walla Walla. This was a significant range expansion across the non-forested Columbia plateau, a distance of 100-150 miles from the nearest known BWA infestations.

Because the mortality of subalpine fir has been widespread and spectacular in recent years in the forests of eastern Oregon and Washington, monitoring plots have been established by Forest Health Protection personnel to observe changes in the forest (Kristen Chadwick [pathologist - Central OR], Connie Mehmel [entomologist - Central WA], Lia Spiegel [entomologist - NE OR]. The plots were intended to cover a range of infestation levels in order to track the infestation and damage over time.

Dan Quiring in eastern Canada recently published an article linking plant hardiness zones with BWA damage. He found that areas of damage in New Brunswick and Newfoundland coincided with areas where mean January temperatures were -11 Celsius or +12 F and above, which corresponds to plant hardiness zone 4a. This information is valuable in framing how we think of zones of susceptibility to BWA. By this standard, BWA would have colonized virtually all available habitat in Oregon by 1990, while Idaho and the northern Rockies (WY, CO, MT) at that time would have had few areas considered susceptible. By 2006, much of Idaho and the northern Rockies resemble the NE Oregon susceptibility map from 1990. As such, we could expect to see expansion of BWA into these newly susceptible areas of subalpine fir.

Balsam woolly adelgid's range and impacts are changing for Idaho and the Rockies

Laura Lazarus, Forest Health Protection, Boise, Idaho

Roadside delimitation surveys were conducted in Idaho from 2006-2011, Idaho Department of Lands and Region 1 and 4 Forest Health Protection, to determine the extent of spread of Balsam Woolly Adelgid (BWA) populations through true fir forest since previous distribution surveys during the late 1990's. Balsam Woolly Adelgid has spread over 200 miles from the original northern Idaho populations, eastward into the Rockies of Idaho, Montana and western Wyoming. A total of 1,287 spots were surveyed for the presence of BWA, and of those, 49 percent were reported as positive. Damages were reported as stem infestations and twig gouting, with heavy stem infestations up to 6,932 feet elevation, moderate infestations up to 7956 ft., and gouting at 15 percent of locations. BWA is now killing trees in southern Idaho, as well as in northern Idaho, although the extent of the mortality and impacts are not yet well understood. Mean January survival thresholds of -11C may prevent BWA from establishing in some areas and allow establishment during warmer winters.

1.3 "Crock pot" of Forest Entomology

Moderated by Chris Fettig (USFS, Pacific Southwest Research Station, Davis, CA)

Entomological research in the USDA Forest Service: Challenges and Opportunities

Christopher J. Fettig[1] and Mary E. Dix[2]
[1]USFS, Pacific Southwest Research Station, Davis, CA
[2]USFS, Research and Development, Arlington, VA (retired)

The USDA Forest Service employs some 34,000 employees and has the mission to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. There are three natural resource-based deputy areas within the Agency. The National Forest System manages 7.8 million hectares on 155 National Forests and 20 Grasslands in 42 states. State & Private Forestry is primarily responsible for fire and aviation management and forest health protection on all lands (i.e., not just National Forest System lands). Research & Development (R&D) is responsible for knowledge development, synthesis and application on a diversity of topics of relevance to the Agency, but often with worldwide implications. R&D has some 525 scientists distributed among five research stations, the Forest Products Lab, and the International Institute of Tropical Forestry.

Forests provide numerous benefits, and phytophagous insects impact virtually all forest processes and uses by influencing ecosystem structure and function through regulation of certain aspects of primary production, nutrient cycling, ecological succession, and the size, distribution and abundance of forest trees. We discuss the state of entomological research within the USDA Forest Service and highlight some recent research efforts.

Recent patterns of observed bark beetle-caused tree mortality in British Columbia and the western US

Arjan J.H. Meddens[1], **Jeffrey A. Hicke**[1], and Charles A. Ferguson[2]
[1]University of Idaho, Moscow, ID;
[2]USDA Natural Resources Conservation Service, Raleigh, NC

In this presentation, we summarized the study of Meddens et al. (2012). The objectives of the study were to estimate the mortality area of trees killed by bark beetles in western North America. Mortality area includes only killed trees and is therefore a more accurate representation of the impact of insect-caused tree mortality than affected area, which is what is typically reported. We created gridded data sets from aerial survey databases produced for the last 10-13 years. We converted either the number of trees killed (US) or outbreak severity (Canada) into mortality area using mean, species-specific tree diameters (US) or percent number of trees killed (Canada). We added a more realistic upper estimate to the US mortality area based on comparisons with fine-resolution remotely sensed imagery in three forest types. We found that mountain pine beetle killed the most trees in the western US and Canada, with the cumulative mortality area in each region about 5.4 million hectares. Most forests in British Columbia and the western US experienced some level of beetle infestation, although most locations had less than 10% mortality area.

Meddens, A. J. H., J. A. Hicke, and C. A. Ferguson. 2012. Spatiotemporal patterns of observed bark beetle-caused tree mortality in British Columbia and the western United States. Ecological Applications **22**:1876-1891.

Goldspotted oak borer and its hosts in California and Arizona

L.J. Haavik[1], T.W. Coleman[2], M.L. Flint[3], R.C. Venette[4] and S.J. Seybold[5]
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Goldspotted oak borer, *Agrilus auroguttatus* Schaeffer (Coleoptera: Buprestidae), is native to Arizona and a new pest in southern California. The host range of this insect is not known but has a major impact on assessment of the risks this insect poses to oaks (*Quercus* spp.). We conducted field and laboratory studies to determine the potential suitability of oak species for goldspotted oak borer.

Following artificial insertions of first-instars in the laboratory, larval galleries were established with greater frequency in red oaks (Section *Lobatae*) compared with other oaks (19% versus 7 or 4%). The red oaks *Q. agrifolia* Née, *Q. kelloggii* Newberry, and *Q. wislizeni* A. DC. were likely suitable hosts for larvae; it was unclear whether white oaks (Section *Quercus*) were. Adult longevity and fecundity varied little by species of oak foliage fed to adults. The host range of goldspotted oak borer is likely limited by suitability of oak species for the larval rather than the adult life stage.

In the field, we found limited evidence that red oaks produce greater densities of goldspotted oak borer, and are therefore better hosts, than white oaks. In California, a species which is taxonomically intermediate between red and white oaks, *Quercus chrysolepis* Liebm., may be an equally suitable host for goldspotted oak borer compared with a co-occurring red oak, *Q. kelloggii*. On red oaks, goldspotted oak borer significantly outnumbered native borers in California (mean ± SE of 9.6 ± 0.7 versus 4.5 ± 0.6 exit holes per 0.09 m^2 of bark for *Q. agrifolia* Née), yet this was not the case in Arizona (0.9 ± 0.2 versus 1.1 ± 0.2 exit holes per 0.09 m^2 of bark for *Q. emoryi* Torrey).

Concurrent Workshops II

2.1 Cone and Seed Pests

Moderated by Ward Strong (Ministry of Forests, Lands and Natural Resource Operations, Kalamalka Research Station, Vernon BC)

Biological control of *Leptoglossus*

Stephen Cook
Dept. of Plant, Soil and Entomological Sciences University of Idaho, Moscow, ID

We have been examining the use of systemic insecticides for use in the management of seed and cone pests in conifer seed orchards. One of the major insect pests of seed orchards in the inter-mountain west is the western conifer seed bug, *Leptoglossus occidentalis*. Western conifer seed bug is capable of feeding on all of our major orchard species including western white pine, ponderosa pine, Douglas-fir and western larch. While conducting work that examined selection and suitability of the various host species, we began seeing egg clutches that had been parasitized. We placed clutches of western conifer seed bug eggs on various host tree species in Moscow, ID. Eggs were collected after a 4-5 day period and brought back to the lab were emerged insects were collected and identified. Some of the egg clutches that were placed on Douglas-fir and Norway spruce subsequently had parasitoids emerge from them. A single species of parasitoid was identified, *Gryon pennsylvanicum* (Ashmead) (Hymenoptera: Platygastridae). When egg clutches were parasitized, all eggs within the clutch were attacked and had the parasitoid emerge from them. No egg clutches that were placed on pine were parasitized. However, it should be noted that only a limited number of egg clutches were used on any host species.

Acknowledgements: The project was conducted as part of an NSF-Center for Advanced Forestry Systems project. We would like to thank the University of Idaho Arboretum for allowing us to place egg clutches on trees within the arboretum and Dr. Norm Johnson (The Ohio State University) for species confirmation. Ben Sloniker, Evelyn Kubik, and Lindsay Menard, were involved with the field and laboratory work.

Seed orchard pest phenomena occurring in the season following a mast seeding year

Nancy van der Laan and **Jim Corrigan**
Kalamalka Seed Orchards, Tree Improvement Branch, Vernon, BC

Mast seeding refers to the sporadic production of unusually large amounts of seed by a plant population. In four Interior hybrid spruce seed orchards located at the Kalamalka Forestry Centre, 2010 was a mast seeding year. This bumper crop experienced minimal pest damage; less than 5% losses were attributed to cone and seed herbivores in the 2010 growing season. In 2011, these same orchards produced very small cone crops. The proportions of cones infested in 2011 by the spruce cone axis midge (*Kaltenbachiola rachiphaga*) and spruce seedworm (*Cydia strobilella*) were an order of magnitude higher than had been seen in any of the previous five years. One year after a mast seeding season, the herbivore: host ratio flipped completely in favour of the pest populations. In 2011, relatively large pest populations attacked greatly diminished host (cone) numbers, resulting in extremely high levels of pest activity on the cones.

While the pest-filled aftermath of a mast seeding season should have little impact on the regeneration ecology of a natural forest stand, every year's crop is valuable in a seed orchard. However, it must be recognized that extreme efforts would be needed to manage pest populations in a post-mast year, and that such efforts would be protecting relatively small potential crops from large pest populations. Seed orchard managers need to consider the cost-benefit ratio of trying to manage small crops in post-mast seeding years. As unpalatable as it may sound, the situation may arise when the cost-effective choice would be to let the pests have a small crop and save the costs associated with trying to protect it from heavy damage.

On a more optimistic note, the unfavourable pest: host ratios seen in a post-mast seeding year are unlikely to persist beyond that single season. Pest herbivore populations should collapse after this season, because of: i) the greatly diminished number of cones available for them to attack in the post-mast season, and ii) the high rates of parasitism on the pest populations contained in these few cones. In the second year after a mast seeding season, cone production should be on the upswing, and populations of the natural enemies of cone herbivores will be at the peaks of their own boom-bust cycles. Meanwhile, populations of cone and seed pests should be at their most depressed levels, and thereby present a minimal threat to the crop.

Is the ponderosa pine coneworm, *Dioryctria auranticella*, becoming a new pest species in western white pine and lodgepole pine seed orchards?

Judy Thomson and **Jim Corrigan**
Kalamalka Seed Orchards, Tree Improvement Branch, Vernon, BC

On June 14, 2011, cones in both western white and lodgepole pine seed orchards were found to be hosting large, late-instar coneworm larvae (*Dioryctria* spp.). It seemed to be much too early in the growing season to find mature larvae of the fir coneworm (*D. abietivorella*) in cones, so some of the coneworm-infested cones were brought into the lab. Adult moths reared from them turned out to be *Dioryctria auranticella*, the ponderosa pine coneworm. This species has been reported to attack cones of both knobcone and ponderosa pines in North America, but we could find no published records of individuals having been found in either western white or lodgepole pine cones. Prior to 2008, no specimens of *D. auranticella* reared from cones of the latter two pine species were present in five major Canadian insect collections. To the best of our knowledge, our specimens represented new host-rearing records for this species in North America.

How does one determine the difference between attacks by *D. auranticella* and *D. abietivorella* in pine seed orchards? The larvae of *D. auranticella* appeared to be quite darkly pigmented relative to those of *D. abietivorella*, and were henceforth christened the 'black Dioryctria.' As well, these individuals had a yellowish anal plate that was not seen on larvae of *D. abietivorella*. The surest way to identify these Dioryctria species is to hold infested cones in containers until adult moths emerge from them. The adults of the two species are very different in colour, and are easily identified as distinct species.

Monitoring done in Bailey Road white pine Orchard 335 in 2011 indicated that about 16% of the observed cones were infested with ponderosa pine coneworms. Dimethoate sprays were applied to Orchard 335 on June 20-21 to limit the damage being caused by this coneworm species. To the best of our knowledge, these sprays represented the first time that specific efforts were made to target *D. auranticella* in a conifer seed orchard in British Columbia.

2.2 Defoliator Outbreaks in Western Conifers: Past, Present, and Future

Moderated by Rob Flowers (Oregon Department of Forestry, Salem OR)

In this workshop, presenters from British Columbia, Washington, and Idaho will summarize the major historic outbreaks of Western spruce budworm and/or Douglas-fir tussock moth in their areas. We will be describing the impacts of these outbreaks as well as discuss how current outbreaks compare to those that have come before. Lastly, we will discuss current vulnerabilities of these forests and how this may relate to previous disturbances or potentially interact with emerging factors, such as climate change, to affect future outbreaks.

Long-term population studies of western spruce budworm in the northern portion of its range

Vince Nealis, NRC-Canadian Forest Service, Pacific Forestry Centre, Victoria, BC

Long-term population series for western spruce budworm were compiled for interior Douglas-fir forests of southern British Columbia. The data show extended persistent and resilient outbreaks since the late 1990s. Population behavior and its relationship to selected mechanisms of change in budworm survival were discussed.

The past and present history of western spruce budworm in Washington

Darci Carlson, USDA Forest Service, Forest Health Protection, Wenatchee Insect and Disease Service Center, Wenatchee, WA

The outbreak history of western spruce budworm across Washington State was examined. Outbreak defoliation pattern changes over time and associated agents were discussed. Western spruce budworm outbreak treatment history was compiled and evaluated. Future outbreak strategies were considered in the context of historical patterns.

Douglas-fir tussock moth outbreaks in southern British Columbia

Lorraine Maclauchlan, Ministry of Forests, Lands and Natural Resource Operations, Thompson Okanagan Region, Kamloops, BC.

In southern British Columbia, Douglas-fir tussock moth has cyclical outbreaks every 8-12 years over a broad geographic range. When historic outbreak patterns are analyzed at a finer spatial scale, a diverse periodicity was revealed. The B.C. range of tussock moth has been divided into five outbreak regions and the periodicity, intensity and duration of outbreaks has been elucidated for each of these regions. Since 1918, there have been ten large scale and distinct outbreak episodes of the Douglas-fir tussock moth in B.C. Within each smaller geographic outbreak region, unique outbreak patterns were revealed that display less regular cycles, and outbreak duration and amplitude that were quite unique to each geographic outbreak region.

During each outbreak cycle, the tussock moth builds in numbers primarily within “new” habitats, albeit very close to historic outbreak areas. On average, in year one of an outbreak cycle where considerable defoliation was noted, the population becomes established at lower elevations. When year one occurs in smaller spot outbreaks (fewer hectares affected in year one), on average these populations occurred at slightly higher elevations. The current outbreak cycle (2008-2011) was the largest recorded in British Columbia with defoliation over 43,000 hectares in four years, and causing 5,841 hectares of Interior Douglas-fir mortality. Over this four year outbreak period, 21,836 hectares were treated with nuclear polyhedrosis virus (NPV) or *B.t.k.*

Current and historical Douglas-fir tussock moth outbreaks in northern Idaho

Neal Kittelson and Tom Eckberg, Idaho Department of Lands, Forest Health Program, Coeur d’Alene Idaho

In northern Idaho, Douglas-fir tussock moth outbreaks have occurred consistently in the same general area about every 8-12 years. However, the current outbreak was abnormal in that defoliation was occurring further north than historic outbreaks and the various hotspots were asynchronous in timing, shown from visible defoliation and population collapse. Defoliation also was observed in the Nez Perce National Forest for the first time since 1974. The earliest visible defoliation (from the ground), was found in 2009 in the most northern part of the current outbreak. Aerially detectable defoliation was seen in this area in 2010, but this localized outbreak apparently collapsed in 2011. In more southern areas, visible defoliation was not documented until 2010 and increased substantially in 2011. Egg mass samples indicate some of the northern areas may be collapsing while the southern portions of the outbreak were still increasing in size.

2.3 Spatial Dynamics of Outbreaking Bark Beetles

Moderated by Joel Egan (Forest Service, Region 1 Forest Health Protection, Missoula, MT)

Spatiotemporal dynamics of transitions from endemic to epidemic regimes: Feedback between population density and distribution contributes to eruptions

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The mountain pine beetle is a native eruptive bark beetle capable of causing the mortality of mature pine trees over many thousands of hectares. Between epidemics, the mountain pine beetle exists as endemic populations that are characteristically scattered and restricted to suppressed and/or damaged pine trees with impaired defenses, which they colonize in direct competition with an assemblage of “secondary” bark beetle species. We conducted a 4-year study (involving 6 stands at 2 sites in southern British Columbia) in which bark beetle populations were censused, and tree and stand characteristics quantified, to determine the temporal and spatial changes in trophic interactions that facilitate the eruption of mountain pine beetle populations from the endemic to the epidemic state. During the study, populations in 4 stands erupted from endemic into incipient epidemics. Population eruptions were characterized by shifting trophic interactions. As populations increased, attacks moved from randomly distributed injured trees, previously colonized by secondary bark beetles to clustered, large-diameter, highly defended trees free from competitors. Access to large-diameter, healthy trees facilitate rapid population increases and transition to the epidemic phase where positive feedbacks ensue (i.e. more beetles = more potential host trees), and local population eruptions result.

Living in a bad neighborhood: The influence of spatial proximity on Jeffrey pine beetle-caused mortality in the Lake Tahoe Basin.

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A Jeffrey pine beetle (*Dendroctonus jeffreyi* Hopkins) (JPB) epidemic caused Jeffrey pine (*Pinus jeffreyi* Grev. and Balf.) mortality throughout the Lake Tahoe Basin from 1991-1996 following multiple years of below average precipitation. Census data, including geospatial location and tree attribute data for 10,721 stems, were obtained from a continuous, 60-acre study area near Spooner Junction that was established to assess JPB activity without management intervention. This epidemic was considered to be at the high end of potential outbreak scenarios based on prior outbreaks documented in the Lake Tahoe Basin.

For each year, the probability of infestation for individual trees was modeled using probit regression. We examined several models, each with single predictor variables that appeared to have the greatest influence on the probability of JPB-caused tree mortality. The predictors included DBH and distance to nearest brood tree as individual tree measurements. One neighborhood-based predictor, total basal area of infected trees within a half-acre neighborhood, was also included as a proxy for localized bark beetle population pressure. Model runs using DBH showed that, for initial attacks in 1991, there was a negative relationship between DBH and the probability of an attack. That is, the smaller a tree's diameter, the higher the probability of that tree being attacked. The beginning of the epidemic (1992) appeared to be a transition year with no significant DBH effect. A switch to a preference for larger diameter trees occurred during the remaining epidemic period (1993 – 1994), where the larger a tree's diameter was, the higher the probability of an attack. During post-epidemic years (1995 – 1996) when the levels of tree mortality declined, DBH effect switched back to a preference for smaller diameters which was similar to 1991. Model runs using distance to nearest brood tree were restricted to within 164 feet of the nearest brood tree to capture a linear response with this variable. Distances greater than 164 feet showed no obvious relationship with probability of tree mortality. The nearest brood tree predictor was significant in all years, with higher mortality associated with closer proximity to a brood tree. There were no obvious changes in the distance to brood tree effect from year to year. Model runs using total basal area of infected trees in half-acre neighborhoods showed significant positive effects on mortality in epidemic years 92 – 94. The effect was not significant during the post-epidemic period from 95 – 96. Additional work will create best-fit models that incorporate multiple predictor variables.

Mountain pine beetle dispersal: Spatiotemporal patterns and role in the spread and expansion of the present outbreak.

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Dispersal has been least understood in mountain pine beetle ecology. We developed a novel regional dynamic conceptual model of mountain pine beetle infestation using the tree mortality estimated from the British Columbia annual aerial overview survey to quantitatively determine short-distance dispersal (SDD) and long-distance dispersal (LDD) at local (forest district) and regional (provincial) scales. The dispersal patterns were characterized based on distances between a sink patch to its nearest source patch. At the regional scale, SDD accounted for 85.3% of mountain pine beetle dispersal to non-infested areas and 96.8% of beetle dispersal to infested areas. Although SDD was a dominant dispersal mode, LDD played a more important role in the early stage of the current mountain pine beetle outbreak. At the local scale, three patterns of dispersal to non-infested areas were identified. First, LDD dominated in the forest districts where only sparse infestations occurred. Second, LDD was a dominant or important factor in the early stages of the infestations in some districts. Third, SDD dominated throughout the infestations in more severely infested forest districts. However, for dispersal to infested areas, SDD was a dominant mode in most of the forest districts. We conclude from the spatiotemporal patterns of dispersal observed at local and regional scales that LDD is a key factor in the initiation and early stage of the infestations in new remote areas, and SDD dominate in the spread and expansion of the outbreak as the infestations intensify and reach epidemic levels. However, it should be conscious that there is uncertainty that LDD might have been over emphasized in the dispersal before local dynamics is fully taken into account.

What goes up does not always come down: Elevational and latitudinal range shifts of mountain pine beetle in western Canada

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Currently, a ten-year outbreak of mountain pine beetle in western Canada covers approximately 17 million hectares of mature pine forest. Recent decades of improved climatic suitability have been invoked as one reason for the insect’s recent range expansion over the historic geoclimatic barrier of the Rocky Mountains into jack pine. We examined thirty years of aerially-mapped populations of mountain pine beetle in British Columbia, Canada. Specifically, we studied latitudinal and elevational movement of endemic-incipient populations of mountain pine beetle and their associations with annual temperature fluctuations in British Columbia, Canada using a quantile

regression approach. In this manner, we are able to quantify which regions of the province exhibited the greatest temperature-associated range expansions north and southwards. Climatic simulations indicated that shifts of increasing mean annual temperatures of only 2C created highly suitable habitats directly west of the invasion zone into northwestern Alberta. Temperature affects population growth at endemic and epidemic levels, and subtle warming at the landscape level likely helped set the stage for range expansion of this insect into jack pine.

Concurrent Workshops III

3.1 Genetics of tree/pest interactions

Moderated by Ward Strong (Ministry of Forests, Lands and Natural Resource Operations, Kalamalka Research Station, Vernon BC)

Stability of host-pest relationships in a changing climate

Greg O'Neill
Ministry of Forests, Lands and Natural Resource Operations, Tree Improvement Branch, Kalamalka Research Station, Vernon, BC

Pests have a defining role in the distribution, structure and function of our forests. Evidence for a changing climate is compelling, and there exist examples of host-pest relationships being affected by climate. What do we know about these relationships, particularly those involving BC's commercial tree species? How is a changing climate likely to affect these relationships and what might be the consequences for the hosts? What type of experiments might lead to better understanding these relationships and lend insight into management opportunities? Provenance trials have seen a resurgence of interest because they are effectively *in situ* climate change trials, and present a valuable opportunity for investigating forest health-genetics interactions in a changing climate.

Population and family variation for mountain pine beetle resistance in British Columbia

Nicholas Ukrainetz, Alvin Yanchuk and Vicky Berger
Ministry of Forests, Lands and Natural Resource Operations, Tree Improvement Branch, Tree Seed Centre, Surrey, BC

We have monitored attack rates for mountain pine beetle (*Dendroctonous ponderosae*) in several lodgepole pine (*Pinus contorta* var. *latifolia*) provenance and progeny tests around British Columbia during the latest outbreak. There was significant variation for attack rates among provenances and families with some populations and families attacked more often than others. The heritability for attack rate is similar to other traits, which are successfully manipulated in the provincial lodgepole pine tree breeding program suggesting that significant gains can be made to improve resistance to mountain pine beetle in our orchard populations. Mountain pine beetle attack rates are strongly influenced by tree size. Larger trees and faster growing populations were preferentially selected by beetles in the provenance tests. In one southern seed planning zone (Thompson-Okanagan), faster growing families grown in progeny tests were preferentially targeted by beetles and there was a strong genetic correlation between growth and beetle attack, however, this relationship is less significant in northern areas. We are now attempting to rank parent trees from 3 seed planning zones for resistance to beetle attack and creating controlled crosses to investigate phenotypic differences between resistant and susceptible families. We will continue to investigate the relationship between growth and mountain pine beetle attack rates, and the differences between the northern and southern populations.

3.2 Sawflies: the other defoliators

Moderated by Kathy Sheehan (DEFOL - Diprionids Eating Foliage for Our Lunch; Prindle, WA)

Invasive Sawfly *Monsoma pulveratum* (Tenthredinidae) on Alder in Alaska

R.E. Burnside, Alaska Dept. Nat. Res., Division of Forestry; Anchorage, AK and
J. J. Kruse USDA Forest Service, R10 Forest Health Protection; Anchorage, AK

Alaska-specific invasive species issues were outlined. Alaska is more vulnerable to invasive species than is generally known. Entry pathways were described, including ALCAN highway, Alaska Marine Highway, International airport cargo transport; via Continental North America, Asia, and Europe. The alder-feeding sawfly *Monsoma pulveratum* is believed to have been introduced to the West Coast by the early 1990's via a European route. It is not known if this sawfly was introduced first to Alaska, or first to the Pacific Northwest and then was moved up and down the coast later. As this sawfly overwinters in woody material, one likely pathway is firewood. This fact has stimulated APHIS and the Alaska Department of Natural Resources to commission firewood screening and wood boring insect rearing from firewood collected at the ALCAN border and purchased from retail outlets.

Green alder sawfly, *Monsoma puleratum*, in the Pacific Northwest

Glenn Kohler, Washington Department of Natural Resources; Olympia, WA

Green alder sawfly, *Monsoma pulveratum*, is native to Europe, northern Africa, and the Near East. The larvae feed on the foliage of many alder species. Unlike most sawflies, mature larvae may burrow into wood and pupate. The first occurrence of this sawfly in North America was reported in eastern Canada in the mid-1990s. In 2007, defoliation of thin-leaf alder, *Alnus incana*, by *M. pulveratum* was observed in Alaska.

In April 2010, a photograph of an adult sawfly on red alder, *Alnus rubra*, in Vancouver, WA was identified as *M. pulveratum*. Washington State Department of Agriculture (WSDA) entomologists subsequently collected adults and larvae at several Washington locations and confirmed the identification. *M. pulveratum* specimens collected as early as 1995 in Whatcom County (northwest Washington) were subsequently identified from the Western Washington University insect collection.

Additional sites were trapped in 2010 and 2011. In 2010, traps were hung from branches of *A. rubra* trees at 32 sites in Washington and in Portland, Oregon. In 2011, cooperators from seven different agencies placed traps in stands of *A. rubra* or *A. incana* at 227 sites throughout Oregon and Washington and in parts of northern Idaho and western Montana. Traps consisted of thin yellow panels (18cm X 14cm) coated with sticky material. Traps were generally set out by April and retrieved and replaced every three to four weeks until October. Sawflies collected were identified by Chris Looney (WSDA).

Forty-five *M. pulveratum* adults were trapped or hand-collected in 2010 and 142 were trapped in 2011. Over the two-year survey, *M. pulveratum* was detected in 23 counties in western Oregon and Washington, two counties in eastern Washington, and two counties in northern Idaho. *M. pulveratum* was collected at 45 out of 227 trapped sites in 2011. The majority of adults were collected in western Oregon and Washington. *M. pulveratum* was not trapped at the majority of sites, despite abundant alder hosts. Minor damage levels to *A. rubra* from *M. pulveratum* feeding did not begin to approach that observed on *A. incana* in Alaska. *A. incana* trapping sites in this survey were not investigated for defoliation damage.

Adapted from a poster by Chris Looney (WSDA), Kathy Sheehan (USFS), Barry Bai (ODA), Darci Carlson (USFS), Jenni Cena (WSDA), Ellen Goheen (USFS), Rob Flowers (ODF), Mark Hitchcox (APHIS), Mike Johnson(WDNR), Sandy Kegley (USFS),Glenn Kohler (WDNR), Eric LaGasa (WSDA), Todd Murray (WSU Extension), Lee Pederson (USFS), Karen Ripley (WDNR), Lia Spiegel (USFS), Nancy Sturdevant (USFS), and Beth Willhite (USFS), as well as a paper from Northwest Science, vol. 86(4):342-345 (2012).

Observations on Pine Sawflies, Colorado and Montana: 2005-2010

William M. Ciesla, Forest Health Management International; Fort Collins, CO

Several episodes of moderate to heavy populations of pine sawflies (Hymenoptera: Diprionidae) are reported from CO and MT.

Pine sawfly activity has occurred in Elbert Co., CO for a several years. The affected area is located on the eastern-most fringe of ponderosa pine at the edge of the Great Plains, east of Franktown. A ground examination in late June 2005 indicated scattered patches of moderate to heavy defoliation. A single larva was observed indicating that the population had transformed into pre-pupal larvae in cocoons. During the following year small areas of moderate to heavy defoliation were mapped during the aerial forest health survey of the area.

In 2009 sawfly activity was again reported from Elbert Co. but much later in the season. A mid-August ground evaluation revealed large numbers of late instar larvae in several locations. Larvae were collected and reared, and adults emerged in late September. These were identified by David R. Smith of the Smithsonian Institute as *Neodiprion autumnalis*, the most wide-ranging of the ponderosa pine feeding sawflies. Populations have been reported over much of the western US and Mexico, where several other pines serve as hosts. It was described in 1986 and was previously known as part of the *N. fulviceps* "complex."

High levels of pine sawfly activity occurred in Mesa Verde National Park, CO between 2006 and 2008 on pinyon pine, *Pinus edulis*. This sawfly was subsequently identified as *Zapdiprion rohweri*, a species indigenous to the southwestern US and one of five known species of *Zadiprion*. Two are native to the US and the others occur in Mexico. During 1996-1998 an outbreak of this sawfly occurred in the vicinity of Canyon de Chelly National Park, AZ.

Localized defoliation indicative of sawfly activity was detected near Gallatin Gateway, MT on lodgepole pine in June 2010. Examination of damaged pines indicated that the defoliation had occurred the previous year and that the 2010 generation of larvae were just beginning to hatch. A sample of larvae and eggs were collected and reared. Adults emerged the following September and were identified by David R. Smith as *Neodiprion nanulus contortae*. This species is known to attack both lodgepole and ponderosa pines and is reported from ID, MT and OR. At least two other outbreaks of this species have been observed in MT; one near Zortman in northern MT during the 1960s and another in 1973 in the Fisher River Basin of the Kootenai NF in northwestern MT. Observations made later in the season by Amy Gannon, entomologist with the Montana State Forest Service, indicated that area of defoliation expanded considerably during 2010 and 2011.

3.3 "Catching up with bark beetles (*or not*)"

Moderated by Iral Ragenovich (USDA Forest Service, Pacific Northwest Region)

British Columbia and Alberta, Canada and portions of the interior western United States have experienced unprecedented mountain pine beetle outbreaks over the last several years.

This workshop was held in an informal discussion format and invoked a lot of good discussion on government policy and options during large outbreaks, project level discussions and what did or did not seem to work, the need for basic research on bark beetle response to pheromones, and the feasibility of landscape area management.

The first part of the workshop focused on the big picture – of dealing with outbreaks at the landscape level, both politically and in terms of management. Extensive outbreaks are occurring in areas where millions of hectares of contiguous areas of overstocked, susceptible lodgepole pine in both BC and the US were experiencing significant mortality from mountain pine beetle. Climatic conditions may have contributed to favoring population increases, either through drought, which caused additional stress on tress, or by temperatures and other factors favoring insect development and survival. When bark beetle populations increase to the levels recently experienced, all rules go out the window. Small, young trees, and typically non-host trees, as well as trees in stands that have been thinned, all succumb to the beetle pressure.

Government policy and response changes more slowly than the beetles, and managers end up focusing on salvage and removal of deadwood, reforestation, and rehabilitation, rather than opportunities for mitigating impacts before outbreaks. BC was finding many uses for deadwood, including a huge industry for shipping pellets to Europe. A land-based investment strategy will ensure that wood will be there in the future. More modeling is needed in order to make appropriate decisions.   The US western bark beetle strategy is focused primarily on safety - removal of dead, or danger trees in high value areas such as picnic areas and along roadsides; reduction and removal of fuels to decrease extreme fire risk and create barriers to fire spread; and restoration. In the State of Washington beetles are attacking stands that were planted after the 1910 fire. They have been conducting sales in high risk stands as well as conducting thinning in order to improve forest health in stands that have not yet been attacked.

The second part of the discussion focused primarily on bark beetle prevention projects such as a Douglas-fir beetle control project on 2000 acres in a ski area in Idaho using a combination of aerial applications of MCH in flakes, as well as bubble caps along stream corridors. There has been an increase of Douglas-fir beetle in the Vanderhoof area and they have been using MCH to repel beetles there. Other projects included push-pull cluster traps and funnel traps in an open center to pull beetles away from stands. These have had success when used in small or isolated areas. Pheromone treatments such as MCH work best in small areas and are not intended for large areas. Verbenone used for preventing/reducing mountain pine beetle has had mixed results. There is an effort to collect additional information about each project – stand information such as condition, density, structure, age of trees, beetle population pressure at the time of application, size of application area, etc., as well as the success of the application. The antidotal information needs to be stitched together to better understand the circumstances and possibly develop a pattern that could explain results. An important missing piece is the additional research needed on beetle response.

Questions arose on how to prove management efficacy? Can we evaluate management efficacy in areas following the bark beetle outbreaks to answer many questions in order to protect the investment in young stands? The results in previously managed stands need to be evaluated in terms of resistance, management strategy (thinning, etc.), context (landscape/temporal), age class mosaics and stand continuity, etc.; however, using a retrospective approach is a murky picture. A controlled experiment at a landscape level would be variable and difficult. The size of the "landscape" would need to be defined. More information is need on basic beetle biology, and computer models would need to be incorporated.

Concurrent Workshops IV

4.1 Bark beetle range expansions and risk assessments

Moderated by Glenn Kohler (Washington Department of Natural Resources; Olympia, WA)

Mountain pine beetle range expansion and risk assessment in Canada

Barry J. Cooke and Vince Nealis
Natural Resources Canada, Canadian Forest Service, Victoria, BC

As of 2011, the mountain pine beetle has spread beyond its historic range to attack lodgepole pine less than 80km south of the Yukon and jack pine in the boreal forest less than 100km west of Saskatchewan. This range expansion has been fuelled largely by long-range dispersal events from outbreaks in British Columbia in 2006 and 2009 with subsequent short-range dispersal through contiguous pine forests, as well as patchily distributed pine in aspen-spruce mixedwood-dominated landscapes. Several lines of analyses make it evident that successful colonization following dispersal has been favoured by historically-anomalous warmer summers and more moderate winters over the last 15-20 years. Despite the rapid rate of eastern spread through the boreal region (average 40km/year since 2002) there has been little evidence of eruptive beetle behavior in the high-volume pine stands in the southern foothills of western Alberta despite MPB's presence there for some time at endemic levels. This region in the eastern foothills is high elevation and so climate may be less favorable for colonization and population increase.

Eastern pine species should now be considered at risk of attack but the time-frame is uncertain. It appears the rate of eastward invasive spread will be influenced more by winter and summer weather affecting survival, flight and attack dynamics than forest structure. Concerned pest managers should adopt the strategies used in dealing with invasive species and rethink how detection and control is conducted if spread management is to be a realistic objective.

Forest Health Evaluation Tool for Small Landowners

Mike Johnson, Washington Department of Natural Resources, Colville, WA

The objectives of the forest health evaluation tool are to provide small forest landowners (SFLOs) information related to current status of client's stands related to forest health, prioritize stands for silvicultural treatments, and evaluate change in stand conditions related to silvicultural treatment. The SFLO, their consultant, or stewardship forester systematically establishes variable radius plots in commercial stands or fixed plots in precommercial stands to obtain the raw data. Recently, improvements have been made to the forest health evaluation tool. The spreadsheets that calculate the outputs from the raw data are now gathered into a "processor" workbook separate from the "master" workbook that contains the raw data. The output generated by the processor workbook is stored in separate spreadsheets in the master workbook along with the raw data. Prioritization output is utilized as input in a third "prioritization" workbook. The prioritization workbook now includes a field related to the treatment status; proposed, scheduled, and completed. The addition of this field facilitates selection of stands for treatment and exclusion of stands already scheduled or completed. Additionally, sorting by stands where treatments have been completed facilitates assessment of the tool's effectiveness. Treatment evaluation output is utilized as input by a fourth "treatment evaluation" workbook. The treatment evaluation and current status summary outputs now include stand density index (SDI) using the Dsum method in addition to the Dq method to provide a more accurate or precise index for multi-species and/or two-storied or multi-storied stands. Conditional formatting has been employed to alter the background color of selected output cells (green, yellow, orange, or red) related to changes with risk thresholds. Field notebook and clipboard data entry forms have been developed. Current efforts are directed at development of a procedural guide for executing the field and office activities. Further refinements are anticipated to include addition of more detailed tabular and graphical outputs for both the current status summary and the treatment evaluation summary and modification of the fir engraver hazard/risk calculation.

Pine Beetle in Southwestern White Pine in the Pinaleño Mountains

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Mountain pine beetle, *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae, Scolytinae), is a native bark beetle infrequently found in the Madrean Sky Island Archipelago, and there is no record of it in the Pinaleño Mountains (32.4^0 latitude). Scattered mountain pine beetle-infested southwestern white pines (*Pinus strobiformis*) were found in 2007 in the Pinaleño Mountains. Additional southwestern white pines have been infested each year since. Mortality each year is minor, but the outbreak has persisted, damage appears to be increasing, and mortality has accumulated to significant levels that affect resource values. Though mountain pine beetle is the most significant insect disturbance agent in lodgepole pine (*Pinus contorta*) forests, and is well studied elsewhere, little is known about the biology and effects in southern Arizona or on southwestern white pine. We undertook investigations to characterize the effects of infestation, determine tree and site characteristics associated with mountain pine beetle infestation, and establish a timeline of outbreak development.

Our objectives are to characterize the effects of infestation, determine tree and site characteristics associated with mountain pine beetle infestation, and establish a timeline of outbreak development. Our approach is to establish plots in infested areas, compare the character of those plots to randomly-located southwestern white pine-inhabiting plots, and date mortality of mountain pine beetle-attacked trees using tree-ring analysis.

Preliminary results are reported by Lynch and O'Connor (2012). We found that mountain pine beetle began killing southwestern white pine as early as 1996, with additional mortality each year since. Activity has increased in the last two years. Stain fungi are evident in most killed trees, but not all. On average, infested plots had similar densities but half the basal area compared to random plots. There was a higher representation of southwestern white pine that were, on average, smaller in diameter than those on random plots. In infested areas, total stocking and the abundance of southwestern white pine has been significantly reduced, creating small openings in the stand canopies.

Lynch A.M., O'Connor C.D. 2012, *in press*. Mountain pine beetle in Southwestern white pine in the Pinaleño Mountains. *In* Gottfried G.J., Folliott P.F. Gebow B. S., Eskew L.G. (Compilers). Merging Science and Management in a Rapidly Changing World: Biodiversity and Management of the Madrean Archipelago III. 1-5 May 2012, Tucson AZ. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-67. Fort Collins CO.

New range of California fivespined Ips in Washington State

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The California fivespined ips (CFI) (*Ips paraconfusus*) is a native pine engraver and a known pest of both young and mature ponderosa pines. Historically, CFI's most northern range has been the Willamette Valley, Oregon in the western Cascade Mountains. In 1999, CFI was first reported causing significant damage to newly established ponderosa pine orchards in the Willamette Valley. In western Oregon, CFI is considered the most important pest in managed pine stands. In 2010 a landowner in Underwood, WA in the Columbia River Gorge reported mortality in both small and large diameter ponderosa pines. Specimens collected from damaged ponderosa pines were identified as CFI. This was determined to be a new record for Washington State after referencing regional insect collections in Washington, Idaho and Oregon. Additional pine mortality occurred in the Columbia Gorge during subsequent CFI outbreaks in 2011. These outbreaks were likely due to recent fire and storm damage and climatic factors compromising ponderosa pine health. Using CFI pheromone-baited Lindgren funnel traps, multiple locations were trapped to determine the presence and flight pattern of CFI during 2010 and 2011. As of 2011, CFI has been collected in Washington as far west as Vancouver, east to Lyle, and north to Toledo and Trout Lake. The highest trap catches occurred in White Salmon, WA and Hood River, OR, areas adjacent to recent outbreaks. Existing range maps for CFI do not include Washington State, despite frequent and repeated bark beetle surveys. These detections could represent range expansion due to changing climate conditions, which may be increasing tree stress or fire occurrence. Alternatively, CFI may have been always present in the region but locally extirpated due to logging activity associated with European settlement. In western Washington State, *I. paraconfusus* may have avoided detection due to the scattered and infrequent nature of its primary host, ponderosa pine. Documentation of the new record locations is important baseline for future studies if the range continues to change. The authors will expand the survey area in 2012 to record the range of CFI in Washington.

4.2. Aerial surveys: Comparison across all borders

Moderated by William Ciesla, Forest Health Management International, Fort Collins, CO and Janice Hodge, JCH Forest Pest Management, Coldstream, BC

Mapping and classification standards in Canada and the US for bark beetles, abiotic agents and damage in aspen and other broadleaf trees were addressed. Also discussed were the limitations of what can be seen, identified and classified during aerial forest health overview surveys.

Summaries of aerial surveys conducted in the central Rocky Mountains (CO, SD and WY) during the 2012 aerial survey season indicate that a single aerial observer, flying a contour pattern at 1000 ft. (ca. 300 m) AGL at about 120 MPH, classified forest area at the rate of 17 acres/second or 1020 acres per minute. Two aerial observers, conducting grid surveys on flight lines spaced at 3 mile (5 km) intervals, classify forest damage at the rate of about 30 acres/second. During this window aerial observers are expected to identify forest cover type, map the location of damaged areas, identify the causal agent(s) and estimate damage severity. In Canada, where overview surveys are made from flying heights of 2500 to 4000 AGL and grid surveys are flown at 3.5-4.5 km intervals, the land area classified per unit of time is considerably larger. These surveys, at best, provide a broad overview of the condition of the forest. They are subjective and the quality of data is only as good as the skill and experience of the aerial observer.

In the US and most Canadian provinces, digital tablets are used for aerial sketchmapping while in British Columbia conventional sketchmapping methods e.g. hard copy maps at 1:100,000 scale, are still being employed.

Different approaches are used to classify intensity of bark beetle infestations in Canada vs. the US. In Canada, infestation levels are classified into four intensity classes based on the proportion of current year's faders in a polygon, or percent of polygon with mortality (for non bark beetle forest health factors):

	BC		YT	AB	QC[b]
Mortality [a]	prior to 2005	2005+			
Polygons					
Trace		<1			
Light	1-10	1-10	1-10	<10	<30
Moderate	11-29	11-29	11-29	11-29	31-65
Severe	>30	30-50	>30	>30	>66
Very Severe		>50			100
Spots	# of trees	# of trees	# of trees	# of trees	

[a] Severities based on % of trees dead within an infested area.
[b] Specific to ice and blowdown damage during the 1998 ice storm

In the US and portions of Canada (British Columbia, Yukon, and Alberta), for individual group kills (spots) the number of current year's faders is estimated. In the US for larger areas of damage, the number of current year's faders/acre is estimated.

In the US comparison of aerial survey data with forest inventory data suggests that aerial estimates of trees per acre have been too low, while studies in British Columbia indicate that the polygon area generally overestimates the area affected. The overestimates are a partially a function of the map scale (1:100, 000) used. However, in the US, there is also a problem with forest inventory data because field crews are not always capable of differentiating between current year and one year old faders.

In 2011, limited attempts were made in the Rocky Mountain Region to make tree per acre counts in polygons of known area from interpretation of oblique digital images taken during survey flights. These have helped improve fader/acre estimates. A test of the Canadian vs. US method bark beetle infestation intensity classification is planned for a mountain pine beetle outbreak area in northern CO for 2012.

Standards for mapping and classification of damage caused by a variety of abiotic agents were discussed. Common abiotic agents that can cause forest damage include: windthrow, winter drying (red belt), drought, hail, frost, wildfire, ice and snow, landslides, inundation, landslides and, less commonly, lava flows from volcanoes. Examples of aerial signatures of damage by several abiotic agents were shown. In the US most polygons are classified as "aerially visible damage" although in some cases extensive damage by wind or ice has been classified into two or more intensity classes. In British Columbia, depending upon the type of damage either defoliation severity codes are used to classify the damage ex. hail damage, or damage codes that are used for bark beetles denoting percent of the polygon affected (Trace, light, moderate, severe, very severe) are used to classify abiotic events like windthrow and declines. Standards elsewhere in Canada are similar to the US with some exceptions particularly catastrophic events e.g. 1998 ice storm in eastern Canada. In these situations more detailed surveys using helicopters and damage codes have been developed to quantify impacts.

Examples of both biotic and abiotic agents that cause damage in aspen and other broadleaf species were presented. A number of agents cause defoliation of broadleaf forests. These include several species of insects (e.g. tent caterpillars, large aspen tortrix, Bruce spanworm, satin moth), frost, hail and high winds. Unless the aerial observer has recent historical data available or follow-up ground checks are made, the causal agent responsible for the defoliation cannot be made from aerial surveys alone. In the US such areas should be coded using a generic "defoliation" code. In Canada defoliation categories vary by province (Table below) and are based on the average percent defoliation in a polygon

	BC	YK	AB	SK	MB	ON	QC		NB	NS	NL
Defoliation [a]							Hardwoods	Conifers			
Light	1-25	<25	<35	do not map light	<35	<50	1-25	1-34	1-30	10-29	do not map light
Moderate	26-65	26-65	36-70	30-69	35-70	51-75	26-60	35-69	31-70	30-69	31-70
Severe	>65	>65	>70	>70	>70	>75	>60	>70	>70	>70	>70
Other	grey trees										>70 with mortality

[a] Defoliation severities based on average defoliation characteristics at a polygon level.

Defoliation can be differentiated from areas of tree mortality by the presence of a gradation from heavy damage to light to none at the edges of the affected areas. This causes boundaries of defoliated areas to appear fuzzy or out of focus. Areas of decline and tree mortality generally have a sharp edge where affected areas adjoin healthy forests. Several agents, including drought resulting in leaf scorch, the leaf fungus, *Marssonina populi*, and the aspen leaf miner (known as serpentine leaf miner in Canada), can cause affected stands to have an orange cast in addition to thin crowns characteristic of defoliation.

A condition known as sudden aspen decline (SAD) has been causing extensive damage to aspen forests both in Canada and the US. In the central Rockies, three strata of damage are used to classify stands affected by SAD using the numerical code 75:

75: Trees with thin crowns present but no mortality
75L: Scattered tree mortality present in a stand
75H: Areas of 100% overstory mortality

In 2012, British Columbia will be considering use of the SAD codes for mapping decline.

Several examples of unusual aerial signatures were shown including:

Ponderosa pine mortality caused by nesting great blue herons
Heavy flowering of New Mexico locust, which can mimic foliar damage
Defoliation by elm leaf beetle in an urban area
Heavy cone crops in spruce forests, which can mimic defoliation
An outbreak of a twig beetle, *Pityophthorus boycei*, in a bristlecone pine forest

Graduate Student Presentations

Bacteria-fungus-host tree interactions: Impacts on mountain pine beetle reproduction

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The mountain pine beetle is one of the most destructive insects in western North America. Historically, the beetle's main host has been lodgepole pine, but with recent range expansions spurred by climate change, is now thriving in lodgepole-jack pine hybrid trees in north central Alberta, and threatens to expand into the jack pines of Canada's boreal forest, where it could cause significant ecological and economic damage. The beetle's success in a novel host, such as jack pine, will depend upon favourable climatic conditions, susceptibility of the host to beetle attack, and successful colonization of that host by the beetle's microbial associates, including symbiotic and opportunistic fungi, and bacteria associated with the beetle and with the host tree. Since phytochemistry differs between lodgepole pine and jack pine, microbial diversity and success will also differ, and will impact the success of the mountain pine beetle. A better understanding of the role of the beetle's microbial associates and the potential constraints present in the jack pine system will provide opportunities for future management. This project focused on determining how interactions between host tree, bacteria, and fungi impact mountain pine beetle reproduction. Phloem sandwich assays containing either lodgepole or jack pine phloem and various combinations of bacteria and fungi were used to determine beetle reproduction under different microbial conditions. Maternal and larval gallery lengths, time required to reach maximum maternal gallery length, number of emerged larvae, and larval density were used as indicators of beetle reproductive success. Results suggest that the role of the bacteria and fungi is mediated by the host, and that the importance of these microbes is dependent upon the biological activities of the beetles. Further, interaction between the beetle and its associated microbes do not appear to constrain the beetle in the invasion of jack pine.

The western conifer seed bug: What it wants and what it needs.

Ben Sloniker, University of Idaho

Leptoglossus occidentalis is an important pest of conifer seed orchards in western North America. In laboratory studies, we tested the feeding and oviposition activity of adult *L. occidentalis* when presented with four conifer hosts and the survival and development of nymphs when confined on individual hosts. Adult *L. occidentalis* fed preferentially on pine hosts over non-pine hosts, and females oviposited on *Pinus ponderosa* more frequently than on any other surface. Adult females presented with only *Pseudotsuga menziesii* or *Larix occidentalis* oviposited as frequently on the enclosure as on host foliage. *Leptoglossus occidentalis* nymphs survived longest and were most likely to complete development on second-year cones of *Pinus contorta* var. *latifolia*. Control, water-only and first-year pinecone treatments did not result in maturation of nymphs to adulthood. Survival time and development of immature insects on *P. menziesii*, *P. ponderosa* and *Pinus monticola* was intermediate between *Pi. contorta* and the least suitable hosts. Only 2% of nymphs feeding only on *P. menziesii* reached adulthood. Additionally, we tested the feeding and oviposition activity of adult *L. occidentalis* when presented with cones from trees that had been treated with different bole-injected systemic insecticides (emamectin benzoate and imidacloprid) during fall or spring treatment periods and development of nymphs when confined on individual hosts of different bole-injected insecticide treatments. Adult male *L. occidentalis* that had not overwintered demonstrated no feeding preference among *P. ponderosa* cones that had been treated with emamectin benzoate or imidacloprid during either treatment period. Nymphs showed no differences in length of survival on *P. ponderosa* cones from different systemic insecticide treatments.

Calibration of walk-through field survey estimates of *Leptoglossus occidentalis* (Hemiptera: Heteroptera: Coreidae) with abundance estimates based on mark-release-recapture techniques

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An important component of effective pest management strategies is the development of economic thresholds. These require standardized population census methods, which have been successfully developed for several insects by establishing the mathematical relationship between abundance estimates using mark-release-recapture methods and walk-through surveys. *Leptoglossus occidentalis* is a pest insect in both lodgepole pine and Douglas-fir seed orchards for which neither a standardized population census method nor an economic damage threshold exists. Concurrent mark-release-recapture studies and walk-through surveys for *L. occidentalis* were conducted both in lodgepole pine (2008 and 2009) and Douglas-fir (2009) seed orchards at the British Columbia Ministry of Forests Kalamalka Seed Orchard and the Kalamalka Research Station respectively. The Jolly-Seber Method alone was used for population estimates in the lodgepole pine orchard and the Schnabel, Schumacher-Eschemeyer, Jolly-Seber and whole-tree methods were used for population estimates in the Douglas-fir block. I was unable to establish a mathematical relationship between any of the population estimates and walk-through surveys in either location, but data from my mark-release-recapture surveys indicated that the walk-through survey appeared unreliable at low populations. Furthermore, my mark- release recapture surveys indicated that spray applications should be scheduled in mid- to late June, as the insect population peaked then in both years.

Changes in the chemistry of pine litter and soils across mountain pine beetle attack stages: Consequences for seedling-mycorrhizal mutualisms.

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Mountain pine beetle (*Dendroctonus ponderosae*; MPB) outbreaks can alter forest structure and composition and accelerate soil nutrient cycles, with potential implications for the management of post-attack site conditions. The goals of this project are to determine differences in pine litter deposition rates and chemical quality in relation to soil nutrition. In 2011, we surveyed eleven 30 x 30 m lodgepole pine stands of varying stages of overstory attack (Control: 0 – 10 m^2/ha; Green-attack: 15 – 20 m^2/ha; Red-attack: 25 – 55 m^2/ha, lodgepole pine basal area attacked). Stands were measured for: 1) intensity, severity, and age of MPB attacks; 2) pine litter deposition rates and chemical quality; 3) soil moisture and nutrient status. Results indicate that stands differ significantly in key aspects of pine litter and soil nutrition. Specifically, basal area (m^2/ha) of attacked lodgepole pine accounted for 82% of the variation for litter deposition rates across all stand types, in which red-attacked versus control stands deposited 85% more litter (Kg/ha), which contained 36% more phosphorus (% dry weight). Soils in red-attacked versus control stands displayed a 29% higher nitrate concentration (Kg/ha), 58% higher phosphorus concentration (Kg/ha), elevated pH values, and 25% more water (% vol.). Our findings demonstrate a novel impact of MPB attacks on litter quality and suggest this effect may potentially be linked to poor foliar nutrient re-adsorption following attack. Further, the lack of detectable differences between control and green-attack stand types suggests a two-year time lag between initial attack and site-level changes in soil moisture and chemical properties. An understanding of these effects and their potential to create legacies in belowground conditions can aid resource managers in post-attack site management decisions.

Utilizing molecular techniques in the development of a biological control program for the invasive goldspotted oak borer (*Agrilus auroguttatus*)

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The goldspotted oak borer (*Agrilus auroguttatus*) is an invasive buprestid beetle that has caused widespread mortality (>21,500 trees) to three species of native California oaks. *Agrilus auroguttatus* is native to oak woodlands in southeastern Arizona, and was likely introduced into southern California via the movement of infested oak firewood. Within its native range, this beetle is not a pest. This may be due, in part, to an absence of co-evolved natural enemies in the introduced range. The development of a classical biological control program with co-evolved host specific

parasitoids is an appealing forest management strategy for *A. auroguttatus* in southern California since it has the potential to be permanent, cost-effective, and environmentally safe.

An effective classical biological control program requires several components such as basic life history information on the pest, and the identification of host specific natural enemies from the pest's area of origin. The use of DNA-based techniques has the potential to identify the area of origin for California's invasive population, and could facilitate the collection of natural enemies that have evolved to exploit the genotype of the invading pest population. Additionally, determining the area of origin for the California population of *A. auroguttatus* may provide insight into its potential invasion routes which may be of use for developing management plans to mitigate unwanted future introductions of forest pests from within the Continental USA.

Preliminary results from our molecular analyses suggest that the Dragoon Mountains in Arizona is a likely source of the California population, an area from which GSOB had not been previously recorded. The first collection (May 2011) of *A. auroguttatus* from the Dragoon mountain range in Arizona suggests that there are additional mountain ranges within the greater home range region that may be suitable for *A. auroguttatus* inhabitation and some of these (e.g., the Whetstones) have not been systematically surveyed for GSOB. Further collections from the Whetstone, Pinaleno, and Patagonia Mountain ranges are necessary in order to definitively pinpoint the geographic source of the California population of *A. auroguttatus*.

Monitoring the ecological responses to a mountain pine beetle outbreak in southeastern Wyoming.

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Recent mountain pine beetle (MPB) activity in the Medicine Bow range of southeastern Wyoming has caused widespread mortality across the landscape. This study initiated in 2007 with the collection of a sediment core. At that time it was observed that a MPB outbreak was beginning in the watershed. In 2008, this study established vegetation plots around the lake to monitor the beetle progression on a year-to-year basis. Within each vegetation plot, tree diameter breast height (dbh) measurements were recorded, attack codes were given to each host species, and understory and over-story vegetation transects were conducted. Repeat measurements were collected annually from 2008-2011 in an attempt to monitor the ecological response of the forest to the outbreak. Preliminary results suggest stand density and dbh are important factors that influence tree susceptibility to attack. This study has also demonstrated that the beetles were primarily attacking larger, less dense host species in the beginning, but throughout the course of the four years, beetle were attacking smaller, more dense host species because they had successfully attacked and killed the larger diameter trees. It is also observed that some trees are surviving the attack regardless of dbh or stand density.

Abstracts for Poster Presentations

P1. A new synthesis and lure for (+)-disparlure

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We have developed a proprietary new synthesis for (+)-disparlure that involves a novel method of ensuring extremely high enantiomeric purity. When analyzed by the USDA-APHIS the synthetic pheromone was determined to have 96% and 99.8% chemical and optical purity, respectively. When tested in the field by the USDA-APHIS catches in traps baited with the USDA standard pheromone on dental cotton wicks fell off steeply at high doses indicating repellence due to increasing levels of (-)-disparlure, whereas catches in traps baited with the new synthetic pheromone fell off only slightly. The new synthetic pheromone was formulated into PVC flexlures, which provide easier handling than string lures. When tested in the field in Wisconsin, catches in Unitraps baited with Contech flexlures or Trécé string lures were not significantly different, and both were significantly higher than catches in traps baited with Hercon strip lures or Scentry grey rubber septa. An experiment designed to test a new plastic bag trap baited with Contech flexlures showed that it was far inferior to Unitraps baited with the same lure. In this experiment, delta traps baited with Contech flexlures caught the expected number of approximately 10 males per trap, about the same number as Safer bag traps, a retail product that proved to be poorly designed to mass trap males. Insertion of a 1 cm^2 block of Vapona into the experimental bag trap significantly improved catches, demonstrating that escapes occurred through the side entry ports. Our results indicate that we have met our two most important objectives of 1) developing a new synthesis that produces (+)-disparlure of the highest quality, and 2) formulating the new synthetic pheromone into a lure that is competitive with the best alternative lure currently available.

P2. On the origin of terpenes: Selection pressure from mountain pine beetle alters defensive strategies of lodgepole pine populations.

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Mountain pine beetle is the most destructive disturbance agent in pine forests in western British Columbia. Historically, the range in which outbreaks have occurred has been limited by climatic variables, most notably minimum winter temperatures. Recently, the range of this insect has expanded and populations of the main host, lodgepole pine (*Pinus contorta* var. *latifolia*), that have not been previously exposed to outbreaks are now being attacked. This is likely due to increasing temperatures in recent decades. Trees outside the historic range have been shown to be naïve, and hence are more likely to be killed and serve as better hosts for the beetle. This phenomenon is similar to what is observed upon the invasion of new habitat by exotic invasive species. The goal of my research is to determine whether selection pressure from mountain pine beetle on populations of lodgepole pine in southern British Columbia has conferred resistance, and what mechanisms may have evolved to do so. We will accomplish this by conducting several experiments in the field and in the lab, with the goal of determining what characteristics of northern naïve populations of pine hosts, both lodgepole and newly invaded jack pine (*Pinus banksiana*), may make them more

suitable for mountain pine beetle outbreaks. This research will help us understand how bark beetles affect host populations over time, and will give us much needed information on the potential for mountain pine beetle to spread to the boreal forest in Canada.

P3. Ecology and management of northern spruce engraver in interior Alaska.

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The northern spruce engraver, *Ips perturbatus* (Eichhoff), is a significant tree-killing bark beetle in the boreal and sub-boreal forests of North America. Its range generally coincides with that of its primary host, white spruce, *Picea glauca*. Other hosts include Engelmann spruce, *P. engelmannii*, Lutz spruce, *P.* × *lutzii*, and in rare cases, black spruce, *P. mariana*, or Sitka spruce, *P. sitchensis*. Outbreaks of *I. perturbatus* in interior Alaska are most frequently associated with forest disturbances and logging debris. When favorable climatic conditions coincide with large quantities of suitable host material, *I. perturbatus* populations may erupt, resulting in the mortality of apparently healthy trees over extensive areas. We review the ecology and management of *I. perturbatus*, a species that appears to be increasing in pest status as a result of recent climatic changes. Furthermore, we describe three years of work conducted to identify effective silvicultural- and, to a lesser extent, semiochemical-based management strategies. We concentrate on the effects of commonly used slash management practices on *I. perturbatus* performance in slash, and on the effectiveness of these practices for minimizing associated levels of tree mortality in residual stands. Finally, we provide recommendations for best management practices based on our research.

P4. Assessment of Jeffrey pine beetle-caused mortality from 1991-1996, Spooner Junction, Lake Tahoe Basin.

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A Jeffrey pine beetle (*Dendroctonus jeffreyi* Hopkins) (JPB) epidemic caused Jeffrey pine (*Pinus jeffreyi* Balf.) mortality throughout the Lake Tahoe Basin from 1991-1996 following multiple years

of below average precipitation. Census data, including geospatial location and tree attribute data for 10,721 stems, were obtained from a continuous, 60-acre study area near Spooner Junction that was established to assess JPB activity without management intervention. This epidemic was considered to be at the high end of potential outbreak scenarios based on prior outbreaks documented in the Lake Tahoe Basin.

We quantified conditions within the study area that supported this outbreak, mortality levels, effect of JPBs on forest attributes, and conditions that were resilient to JPB-caused mortality. The study area was located on south-facing slopes that ranged from 5-20%. Forest conditions that supported this outbreak averaged 15" quadratic mean diameter, 302 stand density index (SDI), 37% canopy cover, and 95% Jeffrey pine host species composition. JPBs caused mortality in 44% of all available Jeffrey pines within the study area at a rate of 74 trees acre^{-1}. Prior to the outbreak 45% of the study area had $\geq$ 40% canopy cover, while only 14% exceeded this level post-outbreak. The JPB-caused mortality (trees acre^{-1}) response had a strong positive, linear relationship with stand density index in a best-fit, mixed regression model that adjusted for significant spatial autocorrelation. Tree mortality occurred in proportion to available host in stems < 30" diameter at 4.5 feet in height (DBH); however, mortality was disproportionally less in stems $\geq$ 30" DBH. Portions of the study area with < 210 SDI or 125 square feet of basal area per acre were resilient to extensive tree mortality even after exposure to high levels of JPB population pressure.

P5. Bark beetle responses to fuels reduction at Blacks Mountain, California

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Mechanical thinning and the application of prescribed fire are commonly used to reduce fuel loads and restore late-seral conditions in interior ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forests, but the propensity for some bark beetles (Coleoptera: Curculionidae, Scolytinae) to attack fire-injured trees has led to questions regarding how management objectives may be impacted by levels of delayed tree mortality attributed to bark beetle attack. In this study, we examined bark beetle responses to creation of mid-seral (low structural diversity; LoD) and late-seral (high structural diversity; HiD) forest structures at Blacks Mountain Experimental Forest, U.S. during a five-year period following the application of prescribed fire (B). Twelve experimental plots (LoD and HiD), ranging in size from 77-144 ha, were split with one half randomly assigned prescribed fire resulting in four treatments (HiD, HiD + B, LoD, and LoD + B). A total of 6,877 pine and fir trees (4.0% of all trees) were killed by bark beetles (all bark beetle species combined), most of which was attributed to western pine beetle (*Dendroctonus brevicomis* LeConte) and mountain pine beetle (*D. ponderosae* Hopkins) in ponderosa pine, and fir engraver (*Scolytus ventralis* LeConte) in white fir [*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.]. The majority of bark beetle-caused tree mortality was recorded on HiD + B (41.5% of trees that were killed by bark beetles) with 30.0%, 23.5%, and 5.0% occurring on HiD, LoD + B, and LoD, respectively. Overall, a significantly higher percentage of bark beetle-caused tree mortality (of available trees) occurred on LoD + B (5.3%) and HiD + B (4.8%) compared to LoD (1.1%). We observed no significant differences in levels of bark beetle-caused tree mortality (all bark beetle species combined) among diameter classes, but the level of western pine beetle-caused tree mortality was concentrated in the large tree component on burned split plots. The implications of these and other results to the

management and maintenance of late-seral conditions in interior ponderosa pine forests are discussed.

P6. Ecological impacts of mountain pine beetle outbreaks in the intermountain west U.S.

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Currently, mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins, outbreaks are widespread across the western U.S., especially in lodgepole pine, *Pinus contorta* Dougl., dominated forests, requiring evaluation of ecological impacts and development of resource strategies that address future forest conditions. Twenty-five 0.08-ha plots were established in each of five states (Colorado, Idaho, Montana, Utah and Wyoming) in predominately lodgepole pine stands with recent MPB-caused tree mortality (n = 125). Within each plot, all trees ≥7.6 cm diameter at breast height (dbh) were tagged with species, dbh, height, height to base crown, status (live or dead), cause of death and year since death recorded. Three 16.1-m Brown's transects were established in each plot to estimate surface fuels, and three 1-m² and one 0.004-ha plots were established to estimate forest floor composition and regeneration, respectively. Since 2004 there has been a significant loss of pines in the larger diameter classes (≥17.5 cm dbh), due primarily to MPB. Reductions in live pine volume ranged from 49% (Idaho) to 67% (Montana) between 2004 and 2011. As a result, substantial changes in the amount and distribution of fuels are expected as needles, branches, limbs and boles fall to the forest floor. Levels of future tree mortality and the fall rates of individual trees are recorded annually. Changes in regeneration, forest floor composition and fuel loads are assessed every three years (next in 2013). The Forest Carbon and Emissions Model will be used to estimate carbon loss and emissions.

P7. Efficacy of emamectin benzoate at reducing defoliation from western spruce budworm

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The western spruce budworm (WSBW), *Choristoneura occidentalis* Freeman, is a periodic and potentially severe pest of true firs and Douglas-fir across the western United States and Canada. In Idaho from 2008 to 2011 moderate to severe defoliation by WSBW was recorded on 1,038,488 hectares of forestland. In 2008, a study was initiated to evaluate the efficacy of stem injections of the promising systemic insecticide, emamectin benzoate (TREEäge) (ArborJet Inc., Woburn, Mass.). The low volume application of systemic insecticides is preferable in sensitive environments,

parks, and other high value areas where few viable options exist for pest control. Our data suggest that at least three years of satisfactory control are possible with injection of TREEäge at rates listed for control of bark beetles

P8. Evaluating aspen damage and decline in the Pacific Northwest

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This study focused on assessing the stand conditions and causal agents affecting aspen in the Pacific Northwest (PNW) by ground-based sampling of damage areas identified in annual aerial detection surveys (ADS). Seventy-one sites dominated by quaking aspen (*Populus tremuloides*) were evaluated in Washington (WA) and Oregon (OR) in 2010 and 2011. Stand and site attributes, aspen regeneration, and the major damaging agents were recorded. In this study, 65% of stands evaluated were found to be in “stable” condition, while 35% were deemed “successional” or “decadent.” Conifer encroachment was common and recorded in 48% and 78% of plots in WA and OR, respectively. Crown dieback in OR was more severe, but overstory mortality of aspen was similar between states and comprised less than one-third of the total number of trees on 72% of the plots. Aspen regeneration was detected in over 90% of the plots, but advanced regeneration was present in only 35% of WA and 63% of OR plots. Live aspen stems (> 5 in dbh) were most frequently impacted by ungulate chewing/rubbing, stem decays, woodboring beetles, and cankers. Aspen regeneration (≤5 in dbh) was most impacted by ungulate feeding, defoliating insects, and foliage diseases. This evaluation of aspen in the PNW did not appear consistent with the rapid overstory mortality and lack of regeneration characteristic of sudden aspen decline (SAD); rather, the majority of areas showed evidence of slow, progressive decline resulting primarily from successional processes and ungulate damage. Management of PNW aspen stands, including conifer removal and fence exclosures, would help to improve their overall health and may be needed to assure their long-term survival in some areas. Aerial surveyors in OR and WA have used these findings to develop a new code, ‘hardwood decline – aspen’ (HDA), that will more accurately depict aspen damage and mortality in the PNW.

P9. Pandora Moth Monitoring in Northern Arizona

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The pandora moth, *Coloradia pandora davisi*, is a periodic defoliator of ponderosa pine in western pine forests of the United States. Outbreaks in Arizona generally last 6 to 8 years and occur every 20 to 30 years. The last outbreak in Arizona began in 1979 on the North Kaibab Ranger District and crashed naturally in 1985 due to a build-up of a nuclear polyhedrosis virus. Historically, pandora moth impacts have been relatively minor (2% tree mortality); however, changing climatic conditions may negatively influence the level of impact. This work spans three years and focuses on developing technologies that improve pandora moth monitoring through modified sampling methods of larvae, egg mass densities and defoliation, the development of sex attractant pheromones, as well as the use of GIS and remote sensing techniques to map the extent and severity over the course of the outbreak. Preliminary monitoring efforts indicate that pandora moth is currently in the early stages of outbreak; during the summer of 2010 we used light traps to estimate the population density (light traps yielded 24,320 moths) and during the summer of 2011 we sampled larvae and defoliation from 58 of the 136 plots (621 larvae were collected, defoliation was negligible at less than 1%). Natural enemies (parasitoids and virus) resulted in less than 1% mortality in 600 larvae and pupae. Moth populations are expected to drastically increase over the next four to six years.

P10. Western Forest Insect Work Conference 2013 in Coeur d'Alene, Idaho

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The 2013 Western Forest Insect Work Conference will be held March 4-7 in beautiful Coeur d'Alene, Idaho. Listed are a few activities to look forward to:

- A journey back to 1919 to discover the Bureau of Entomology Coeur d'Alene Insect Investigation Field Station and the lives and work of entomologists from that era.
- An insect photo contest last held at the 1969 WFIWC in Coeur d'Alene.
- Hike on Tubbs Hill—a natural area next to the hotel.
- Visit the numerous shops, art galleries, and restaurants downtown.
- Listen to marvelous local music.
- Ski at one of the many ski resorts within an hour of Coeur d'Alene.

The organizing committee is currently soliciting suggestions for workshops and plenary sessions. Please submit suggestions for the program to Joel Egan, jegan@fs.fed.us, or Brytten Steed, bsteed@fs.fed.us. Any comments or suggestions on local arrangements can be sent to Sandy Kegley, skegley@fs.fed.us, or Nancy Sturdevant, nsturdevant@fs.fed.us

P11. Life under the bark - Profiling the relative abundance of mountain pine beetle fungal associates across the developmental stages of beetle progeny in galleries within lodgepole pine.

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The mountain pine beetle (MPB) *Dendroctonus ponderosae*, a native beetle in western North America, inhabits lodgepole pine and other pine ecosystems. The majority of the MPB's life cycle takes place under the bark of its host tree where the progeny develop in the presence of fungi, bacteria, mites, and nematodes. Fungi closely associated with the beetle include the ascomycete ophiostomales: *Grosmannia clavigera, Leptographium longiclavatum, Ophiostoma montium* and

Ceratocystiopsis sp.1. To develop a better understanding of the interactions between the beetles, fungi and host trees, we used target-specific DNA primers with qPCR to profile the relative amounts of these fungi through the egg, larvae, pupae, and teneral adult developmental stages in field-attacked lodgepole pine trees. Applying a combination of multivariate, pairwise and univariate analysis of covariance, we detected that *O. montium* did not show any change over the beetle lifecycle. *Leptographium spp.* (*L. longiclavatum* and *G. clavigera*) did not show a significant increase on their own; however, they show increasing trends and they contribute to the overall difference between the life stages. *Ceratocystiopsis* sp.1 was significantly more abundant after the larval stage. *Leptographium* and *O. montium* grow in and stain the tree phloem and sapwood, while *Ceratocystiopsis* sp.1 grows in the beetle gallery and produces no dark pigment. This fungus has not been formally described and has been largely ignored by other MPB studies, and it may be important in the nutrition of the teneral adults.

P12. Mapping cumulative effects using aerial detection survey data and GIS.

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Aerial Detection Survey (ADS) data is a great tool for assessing effects of forest damaging insects and disease. However, because the attribute design allows for multiple Damage Causing Agents (DCA), Hosts, and Damage Types for a single polygon, calculating year end totals can be cumbersome. The issue is compounded when analyzing multiple years ADS data because of overlapping polygons. From year to year a particular DCA can be present in the same area and to be accurate, when analyzing multiple years ADS data, a particular area should only be counted once. An ArcGIS script tool (AddADS) was developed that allows for summation of Trees Per Acre (TPA), Number of Trees Killed, and Severity Rating, taking into account multiple DCA's, Hosts, and Damage Types over single or multiple years. The tool also recalculates acreage so any particular area is only counted once in the analysis. To go along with AddADS, another script tool (AddNF) was produced which calculates Flown/Non-Flown areas over multiple years. This tool also recalculates acreage to eliminate overlapping areas while keeping track of which and the number of years a particular area was not flown.

P13. Interactions of an invasive bark beetle with a forest pathogen: Range expansion of mountain pine beetle in jack pine forests and impact of dwarf mistletoe

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In recent decades, mountain pine beetle (*Dendroctonus ponderosae*) has killed millions of lodgepole pine trees (*Pinus contorta*) in British Columbia, and there is a threat of an easterly expansion of mountain pine beetle into jack pine forests (*P. banksiana*). A proactive approach to the arrival of mountain pine beetle in the boreal forest could result in development of pre-emptive management strategies. The further easterly expansion of mountain pine beetle will be constrained by climate and the amount of susceptible trees, which tend to be weakened or stressed pine trees. Lodgepole pine dwarf mistletoe (*Arceuthobium americanum*) is a native tree pathogen of jack pine that induces significant stress and causes extensive damage throughout its range in Alberta to Manitoba. Dwarf mistletoe infection can change chemical properties of trees, and these changes may have consequences for tree resistance to subsequent attacks by other organisms. In my research, I will study whether dwarf mistletoe will influence jack pine susceptibility to mountain pine beetle. This interaction is important because the eastward expanding wave of mountain pine beetle will likely first encounter these highly abundant diseased jack pine trees and colonize them trees upon arrival. In this study, I will conduct field and greenhouse experiments to determine whether infection by a widespread native pathogen alters jack pine suitability by changing its physical and chemical defenses to mountain pine beetle and affect initial establishment and survival of mountain pine beetle populations.

P14. Over-wintering mortality increases sex-ratio bias of a size-dimorphic bark beetle

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Life history traits such as body size at maturity are likely to influence mortality during development. When sexual size dimorphism exists, differential energetic demands can lead to sex-biased mortality. This is a proximate mechanism that could explain biased sex ratios. Mountain pine beetles typically have female biased populations (2:1) and females are 37% larger than males. High rates of mortality occur as developing beetles over-winter and the relatively smaller males could be more susceptible to stresses. If mortality is not a sex trait but a size trait, small females will be more susceptible than large females. Higher mortality of the smallest individuals of both sexes has been shown in adults and was tested here in juveniles. We studied survival, sex ratio and body size of beetles from naturally attacked logs by applying three treatments: pre-winter, below-snow and above-snow. Compared to beetles from logs that did not over-winter, survival decreased and sex-ratio bias increased. Female body size increased significantly in the below-snow treatment, while male body size did not change. This indicates that mortality occurs over the entire distribution of male size but may be selecting against the smallest females. This mechanism could potentially maintain sexual size dimorphism in this species.

P15. Green alder sawfly, *Monsoma pulveratum* – Pacific Northwest surveys in 2011

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Green alder sawfly (GAS), *Monsoma pulveratum*, is native to Europe, northern Africa, and the Near East. The larvae feed on the foliage of many alder species, and – unlike most sawflies – mature larvae may burrow into wood to pupate. The first occurrence of this sawfly in North America was reported in eastern Canada in the mid-1990's, and then in 2007 defoliation of thin-leaf alder was observed in Alaska.

In April, 2010, an adult sawfly was photographed on red alder in Vancouver, WA, and identified when the photographs were posted on bugguide.net. WA State Dept. of Agriculture entomologists (WSDA) subsequently collected adults at several locations in WA and confirmed the identification. In the spring of 2010, adults were trapped in several WA locations; although very little trapping was done in OR, one GAS adult was hand-collected in Portland, OR.

In 2011, cooperators from seven different agencies conducted sawfly surveys throughout Oregon and Washington as well as parts of northern Idaho and western Montana. Often these agencies "piggybacked" the sawfly trapping onto surveys aimed at other insects. Traps consisted of thin yellow panels (18cm x 14cm) coated with sticky material, which were hung from alder (usually red alder) branches. Traps were generally set out in April (depending on weather conditions), and retrieved and replaced at ~4 week intervals until September or October. Sawflies from retrieved traps were identified by Chris Looney (WSDA).

Forty-five GAS adults were trapped or hand collected in 2010, and 142 GAS adults were trapped in 2011. Altogether, GAS was detected in 18 counties in Washington, 7 counties in Oregon, and 2 counties in Idaho. Most adults were trapped in western WA and OR, but even there, GAS was not trapped in many areas with abundant alder hosts.

P. 16. To see or not to see: Visual host orientation by Warren root collar weevil

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The Warren root collar weevil (*Hylobius warreni* Wood) is a native, long-lived, flightless insect that feeds on a variety of conifers. While adult feeding does not typically damage mature trees, larval feeding at the root collar can girdle and kill young trees. In recent years, mortality due to larval feeding has become an emerging concern in western Canada, especially in areas where lodgepole pine has been replanted in the wake of salvage harvesting within the mountain pine beetle epidemic. Little is known, however, about the cues used by Warren root collar weevils in finding and orienting to their hosts. No evidence of attraction of adult insects to host volatiles was found in laboratory experiments in Y-tube olfactometers using fresh host material. Subsequent field experiments with visual silhouettes in the absence of chemical cues indicated that host orientation may be primarily visual. Long-range chemical attraction may be unimportant for this insect. Warren root collar weevil is flightless, so does not need to rapidly sample host cues while engaging in host choice during flight.

P17. The effect of cold exposure on the spring emergence behaviour of the eastern larch beetle, *Dendroctonus simplex*, (Coleoptera: Curculionidae).

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Climate change has been implicated in contributing to the increasing frequency and severity of bark beetle outbreaks. In Minnesota, an ongoing outbreak of eastern larch beetle, *Dendroctonus simplex*, has been occurring since 2000. Shorter, warmer winters are suspected to be a contributing factor to the outbreak. This study examines the over-wintering biology and spring emergence behaviour of eastern larch beetle.

Tamaracks infested with adult beetles were harvested in the field in late October, 2011, wrapped in tarpaulins, and placed in an outdoor storage area. Immediately after harvest and at regular intervals throughout the winter, subsamples of the infested logs were brought into the lab. Bolts were placed in cages to allow beetle emergence. The number of days until first beetle emergence and the number of days needed for beetles to complete emergence were compared to the duration of cold exposure of the adults, calculated as cooling degree days (°C) below a 5 °C threshold. Increasing cooling degree days resulted in a significant decreases in the number of days until beetles initiated emergence from over-wintering galleries, and successfully reduced the number of days need to complete emergence. Our results suggest that eastern larch beetles can successfully emerge from overwintering after being exposed to as little as 106 cooling degree days, and hence may engage in advanced spring emergence if current climatic trends continue to create favourable environmental conditions at earlier times in the year. Current work is focused on examining potential differences in reproductive viability of the emerging adults.

P18. Bark beetle activity associated with tornado-damaged ponderosa pine in northern Arizona.

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The US National Oceanic and Atmospheric Administration confirmed that at least six tornados occurred in ponderosa pine forests of northern Arizona during the early morning of October 6, 2010. Satellite imagery and aerial surveys found approximately 2,400 ha of moderately high to severe damage across nearly 80 km of tornado paths, plus >6,600 ha of low to moderate damage. There was an array of tree damage including windthrown trees still having root to soil contact and trees snapped off at various heights. Certain species of bark beetles, mainly engraver beetles (*Ips* species), are known to infest storm-damaged pine and subsequently cause tree mortality in nearby areas. We began monitoring bark beetle and wood borer activity associated with tornados during the spring of 2011 using pheromone-baited traps and three ground sampling approaches. Based on trap catches, *I. pini* exhibited a large population increase during the summer of 2011. External evaluation of down material and stobs (the standing portion of broken trees) found *Ips* activity was greater in smaller sized material and broken tops that were shaded compared with sunlit material. Wood borers and *D. valens* were more common in sunlit stobs than shaded stobs; however, the opposite pattern was observed for windthrow and broken tops. Other *Dendroctonus* species were most common in shaded areas. Analysis of bark samples from windthrown trees found an inverse relationship between number of *I. pini* nuptial chambers and log diameter and also *I. pini* egg galleries and log diameter. *Ips pini* attacks and emergence per infested bolt were greater in shaded conditions compared to sunlit conditions. Similar attack densities were found in broken tops and windthrown trees, although there was slightly higher emergence from windthrown trees. We will continue to monitor beetle populations in 2012 and survey for infested trees in the vicinity of tornado swaths.

P19. Quantifying arthropod diversity in the Selkirk Mountains of northern Idaho and eastern Washington.

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

P20. Dispersal of mountain pine beetle and impacts of management

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Efforts to control the Mountain Pine Beetle infestation in British Columbia and Alberta include large-scale landscape manipulations such as clearcutting, and cost-intensive techniques such as green attack tree removal. Unfortunately, it is unclear just how effective these techniques are in practice. I will present a spatially-explicit hybrid model for the Mountain Pine Beetle (MPB)

dispersal and reproduction. The model is composed of reaction-diffusion-chemotaxis PDEs for the beetle flight period and discrete equations for the overwintering stage. I will discuss the impacts of management in the PDE model.

P21. Flight activity and lipid content of *Dendroctonus ponderosae* in relation to sex and age

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The mountain pine beetle, *Dendroctonus ponderosae* Hopkins (Coleoptera: Scolytinae) is native to western North American pine forests and is currently causing unprecedented damage in lodgepole pine, *Pinus contorta* Douglas stands in western Canada. Although aspects of its flight behaviour are documented from field experiments (e.g. flight threshold temperature, humidity and beetle quality), *D. ponderosae* flight capacity is not well understood. We investigated the flight activity and lipid content of differently-aged male and female mountain pine beetles. Beetles were reared from infested lodgepole pine bolts collected in northern Alberta in the fall of 2011. Male and female beetles from three age groups (1-3 days, 5-7 days, 9-11 days post-emergence) were flown for 24-h flight period on automated flight mills and flight distance, duration and velocity were recorded. After flight, beetles were killed and lipid content was measured using soxhlet fat extraction. The lipid content of flown beetles was compared to that of unflown control beetles.

Group Photographs from WFIWC 2012, Penticton, BC

Back: Andy Eglitis, Celia Boone, Kathy Bleiker, Neal Kittleson, Steve Cook
Front: Elizabeth Campbell, Ed Holsten, Andy Graves, Barbara Bentz, Sandy Kegley, Mary Reid

Back: Joel Egan, Shaun Strohm, Leanna Lachowsky, Mike Johnson, Glenn Kohler
Front: Jim Corrigan, Darrell Ross, Rob Flowers, Rich Hofstetter, Iral Ragenovich

Back: Judy Thomson, Dean Christianson, Mark Schultz, Jennifer Burleigh, Lucy Stad
Front: Hilary Graham, Roger Burnside, Chris Fettig, Gabriella Zilahi-Balogh, Joan Westfall

Back: Laurel Haavik, Julie Brooks, Janice Hodge, Pat Ciesla, Janet Therrien, Kit O'Connor
Front: Bruce Thomson, Tamara Richardson, Babita Bains, Olle Rosenberg, Jennifer Klutsch, Paul Cigan

Back: Andrew Hunsberger, Brian Van Hezewijk, Caroline Whitehouse, Ken Raffa, Kathy Sheehan, Heather Rice, Danielle Reboletti
Front: Robert Hodgkinson, Leo Rankin, David Wakarchuk, Ken White, Brian Aukema

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