Western Forest Insect Work Conference

Victoria, BC

March 29 - April 1, 2005

Western Forest Insect Work Conference Executive:

Chair	Darrell Ross
Past Chair	José Negron
Secretary	Lia Spiegel
Treasurer	Ladd Livingston
Councilor	Jennifer Burleigh
Councilor	Tim McConnell
Councilor	Danny Cluck

Victoria Conference:

Program Committee	Peter Hall
Local Arrangements	Lorraine Maclauchlan

DISCLAIMER

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Conference Program

Date	Time	Title	Moderator
March 28	13:30 – 19:00	Registration	
	19:00 – 21:00	Reception	
	19:00 – 20:00	Executive Committee Meeting	Darrell Ross
March 29	08:30 – 10:00	General Meeting	Darrell Ross
	10:30 – 11:00	Opening Address	Dr. Paul Addison
	11:00 – 12:00	Scholarship Presentation	Kathy Bleiker
	13:30 – 15:00	Workshops:	
		Regeneration Issues/Seed & Cone	*Robb Bennett*
		Impact of Treatments on Non-targets	*Ken White*
		Beetle Outbreaks – How did we get here?	*Alan Carroll*
		Forest Health Monitoring	*Tim McConnell*
	15:30 – 17:00	Workshops:	
		Gypsy Moth Status and Eradication	*Dave Bridgewater*
		New Management Directions – Wood vs. View	*Mike Wagner*
		Preventing the Next "big" Outbreak	*Ken Gibson*
		Detection/Aerial Survey – methods and standards.	*Tim Ebata*
	19:00 – 21:00	Poster Reception	
March 30	08:30 – 10:00	Workshops:	
		Are Insect Outbreaks Increasing?	*Vince Nealis*
		Environmental Impact Studies	*Connie Mehmel*
		Verbenone/MCH/Mass trapping/Non-host	*Leo Rankin*
		Urban Forest Pest Issues	*Jerry Carlson*
	10:30 – 12:00	Graduate Student Presentations	*Kimberly Wallin*
	13:30 – 15:00	Panel:	
		Going…Going…Gone – Supply and demand of entomologists	*Peter Hall*
	15:30 – 17:00	Tours	
	19:00 – 21:00	Banquet and Founders' Award	Gary Daterman
March 31	08:30 – 10:00	Workshops:	
		Emerging Technologies in Forest Entomology	*Dezene Huber*
		Future Role of Silviculture in IPM	*Peter DeGroot*
		Decision Support Systems – Development	*Terry Shore*
		Climate Change – Special Workshop	*David Gray*
	10:30 – 12:00	Panel:	
		Damaged Wood	*Daniel Lousier*
		Climate Change – Special Workshop	*David Gray*
	13:30 – 15:00	Workshops:	
		Insect Status Reports from each Region	*Don Grosman*
		Decision Support Systems – Applications	*Marvin Eng*
		Exotic Introductions and Exotic Insects	*Dave Holden*
		Climate Change – Special Workshop	*David Gray*
	15:30 – 17:00	Workshops:	
		Defoliator Impacts, Management and Control	*Karen Ripley*
		Impacts and Assessments of Management	*Art Stock*
		High Elevation Forests/Extreme Environments	*Lorraine Maclauchlan*
		Climate Change – Special Workshop	*David Gray*
April 1	08:30 – 10:00	Panel:	
		What's in the Future?	*John Borden*
	10:30 – 12:00	Final Business Meeting	*Darrell Ross*
		Adjourn	

General Meetings

Executive Committee Meeting

28 March 2005

Darrell Ross called the meeting to order at 5:05 pm.

Present:

> Darrell Ross: WFIWC Chair and Chair, Memorial Scholarship Committee
> Tim McConnell: Councilor
> Ladd Livingston: Treasurer
> Ken Gibson: Chair, Founders' Award Committee
> Peter Hall: 2005 meeting arrangements
> Karen Ripley: Chair, Memorial Scholarship Fundraising Committee
> Jennifer Burleigh: Councilor
> Brytten Steed, Chair; Common Names Committee
> Lia Spiegel: Secretary

Peter Hall gave updates on program changes and conference registration and income. The talk at Pacific Forestry Centre has been moved to the hotel due to the large number of participants, but the field trips remain unchanged. The Initial Business Meeting will break at 9 am for the keynote speaker and continue after the keynote. There are 167 registrants to date, 79 Canadian, 88 US. Costs to date: catering, miscellaneous, posters: $28,000 CD. Income & Donations: The Canadian Forest Service and BC Ministry of Forests combined have donated approximately $20,000 CD. These contributions combined with registration income total approximately $50,000 and put the current meeting firmly in the black.

Bob Coulson announced that NAFIWC would take place in Asheville, NC May 22-26, 2006. He would like us to postpone WFIWC for one year to accommodate the North American meeting.

Lia Spiegel read the minutes of the 2004 Final Business Meeting.

Old Business:

There remains the need to follow up at the initial business meeting on the status and availability of Western Forest Insects reprints with Tom Hofacker.

New Business:

Treasurer's Report: Submitted and read by Ladd Livingston. Highlights:

Balance from 2003 meeting in Mexico	$636.15
Total Interest Income from CD's (to savings account)	$245.69
Deposited to Scholarship CD	$730
Memorial Scholarship Fund current balance	$21,392.80
McGregor Fund (only change is interest income)	$5,120.00
Savings (available for scholarships)	$1,044.09

Lower interest earnings this year due to lower interest rates. New CD interest rate is double this year up to 2.5%.

Ladd will be more than happy to work with his replacement to set everything up. The CD's mature in December and he will be available then to work on the transfer.

Tim and Darrell will audit the treasurer's books immediately after this meeting and report any discrepancies, if found, at the Initial Business Meeting.

Common Names Committee: Brytten Steed reported that many names have come in this year and most are exotics. The committee is reviewing the process for exotics. *Orthotomicus erosus* is currently proposed but the rules cannot be followed with only the current 5 committee members, 7 members are needed. There is a standing request to approve 204 common names by ESA that are in Western Forest Insects. ESA thinks they can do 5-10 per month and is currently unwilling/unable to do a mass approval. Brytten attended the ESA annual meeting in Salt Lake City and found out that individual insect submissions are now submitted and reviewed electronically. The Committee proposes new rules of order to replace the 1958 rules to allow for, among other things: actions on name submissions when the committee has fewer than 7 members, coordination with the Canadian Entomological Society, and ongoing submissions year-round. Brytten will present a motion during the Initial Business Meeting to replace the old rules.

There was some discussion of why we need official common names. Individuals submit names that are important to them and historically have gotten agreement from the WFIWC membership. We will ask Kathy Sheehan to put a table of insects without approved common names on the website along with instructions for submission.

Founders' Award Committee: report submitted and read by Ken Gibson.

Bill Ciesla has been chosen for the 2005 Founders' Award. The committee currently has no carryover nominations and will encourage nominations for 2006.

Gary Daterman will present his address at the banquet on Wednesday night. Committee members include Staffan Lindgren, Jill Wilson, Terry Shore, Barb Bentz, and Ken Gibson, chair. The chair votes only if there is a tie.

In the absence of History Committee members at the meeting this year, Lia Spiegel will read the History Committee report at the Initial Business Meeting tomorrow morning. There are no issues in it needing the attention of this committee.

Memorial Scholarship Committee: report given by Darrell Ross.

Katherine Bleiker from the University of Montana, recipient of the 2004 Memorial Scholarship, is giving an invited presentation on Tuesday and she will receive a plaque then. This year, three PhD and two M.Sc. students applied for the scholarship. Andrew Graves, a PhD student working with Steve Seybold at the University of Minnesota will receive the scholarship for his studies on *Ips perturbatus* in AK. The chair will send a letter informing this year's recipient of the award along with a cashier's check soon after this year's meeting.

Memorial Scholarship Fund-raising Committee: report given by Karen Ripley.

$377 in scholarship funds were raised in 2004. Silent Auction submissions are going well and income is $200-$500 annually. Lorraine issued a challenge to match donations, Canadians *vs*. other nations. Canadians have accumulated $175 so far. For investments, Karen suggested maybe we can develop a plan to divide money so that some is invested more aggressively and some more conservatively. Perhaps in changing between two treasurers we can propose at the Final Business Meeting to look into alternatives. Currently, investments are CD's and adding more money to these is not possible. Also, all are annual and higher interest is available by increasing the length of time of investment.

We need a new Treasurer and Councilor. Chair appointed Ladd Livingston and Tim McConnell to chair the respective committees to find possible replacements for their positions.

There was some discussion of the need to change the constitution to reflect the current practice that the meeting hosts compile and distribute the proceedings rather than the secretary, who is currently tasked with the job in the constitution. Lia will draft a motion to present at the Initial Business Meeting to make the constitution consistent with current practice.

Darrell mentioned Article II currently reads "western US and Canada" and that this should be changed to "western North America". Lia will also draft a motion for this change to present at the Initial Business Meeting. Ladd has the latest version of the constitution and it differs from that on the web. Lia will work with Ladd to get the latest version and see that Kathy Sheehan puts it on the web.

Does NAWIWC have a steering committee that includes WFIWC members to provide liaison between the groups to ensure awards and committee meetings of WFIWC are included in NA meeting? This will be discussed during the Initial Business Meeting.

The need for a 2007 meeting place and hosts will be discussed at the Initial Business Meeting.

Meeting adjourned at 6:25 p.m.

Initial Business Meeting

29 March 2005

Chair Darrell Ross called the meeting to order at 8:35 am.

There were approximately 80 people in attendance.

Darrell noted that nearly 170 people had registered for the meeting and Victoria had been chosen 7 times for WFIWC meetings, far more than any other location.

Lia Spiegel read the minutes of the 2004 Final Business Meeting.

The only old business noted was the need to follow-up on the availability of CD's of the reprints of Western Forest Insects.

One change to the agenda is the Initial Business Meeting will break from 9-9:30 to allow Paul Addison, the Keynote speaker, to give his address early to allow his early departure to Ottawa. The business meeting will then resume at 9:30.

<u>Treasurer's report</u>: Submitted and read by Ladd Livingston (attached).

Ladd noted that interest income from CD's is low but the interest rate on recently purchased CD's is more than double the previous rate, now up to 2.5%.

<u>Common Names Committee report</u>: Submitted and read by Brytten Steed (attached).

The Common Names Committee has been active on 3 issues this year. There is a new common name submission for *Orthotomicus erosus*. This submission will be posted during the meeting for review by the WFIWC membership. Let Brytten know by April 8 if there are any objections. If there are no objections, it will be submitted to ESA.

The second item concerns the 1958 Rules of Order. The committee is proposing new Rules of Order that will be posted along with the old Rules of Order during the meeting for review.

The final item is that the committee is slowly working through the common names in Western Forest Insects to get them approved. There are 204 common names that are not ESA approved names.

Founders' Award Committee report: Submitted and read by Ken Gibson (attached).

Bill Ciesla is the 2005 award recipient. Submit nominations to any committee member until the due date of December 15, 2005. Rules for nominations are on the website. Committee members are Terry Shore, Jill Wilson, Staffan Lindgren, Barb Bentz, and Ken Gibson.

Memorial Scholarship Committee report: Submitted and read by Darrell Ross (attached).

There were 5 applicants for the 2005 scholarship. The recipient of the 2005 scholarship is Andrew Graves. He is a PhD student at the University of Minnesota working with Steve Seybold, studying the chemical ecology of *Ips perturbatus* in Alaska.

Memorial Scholarship Fundraising Committee report: given by Karen Ripley.

The annual silent auction is Tuesday night during the poster session. This provides a good income for the scholarship and the many unique items donated are much appreciated. This year Lorraine Maclauchlan has challenged other nations to exceed the amount donated by the Canadians.

History Committee Report: submitted by Mal Furniss and Boyd Wickman read by Lia Spiegel (attached).

Old Business

Tom Hofacker reported that the Washington Office issued 500 hardcover scanned reprints of the 1977 edition of Western Forest Insects. All but a handful were distributed to the regional US Forest Service Forest Health Protection offices. No CD is currently available.

Region 3 in Albuquerque still has many copies. Reprinting was much quicker and less costly than anticipated. The possibility of repeating this process is slim as the USFS agreed to copy the original outdated edition during the interim while a new edition was being written. Jesus Cota from the Washington Office will query all regions to find out which have copies still available. He will then have Kathy Sheehan put the information on the Conference website.

Nancy Gillette reported that Jan Volney is in charge of updating Western Forest Insects for a new edition and he and José Negron have made some progress on it. Darrell will speak with Jan about the current status of the new edition and the possibility of creating a separate committee to work on the update of which Jan would be chair.

New Business

Brytten Steed motioned to accept the new rules of order as posted and reviewed during the week.

Regarding references to the duties of the Secretary and the Proceedings:

Lia Spiegel motioned to strike the last sentence of Article IV(3) in the Constitution. Lia Spiegel motioned to add the following sentence to Article VI regarding Proceedings: "The organizers of the annual meeting are responsible for the preparation and distribution of the proceedings." Motion seconded, all in favor, no one opposed.

Darrell Ross motioned to change the final part of Article II (3) from "…information on forest insect problems of the western United States and Canada" to "…information on forest insect problems of western North America." Motion seconded, all in favour, no one opposed.

Councilor Tim McConnell's term expires with this conference and a replacement is needed.

Treasurer Ladd Livingston has served for 16 years and is retiring this fall. A replacement is needed and it is recommended the treasurer be a U.S. citizen to facilitate the transfer of the account.

Bob Coulson announced that Asheville, North Carolina will be the site of the 2006 North American Forest Insect Work Conference. The meeting will be held May 22-26 at the Renaissance Hotel. The update/revision of Western Forest Insects will be on the agenda. Peter Hall motioned that WFIWC for 2006 be held in conjunction with the NAFIWC. The motion was seconded and passed unanimously.

Darrell Ross will write a letter to Kier Klepzig, NAFIWC 2006 organizer, to ensure WFIWC business meetings, memorial scholarship presentation and Founders' award are structured into the meeting. Darrell will also offer WFIWC participation on the organizing committee.

Barb Bentz announced that the Bark Beetle Genetics meeting will be held just prior to the NAFIWC from May 19-20, 2006, also in Asheville. Anyone with an interest is invited.

An updated member list is available for review and correction by members during the meeting.

Motion for adjournment by Bill Ciesla at 10:15, motion seconded and passed unanimously.

Treasurer's Report: Submitted by R. Ladd Livingston, Treasurer.

Highlights of the past year:

Item		Amt ($)
Sale of various items during year		30.00
San Diego: Silent Auction	182.00	
Sales	95.00	
Donations	100.00	
	Total	377.00
Donations for Scholarship Fund received with 2005 reg'n.		CD 175.00
Charges for Commercial Booth, 2005 meeting		CD 400.00
Balance from 2003 meeting in Mexico		636.15
Total Interest Income from CDs (to savings account)		245.69
Deposited to Scholarship CD		730.00
Award of scholarship (from savings account)		500.00

Correction of 2004 report: Donations for scholarship received with 2004 registration were $150 rather than $120 as reported.

All monies received are deposited into the checking account. I keep track of the amounts received from donations and sales whose specific purpose is to go into the scholarship funds. These funds, plus any balance over $4,000 from the checking account, are added to the CDs as they mature each year, in mid-December. After adding the new funds, the CDs are reinvested for another year. Increased percentage gained on CDs in 2005 – up to 2.5%.

Current Status of Accounts:

Account	$	Comments
Checking Balance	$3,570.12	
Regular Savings	$1,044.09	These are the funds available for scholarships.
McGregor Fund	$5,120.00 (no change)	Interest is deposited to regular savings account on a quarterly basis
Memorial Scholarship Fund	$20,662.80 (+$730)	Interest is deposited to regular savings account on a quarterly basis
TOTAL	$30,397.01	

Common Names Committee Report for 2005: submitted by Brytten E. Steed

Committee Members – As of this writing, March 23, 2005, the Common Names Committee (CNC) membership consists of Lee Humble, Iral Ragenovich, Lee Pederson, Diana Six, and Chairperson Brytten Steed. New members Lee Pederson and Diana Six were approved by WFIWC Chairperson Darrell Ross in 2004.

The CNC has been active in several areas this year including a new common name submission, coordinating with the Common Names Committee of the Entomological Society of America (ESA) on processing mass submissions, and evaluating the current Rules of Order for the CNC. Details on these three issues are noted below:

Issue 1: new common name submission for Orthotomicus erosus

1) The CNC received a proposal for *Orthotomicus erosus* to be given the common name of "Mediterranean pine engraver". The proposal appears complete and ready to submit to ESA. The CNC has not yet submitted the proposal to ESA due to questions about proper WFIWC protocol.
2) Current rules require presenting the proposal to the WFIWC membership at the annual meeting with a 30 day waiting period for comments.
3) Final processing of this proposal will be decided after Issue 3-New Rules of Order (see below) is resolved. The issue of the *O. erosus* submission could be resolved in several ways including:
   a) the WFIWC membership vote at the final business meeting on the acceptance of the *O. erosus* proposal; the proposal will be available on the bulletin board of the meeting for review; the CNC accepts the application as it stands but will consider comments.
   b) The O. *erosus* proposal be subject to a new set of rules of order if approved at the final business meeting of this annual conference.

Issue 2: submission of the 204 common names in the Western Forest Insects publication that do not have approved ESA common names

1) There are 473 common names listed for the taxa contained in Furniss and Carolin (1977), Western Forest Insects. Of these, 204 names are not formally approved ESA names. We have hopes of simplifying the submittal/approval process by coordinating with the ESA Common Names Committee.

2) Continued conversation with the ESA CNC, Chairperson Wayne Gall, has resulted in the following final recommendations for WFIWC common name submissions:

   a) Use the electronic form on the web; ESA protocol requires that it pass through ESA headquarters on the way to the ESA CNC.

   b) No more than 10 names per month submitted to the ESA CNC.

   c) ESA does not have protocol to work with other CNC groups (e.g. Entomological Society of Canada; Southern Insect Work Conference; North Central Forest Insect Work Conference; International World Congress of Entomology) so we would have to do that prior to submission to the ESA.

   d) Complete applications will move much more quickly and promote cooperation on subsequent submissions.

3) The WFIWC CNC is proceeding with some steps to move this process forward:

   a) The list of 204 names is being presented to the WFIWC membership during this meeting to ask that individual members 'champion' particular names.

   b) Form to be completed for submission to both the ESA and ESC has been completed.

   c) New rules of order are being proposed that take into consideration modern technology and the task of proposing >200 common names over the next 3-5 years.

Issue 3: proposal to change the Rules of Order for the CNC

1) The rules presently in effect were created in 1955 (updated in 1958) and are cumbersome and difficult to adhere to in the current environment of technology, and increased potential for introduction of new invasive species. Nor do they recognize the need to coordinate with the ESC to maintain nomenclature consistency on both sides of the border. Modern technology methods are not considered in the submission process. A copy of the old rules is available (see below).

2) We would like to submit a revised Rules of Order to the WFIWC membership during this meeting (see below).

Western Forest Insect Work Conference Common Names Committee

Rules of Order (1958)

Originally adopted at the 7th annual Conference in Spokane, WA, December 3, 1955 and revised and approved at the 9th annual Work conference in Corvallis, OR, February 28, 1958, the rules currently read:

1) That the Common Names Committee of the Western Forest Insect Work conference be a standing committee of seven members appointed for an indefinite term by the Conference Chairman. The chairman shall be an ex-officio member.

2) That the Conference submit all proposed changes in the list of common names approved by the Entomological Society of America through the common names committee (WFIWC) and that such changes be kept to a minimum.

3) That members of the Conference likewise submit all proposed new names through the Common names Committee (WFIWC) on a standard form prescribed by the Committee.

4) Five or more positive votes by members of the Common names Committee constitute approval; of a proposal, except that two negative votes are sufficient for rejection.

5) The list of Committee-approved names will be submitted annually to the membership at least 30 days prior to the annual meeting. Names not objected to within 30 days after the conference will be referred by the Conference chairman to the ESA Common Names committee for action. Names receiving objections will be reconsidered by the Common Names Committee (WFIWC) which will sustain or over-ride the objection as provided for in rule 4.

6) That current lists of approved and unapproved common names will be maintained and submitted to members as needed.

7) That liaison be maintained with eastern committees on common names of forest insects.

Western Forest Insect Work Conference Common Names Committee

Proposed Revision of Rules of Order (2005)

The original Common Names Committee (CNC) Rules of Order were adopted in 1955 and revised in 1958. Taking into consideration a potential increased workload for the CNC, the development of new technology and websites, and the appropriateness in submitting the names to both the Entomological Society of Canada and the Entomological Society of America, the CNC is proposing the following revised Rules of Order:

Structure

The Common Names Committee (CNC) of the Western Forest Insect Work Conference (WFIWC) shall be a standing committee of no less than three and no more than seven members, appointed for an indefinite term by the Conference Chairman.

Roles

1) The role of the CNC shall be to facilitate the development of, and standardization of, common names for the WFIWC, for submission to the Entomological Society of America (ESA) and the Entomological Society of Canada (ESC). The burden of gathering the necessary information for submission will rest with those making the application.
2) The CNC will endeavor to ensure that changes to existing common names, and new common names will be submitted to both the ESA and the ESC, and will submit these changes as needed, as appropriate, and in the proper format required by these bodies.
3) In addition, the CNC will serve as the liaison and coordinating body to other regional forest insect common names committees, as well as the liaison to the national entomological societies' common names committees.
4) Current lists of approved and unapproved common names will be maintained by the CNC.

Process

1) Members of the WFIWC, will submit all proposed new names through the Common Names Committee (WFIWC). Members submitting common names will be responsible for gathering and filling out the relevant information required for submission to the ESA and ESC.
2) Submissions can be submitted to the CNC any time during the year.
3) Submissions will be submitted to the CNC in a standard format prescribed by the CNC. The CNC will review the proposals to see if all required information is provided, and request additional information, as necessary.

4) Once the proposal meets the requirements for format and information, submissions will be posted on the WFIWC website for 30 days. The CNC will notify the members of the WFIWC, using the electronic membership list maintained by the WFIWC, that the proposed submission is available for review and comment.

5) If no comments are received at the end of the 30 days, the CNC will submit the proposal to the respective Entomological Societies.

6) Comments sent to the CNC will be reviewed and summarized, and posted on the web for an additional 30 days. If concerns are resolved, the proposal will be forwarded to the respective Entomological Societies.

7) If the proposed common name generates significant and conflicting comments, at the end of the second 30 days, the CNC will table the proposal and present it to the full membership at the annual meeting for discussion and vote.

8) No decisions will be made regarding forwarding a proposal to the national societies without a quorum minimum of 3 CNC members, or a majority of the CNC membership, whichever is applicable.

Founders' Award Committee Report: Submitted by Ken Gibson, Committee Chair.

On behalf of the Founders' Award Committee, I am pleased to announce that Bill Ciesla is the Founders' Award recipient for 2005. Bill has been notified, and is planning on being present when the announcement is made to conference membership at the initial business meeting.

Dr. Gary Daterman, recipient for 2004, will present the Founders' Award address at the banquet, this Wednesday evening. Gary's plaque will be presented at that time. Costs incurred for the plaque --$258.72—have been paid by Ladd Livingston, WFIWC Treasurer.

The "traveling" Founders' Award plaque will be on display at this meeting. I will announce, at the initial business meeting, that nominations for 2006 will be accepted until 15 December 2005.

Respectfully submitted,

Ken Gibson, Founders' Award Committee Chair

WFIWC Memorial Scholarship Committee Report, 2004: Submitted by Darrell Ross, Committee Chair.

Katherine Bleiker, a Ph.D. student at the University of Montana working with Dr. Diana Six, was selected as the recipient of the 2004 WFIWC Memorial Scholarship. Katherine's selection was announced at the Initial Business

Meeting in San Diego. Katherine will be giving an invited presentation at the Victoria meeting.

Five applications were received for the 2005 Memorial Scholarship. Two of the applications were from students pursuing M.Sc. degrees and three were from students pursuing Ph.D. degrees. The committee selected Andrew Graves, a Ph.D. student at the University of Minnesota working with Dr. Steve Seybold, as the recipient of the 2005 Memorial Scholarship. Andrew's dissertation research is focused on the chemical ecology of *Ips perturbatus* and other insects in Alaska.

The committee encourages all qualified graduate students to apply for the 2006 Memorial Scholarship. The deadline to submit applications is January 15, 2006.

WFIWC History Committee Report, 2004: Submitted by Boyd Wickman and Malcolm Furniss, March 2005.

The WFIWC/Forest Entomology archives (University of Idaho Special Collections Library) was enriched by the deposition of Ronald W. Stark's "Publications and Writings", 1948-1995. This material was provided by his daughter, Debi Macaulay and inventoried by M. Furniss before being deposited. The abundant manuscripts are accompanied by correspondence and cover many subjects, not all entomological. The storage location for retrieval is MA 2004 -16.

The Archives now has a complete set of WFIWC Proceedings, accomplished with the help of Ladd Livingston and Boyd Wickman who provided proceedings for several missing years.

Still in relation to the Archives, M. Furniss deposited 132 unpublished reports of the 1920s – 1950s mostly prepared by staff of the western Forest Insect Laboratories of USDA, Bureau of Entomology prior to dissolution of the Bureau in 1953. They are accompanied by a listing (citations) consisting of author, year, title, agency, and pagination. Location is MA 2004 - 05.

A manuscript by M. Furniss was submitted to the American Entomologist entitled: Robert Livingston Furniss (1908-1980) - Tall Timber: Post-war Assignments to Japan, 1949 and 1950. His assignments related to extensive killing of pines in Japan, a country seeking to recover from WW II and whose forests produced only 30% of its needed wood. During the first 4 years after the war, losses exceeded annual growth. Bob Furniss wrote many letters to his wife, Frances, describing his experiences. These letters, interspersed with humor and pathos, and his excellent color slides of Japan - including its landscapes, structures, people, and customs - compelled that this small segment of his life be shared.

Aided by our superb Web Master, Kathy Sheehan, the WFIWC website now contains the Founders' Award addresses of several recipients. Recent additions were those of Les Safranyik and Dave Wood. We have also added the Hopkins Award address by John Moser. This award is the Southern Forest Insect Work Conference equivalent of our Founders' Award. Although John resides in Louisiana, he has participated in many WFIWC meetings and has described mites associated with western bark beetles. Several of these addresses are biographical in nature and display a personal side not evident in their publications. It may be added that a mark of distinction of a fair segment of these recipients was that they were not highly tuned to scholastic endeavor in their youth.

M. Furniss has clarified and posted on the Website the origin of the present-day WFIWC about which there has been confusion. Contributing to the lingering confusion was the lack of a numbered proceedings for the first meeting, Portland, OR, December 7, 1949, and erroneous designation of the second meeting (Fort Collins, CO, December 15-16, 1950) as the first annual WFIWC. The explanation is accessed by the following links: Administration\ History.

Boyd Wickman has written a 16-chapter manuscript entitled: Harry E. Burke and John M. Miller, Pioneer Forest Entomologists: A History of Early Forest Entomology in the West now awaiting publication by the PNW Research Station. The Burke and Miller families who provided diaries and other personal information and photos aided this lengthy effort. Some of Burke's photos have been put on a CD for deposit in the WFIWC archives. Burke (1878-1963) was the second person hired by A.D. Hopkins in the Bureau of Entomology, Division of Forest Insect Investigations, after its establishment in 1902. He and Miller (1882-1952) worked in several western states, primarily California and Oregon.

Boyd assisted Les Joslin, a contract writer, to prepare a draft of the History of Forest Research in Central Oregon. Much of this history centres on the Pringle Falls Experimental Forest, where F. Paul Keen began research in 1931 that resulted in the Keen tree classification by which ponderosa pine trees could be classified according to their susceptibility to bark beetles. The PNW Research Station will publish the manuscript.

Boyd also went to Mare Island, California, to inventory Bureau of Entomology Forest Insect Lab unpublished reports in the PSW/R-5 library. They were subsequently moved to the Forest Service West-wide Library in Ogden, UT. Address is RMRS Library, USDA Forest Service, Rocky Mountain Research Station, 324 25th St., Ogden, UT 84401, 801-625-5447 / 801-625-5129 (fax). Carol Ayer is the Director of the Ogden Library.(cayer@fs.fed.us.). Boyd's inventory will be deposited in the WFIWC Archives.

Submitted by Malcolm Furniss and Boyd Wickman

March 2005

Final Business Meeting

1 April 2005

Darrell Ross called the meeting to order at 10:35 a.m.

There were approximately 36 people in attendance.

Lia Spiegel read the minutes of the Initial Business Meeting. Ladd motioned to accept the minutes, all in favor, no one opposed.

Treasurer's report was given by Ladd Livingston. In the scholarship fundraising challenge the Canadians were initially ahead, Other nations moved ahead, then Canadians were ahead this morning by $12. This resulted in several U.S. folks offering money on the spot. The total amount raised from the challenge was $700.

Ladd nominated Karen Ripley as Treasurer. Karen then resigned her position as Memorial scholarship Fundraising Committee Chair. Ladd nominated Kimberly Wallin as chair of the Memorial Scholarship Fundraising Committee. These nominations were seconded and approved unanimously. Steve Cook and Jennifer Burleigh volunteered to serve on the Memorial Scholarship Fundraising Committee.

Tim McConnell nominated Joel McMillin as Councilor. Motion to close nominations by Bill Schaupp. All in favor, no one opposed. Joel begins his term as Councilor at the end of this meeting.

Motion on the floor from the Initial Business Meeting to change the rules of order for the Common Names Committee. Motion passed with no opposition.

Scholarship Fundraising Committee report given by Karen Ripley. The challenge raised $700 while the silent auction earned $800. Thanks to all the contributors of items. Several people received recognition for outstanding donations: The highest quality items donated were the hand painted eggs by Iral Ragenovich. Dion Manastyrski received recognition for donating the item with the highest aesthetic appeal. Tom Hofacker, who donated the book *Bark Beetle Enemies of California Forests*, and Leo Rankin, who donated several raku pieces, were recognized for highest earnings. Bill Ciesla was recognized for donating his own drawings and paintings.

New Business

John Harris motioned that members who are retired and not actively working in the field of entomology and not otherwise supported can register and attend annual meetings for a minimal or no fee, not including actual costed items such as meals. This information will be located in the meetings guidelines on the web. Kathy Sheehan will also be asked to move the items regarding the waiving of fees for Scholarship and Founders' awardees to the meetings guidelines section. All in favor, no one opposed.

There was some discussion on the format of the workshop that has evolved from an open exchange of ideas to mostly formal presentation with little discussion. Several suggestions were made to foster discussion and debate: (1) shorten the length of time allowed for each presenter, thus ensuring more time for discussion at the end of presentations, (2) have formal presentations as they are now but followed by a discussion session of equal length (format to be determined by meeting organizers), (3) select presenters to purposely present opposing views, or (4) utilize a debate format with individuals representing both pro and con viewpoints on an issue. It was agreed to put these suggestions on the website with the meeting guidelines.

The 2007 meeting needs a host. It was generally agreed that Regions 2 and 4 have hosted most distantly in the past. Brytten agreed to talk with the Boise FHP office regarding hosting the 2007 meeting.

Meeting adjourned at 11:20 a.m.

Scholarship Presentation

Kathy Bleiker, PhD Student, College of Forestry and Conservation, University of Montana, Missoula, MT 59812 USA

Darrell Ross (WFIWC Chair, 2005), Kathy Bleiker (2004 Recipient)

Not all fungi are created equal: Interactions among the mountain pine beetle and its bluestain fungal associates

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

Many bark beetles are closely associated with fungi. Some bark beetles even possess specialized invaginations in the exoskeleton (called mycangia) to ensure transport of their fungal associates between trees. So, what drives these close associations that bark beetles have with fungi? The nature of the interaction has been debated. One hypothesis holds that the interaction is mutualistic - in exchange for transport the fungi help the beetle kill the tree; however, the vast majority of bark beetles attack trees that are already dead or dying. Furthermore, many aggressive bark beetles have associations with nonpathogenic fungi, suggesting that other factors may also be involved in driving the interaction. Research on the closely related ambrosia beetles and on the southern pine beetle system suggests that fungal associates may confer nutritional benefits to the beetles. Using the mountain pine beetle (MPB) (*Dendroctonus ponderosae*) and its two main mycangial filamentous fungal associates (*Ophiostoma* *clavigerum* and *O. montium*) as a model system, we tested the hypothesis that bark beetles gain nutritional benefits from some of their fungal associates. We also investigated competitive interactions between the two fungi.

MPB is closely associated with two mycangial filamentous fungi, *O. clavigerum* and *O. montium* (Ascomycetes in the family Ophiostomataceae). Both *O. clavigerum* and *O. montium* share adaptations for insect dispersal, such as sticky spores. However, *O. clavigerum* exhibits a higher tolerance for oxygen deprivation and grows faster at room temperatures than *O. montium*, which can withstand higher temperatures (32^{o}C). There is also evidence that *O. clavigerum* has cospeciated with MPB, indicating a long shared evolutionary history with the host, while *O. montium* appears to be a relative newcomer to the system (work by Six and Paine).

In a field study, the mean pronotal width of beetles emerging from naturally attacked trees carrying only *O. clavigerum*, *O. montium* or neither fungus (yeasts may have been present in any group) in the mycangia were compared. The mean pronotal width of beetles emerging with *O. clavigerum* only was significantly larger than beetles emerging with no filamentous fungi. The mean pronotal width of beetles emerging with *O. montium* was not significantly different from either of these two groups. These results suggest that *O. clavigerum* may provide some nutritional benefit to MPB. Although it is likely that beetles fed on the fungus they emerged with, at least during maturation feeding, they may have also fed on the other fungus as larvae and/or young adults in these naturally attacked trees. Thus, we conducted a laboratory study where surface sterilized MPB eggs were reared to adulthood in phloem sandwiches with *O. clavigerum, O. montium*, both fungi, or neither fungus. In addition, newly eclosed beetles were switched between treatments as well as within treatments (controls). Results of the laboratory studies indicate that *O. montium* may act as a dietary supplement for MPB and be especially important during maturation feeding. Beetles developing with *O. montium* or both fungi consumed significantly less phloem, but were not significantly smaller, than beetles developing with *O. clavigerum* or neither fungus. Young adult beetles consumed the conidia that usually lined the pupal chambers of *O. montium* treatments and ingested significantly less phloem as young adults during maturation feeding than insects developing with neither fungus or with *O. clavigerum* (*O. clavigerum* did not sporulate as readily as *O. montium* in the pupal chambers). In the rare case where *O. montium* conidia were lacking or sparse in the pupal chamber, young adults ingested more phloem before attempting to emerge than insects in sandwiches with abundant conidia in the pupal chamber. Studies examining the effects of the fungi on the next generation (F_1) as well as differences between the two fungi that may account for differential nutritional effects on beetles are in progress.

Differential nutritional effects of fungal associates may have substantial impacts on bark beetle population dynamics. Evidence for the effect of fungal associates on the population dynamics of their host beetle has been found in the southern pine beetle system where changing fungal complements are associated with shifts from outbreak to non-outbreak status (work by Bridges and Moser). Both *O. clavigerum* and *O. montium* have been found in MPB populations sampled by Six and Bentz in Idaho and Montana, although their proportions vary greatly from population to population as well as over a season and between years within a population. Interactions among environmental conditions and the competitive abilities of each fungus may determine what fungus predominates at a given time, and ultimately which fungus interacts with the host beetle.

In a laboratory study, we examined the competitive abilities of *O. clavigerum* and *O. montium* on media amended with varying amounts of potassium chloride and sucrose to yield different water potentials. At room temperature, *O. clavigerum* grows faster at higher water potentials than *O. montium*, while *O. montium* appears to have the advantage at lower water potentials. Results for the potassium chloride and sucrose controls were somewhat confounding and another method of altering water potential is being investigated. In addition to the laboratory study, we conducted a field study where the abundance of *O. clavigerum* and *O. montium* was sampled in 15 naturally attacked trees over the one year life cycle of MPB. Preliminary data analysis of 3 sample times showed a strong shift over time towards *O. montium* in a few trees; however, in other trees the relative abundance of the two fungi remained constant or showed an increase in *O. clavigerum* over time. Phloem moisture content, measured at each sample time, and a 4^{th} sample time will be incorporated into the analysis in the near future.

O. clavigerum and *O. montium* do not appear to be created equal in terms of competitive abilities or conferring nutritional benefits to MPB. As water potential of media decreases, the competitive advantage may switch from *O. clavigerum* to *O. montium*; however, field results from sampling fungi in naturally attacked trees may not support this. While fungal-feeding does not appear to be obligate for MPB, it may be beneficial. The implications of a dietary supplement to this aggressive bark beetle that kills trees by attacking *en masse* are two-fold: a reduction in intraspecific competition at high population levels (outbreaks); and improved nutrition when beetles are in marginal host trees (e.g., endemic population levels, during or after sustained outbreaks when prime hosts have been depleted). Somewhat conflicting results between field and laboratory studies on the nutritional effects of fungal associates on beetles, suggest the interaction among MPB and its fungal associates may not be as simple as ‘good fungus, bad fungus’. Dynamic conditions (e.g., changing environmental conditions, quality of food source, population density) may constantly shift the nature or outcome (e.g., mutualistic, antagonistic, neutral) of interactions among MPB and its fungal associates. Thus, the effects of fungal associates on bark beetles may change over time and space.

Award to Ladd Livingston

Ladd Livingston has served the Western Forest Insect Work Conference as an active participant and in the position of Treasurer for many years and has been instrumental in ensuring that the conference is financially strong and fiscally responsible. Ladd's dedication to the conference has significantly contributed to its overall success. 2005 marks the last conference that Ladd will attend in an official capacity and it is the wish of the conference to recognize his superb efforts and contributions.

Ladd's humour and rational perspectives will be sorely missed. A special plaque was commissioned for Ladd to recognize his contributions. The plaque is carved in western red cedar and displays the "unofficial" WFIWC logo.

Peter M. Hall (2005 Program Committee), Ladd Livingston (WFIWC Treasurer), Lorraine Maclauchlan (2005 Local Arrangements Committee)

Founders' Award Address

Dr. Gary Daterman received the 2004 Founders' Award, the 12th such award to be given since its inception. The Founders' Award is given to an individual who has made an outstanding contribution to forest entomology in the west. The award recognizes significant contributions in pest management, extension-consultation, research, and teaching. The Founders' Award is intended to show the appreciation from the peer group for excellence. Dr. Daterman amply fills the criteria of excellence.

Gary Daterman

Darrell Ross introduced Dr. Daterman.

Career Ramblings

Dr. Gary E. Daterman, USDA-Forest Service, Retired

To begin, I want to say that I am deeply honoured to receive this award. This will most certainly be filed away in my memory as one of the highlights of my career. It is humbling to me because I am very much aware there are many of you at least as qualified as I am to receive this award. I do wish to thank Darrell Ross for nominating me, and all those that supported my nomination in any way.

My presentation today will begin with an explanation of how I came to be a forest entomologist, and then some discussion about what I remember as some of the most memorable events over the course of my career. My remarks are in chronological order and based on the major insects studied, significant research findings, and selected comments on items of human interest.

Getting started:

Most of my childhood years were spent in northern Illinois where a strong interest in nature was developed through the usual routes of fishing, hunting, amateurish attempts at making butterfly collections, and just general exploration of the great outdoors. This interest did not, however, manifest itself in a firm decision as to "what I was going to be when I grew up". In fact, during my first three years as an undergraduate at the University of California at Davis, I changed my major curriculum many times. Successively, I majored in pre-veterinary medicine, economics, geology, and finally (of all things) political science as a preparatory degree for entering law school. One year prior to my expected graduation from UC-Davis, I had settled on transferring to UC Berkeley the following year in order to pursue a law degree. It was at that point, however, that a small insect intervened.

I had spent three successive summer breaks working on a fire crew in Lassen National Forest in northern California. Our crew was part of the staff of the old Pit Ranger District, which has long since merged with the Hat Creek Ranger District. We were assigned to a fire camp some 20 miles south of Fall River Mills on the Pitville Highway. In those years, this so-called highway was either a mud hole or a dustbin, depending on the season. Our fire camp consisted of a bunkhouse and a cook shack with a side room that served as the foreman's quarters and office. We had no running water or electricity, but even though the amenities were minimal I have fond memories of card games, horseshoes, and softball games in which we used a pick handle for a baseball bat. It was in 1960, during my third summer at that camp, that we noticed many dead and dying young ponderosa pines around our buildings and grounds. Closer inspection of those dying trees showed boring dust being produced by small reddish brown beetles tunneling in the inner bark. These fascinating little creatures were soon identified as an *Ips* species of bark beetle by our camp superintendent, Ken Swain, a Junior Forester recently graduated from Oregon State University. Many of you will no doubt recognize that name as Ken eventually held various positions in the USFS Forest Health Protection branch, and recently retired as the Director of Forest Health Protection in Atlanta, GA.

As you may have guessed, it was no doubt that encounter with an *Ips* beetle that first set my mind on forest entomology, or something akin to it, as a career. Returning to UC-Davis at the end of that fire season saw me poring over college catalogs seeking graduate study opportunities where such a major was possible. The draw of the Pacific Northwest with its magnificent forests and outstanding fishing opportunities persuaded me to head north, and I was soon enrolled in graduate school at Oregon State University. Funding for a graduate refugee from the liberal arts, however, was non-existent; and this necessitated many hours of working a checkout counter at the local Safeway store as a survival mechanism. Once again, however, a small insect intervened.

This time it was the Douglas-fir beetle. As luck would have it, I had enrolled at Oregon State University prior to the occurrence of a monumental hurricane, the so-called Columbus Day Storm of 1962. The millions of trees blown down in that storm literally "set the table" for the Douglas-fir beetle, and staged the obvious threat of a subsequent beetle epidemic. These conditions soon led to increased research funding for the forest entomology professors at Oregon State University at that time, Drs. Julius Rudinsky and Bill Nagel. By this time I had completed a few quarters of graduate work, and Dr. Rudinsky took a chance and hired me as a half-time research assistant to participate in work on his National Science Foundation grant. I emphasize that he took a chance because I was certainly still very much a neophyte student of forest entomology! I was, of course, very grateful, very happy to give up my job checking groceries, and extremely pleased to be "off to the races" in pursuit of a graduate degree in forest entomology.

The Ambrosia Beetle, *Trypodendron lineatum* (1960's):

My research topic for a masters degree was to determine the diurnal and seasonal flight patterns of resident bark beetle species. This was accomplished by periodic sampling of flying insect populations with the use of power-driven nets. These nets had previously been developed at the Boyce Thompson Institute by Peter Vité and his associates, and they were highly effective in yielding rich captures of diverse and numerous forest insects. After months of sampling plus the counting and sorting of captured insects, the work became somewhat routine, and I confess that my enthusiasm began to wane. Once again, however, a small insect intervened, and this time it was the lined ambrosia beetle, *Trypodendron lineatum.*

During one day of sampling I noted that a particular net was repeatedly capturing large numbers of this particular species. A closer look revealed the net was close to a small tree branch covered by white boring dust caused by this species. Although I had been assisting with Dr. Rudinsky's and Orlo Jantz's experiments with Douglas-fir beetle pheromone, this serendipitous experience with *T. lineatum* was what truly sparked my interest and enthusiasm in the power of pheromones to influence an insect's behavior. Some very simple experiments with the boring dust and with individual beetles confined in small log sections quickly confirmed that *T. lineatum* was producing a very potent aggregation pheromone, a new finding. As a result of this experience I was permanently sold on the potential of insect pheromones for pest management applications. As you all know, the chemical structure of the *T. lineatum* pheromone was later identified by Milt Silverstein, John Borden, and colleagues, and it has been developed and in commercial use in mass-trapping programs for many years.

European pine shoot moth (1960's and 70's):

Upon completion of a Masters degree at Oregon State University, I was very fortunate to land a job with the USFS Pacific Northwest Research Station, with my assigned duty station at the Corvallis Forestry Sciences Laboratory. This time it was the European pine shoot moth, *Rhyacionia buoliana*, that was responsible for my good fortune. As most of you are aware, this insect was introduced to North America from Europe, and to the Pacific Northwest by way of the Lake States Region of the United States and Canada. Its discovery in the Seattle and Spokane, Washington areas, in 1959, touched off more than a little panic in the forest industry, and among forest entomologists. As it turned out, that response was somewhat of an over-reaction. However, one of its immediate effects was increased research funding and additional positions in forest entomology. Once again, a small insect had played a pivotal role in the direction of my career aspirations. The series of events this time were especially fortuitous as I was permitted to use my research results for a PhD program at Oregon State. As in many life experiences there was also a downside to this chain of events. Namely, that I would need to apply my full attention to research on this new insect which meant dropping all my ongoing bark beetle research, to which I had become strongly attached. I was most reluctant to do this, and I expect those of you working with bark beetles would readily understand that reluctance for abandoning work on such fascinating creatures. Nevertheless, I was most appreciative of acquiring a full time research position at this early stage of my career.

My research efforts on the European pine shoot moth represented one increment of a cooperative US Forest Service and Washington State University project to develop a sterile male program for eradication of the insect from the Pacific Northwest. Notwithstanding what you might think about the need or feasibility for such a project, keep in mind the value of focusing research activities on any problem, and the increase in knowledge that can result, whether or not the particular results were expected or foreseen. Principal cooperators at Washington State included professors Bob Harwood and Alan Berryman. One of my first assignments was to devise a caging device that would ensure that reproduction would occur under laboratory conditions. Certainly there was a clear need for the project, as mating was a prerequisite for evaluation of sterilization approaches, and also to perpetuate a laboratory colony of the insect. This problem was eventually solved, although not without some difficulties. Of primary value to me were the insights gained regarding the influence of the sex pheromone for mating to occur under any conditions, and the related value for developing a laboratory bioassay to evaluate potential pheromone components.

It was about 1970 when Dr. Doyle Daves and his colleagues in the Chemistry Department at the Oregon Graduate Center in Beaverton, Oregon entered the fray on European pine shoot moth, and a concerted effort to identify the insect's sex pheromone was initiated. We were successful in this effort and the identity of a new insect pheromone was published in 1974. This compound plus the addition of a second pheromone component later reported by Tom Gray and others is now used in BC, CA, and the Pacific Northwestern States to detect the insect's presence in and around commercial nurseries and Christmas tree plantations in order to define infested areas warranting quarantine to reduce further spread of the insect.

Certainly one of the highlights of the European pine shoot moth research was the successful identification of its pheromone, and the subsequent development and application of the pheromone for detection surveys. This was not only a research achievement, but also a successful demonstration of effective teamwork among many organizations. The technology for chemical analysis used at the Oregon Graduate Center in the early 1970's required a comparatively large quantity of insects, and roughly 40,000 female moths were collected and processed to accomplish the extraction and collection of the active pheromone component needed for analysis. These collections required the combined efforts of entomologists and seasonal workers from ODF, WDNR, USFS-PNW, USFS-FPM, and WSU Agric. Experiment Sta. facilities in Puyallup, WA.

I can recall many excursions around the city of Seattle to collect infested pine shoots, or to observe moth behavior, as the insect was most readily found on ornamental pines in parks, golf courses, around churches, cemeteries, and other such landscaped locations. Our activities often drew curious stares, questions, and in some instances, rather derisive comments about what we were doing. I recall one early evening when several of us were wandering around Volunteer Park observing flight and mating behavior of the moths. We even had a couple of insect nets in evidence, and no doubt made quite a picture as we closely studied the pine branches in the twilight hours. A few of the more curious onlookers would occasionally ask questions, and my supervisor at the time, Val Carolin, was most willing to describe our work with emphasis on terms like mating behavior, sex pheromone, sterile male technique, and so forth. No doubt those instances served to raise eyebrows even further. I have always thought there was a certain irony in my having to work so much of my first assignment in metropolitan Seattle, considering that one of the primary attractions for my pursuing a career in forest entomology had been the expectation of working in forested areas far removed from cities.

Although the identification and development of the shoot moth's pheromone was very gratifying, some other work on *Rhyacionia buoliana* was also very personally rewarding. There had always been a question about the potential for the insect to spread within the western pine zone, as that potential was most relevant to the economic impact the insect might cause. Based upon studies of historic weather records for the West, some intensive laboratory evaluations of the effects of low humidity, and field observations of the insect caged on ponderosa pine saplings located within the pine zone south of Bend, OR, we developed estimates of where the shoot moth was most likely to become established in western North America. Those areas were delineated some 35-years ago, and to my knowledge the predictions have generally held up. I recall that the fieldwork for this evaluation also drew some rather pointed comments from the curious! To gain approval from the Oregon Dept of Agriculture to study the survival of eggs and larvae within the pine zone, we were required to fence infested pine saplings with a six-foot chain link fence topped with three strands of barbed wire. The purpose, of course, had nothing directly to do with the insect, and everything to do with keeping curious passersby from possibly moving infested branches elsewhere and causing a new infestation. The local contractors that put up this 60 X 30-ft fence, had great fun asking me how far and fast I expected the trees to move, where I expected them to go, etc.

The Douglas-fir Beetle (1970's):

In the early 1970's, at about the time European pine shoot moth work had culminated, I was handed the opportunity to work on a large cooperative evaluation of methylcyclohexenone (MCH), the anti-aggregative pheromone of the Douglas-fir beetle. Mal Furniss of the USFS Intermountain Research Station was to head the study and establish and maintain Idaho plots, Galen Trostle would look after Utah plots, and Pete Orr, USFS-Region 6, and I, would establish and maintain plots in western Oregon and Washington. Other key cooperators on this study included Julius Rudinsky from Oregon State University, LeRoy Kline from Oregon Dept of Forestry, Leon Pettinger from USFS-Region 6, and Mark McGregor from USFS-Region 1. The study was designed to evaluate the capacity of MCH to prevent infestation of felled Douglas-fir from Douglas-fir beetle infestation. The study was well replicated, evaluated four dosages of MCH, was intensively monitored, and yielded results that clearly demonstrated that MCH could protect felled trees from beetle infestation. I very much enjoyed work on this project as it permitted my returning to bark beetle research, and it was very gratifying work as the results were so promising for management applications. Although I would have preferred to continue on this cooperative effort, that was not going to be the case as once again another insect had entered the picture and was about to re-allocate the efforts and direction of many western forest entomologists.

The Douglas-fir Tussock Moth (mid 1970's):

In 1972 through 1977, one of the largest Douglas-fir tussock moth epidemics in recorded history occurred in western North America. Hundreds of thousands of acres were defoliated with the majority of the outbreak occurring in northeastern Oregon, southeastern Washington, and northern Idaho. Other areas of western North America were also affected, including interior British Columbia, although the years of outbreak activity varied somewhat among western sub-regions. Defoliation by the tussock moth was highly visible, and during the period of the outbreak, coincided in some cases with catastrophic wild fires. Consequently, the public was very much aware of "the moth", as the timber industry was screaming for control measures, politicians were beating drums on their perceptions of what needed to be done, and the news media was having a field day calling for measures to stop the moths "march to the sea". In such a scenario, research administrators saw a ripe opportunity to secure additional funding. And thus was the USDA Combined Forest Pest Research and Development Program funded in 1974. The CFPP was designed to be a national, short-term program to reduce damage being caused by the tussock moth, gypsy moth, and southern pine beetle. Each of these respective insect programs was soon labeled as one of the “big bug” programs.

Many, perhaps a majority, of western forest entomologists were soon mobilized to conduct research in support of the Douglas-fir Tussock Moth Program. At the Corvallis Forestry Sciences Laboratory, all but two of the resident forest entomologists were assigned to the tussock moth program. This was quite a cadre of scientists because in those days we had four research projects with a total of 17 entomologists or insect microbiologists on the staff. In addition to our staff at the Corvallis Lab., entomologists from other western research stations, FPM units, state agencies, universities, the British Columbia Forest Service, and the Canadian Forest Service’s Pacific Forest Research Centre laboratory in Victoria, BC, were also involved. The outcome of the Tussock Moth Program was quite successful as it served to coordinate and synthesize ongoing research efforts that in many cases had been in progress for years. In Corvallis, for example, Hank Thompson, Mauro Martignoni, Milt Stelzer, John Neisses, and others had been developing a nuclear polyhedrosis virus as a microbial pesticide for tussock moth for over 10-years; Boyd Wickman, Dick Mason, Torgie Torgersen, Bob Campbell, Roy Beckwith, and others had been researching the population ecology of the insect for years, Bohdan Maksymiuk, George Markin, and others had been developing formulations and spray technologies for both microbial and traditional pesticides for years; and, in my own case, I had been working with cooperators at the Oregon Graduate Center in an effort to identify the sex pheromone for approximately a year prior to the formal establishment of the Tussock Moth Program.

The tussock moth pheromone was identified in 1975 as a 21-carbon monounsaturated ketone, a unique compound among insect pheromones that had been identified up to that time. Doyle Daves and colleagues at the Oregon Graduate Center’s Department of Chemistry were outstanding in their research efforts to both identify and then synthesize this pheromone. A di-unsaturated compound that also appeared in our pheromone extracts was another suspect as a possible second pheromone component. Our efforts to chemically identify and validate the activity of a second compound, however, were unsuccessful. It wasn’t until over 20-years later that Gerhard Gries and colleagues successfully identified an active di-unsaturated ketone component of the tussock moth pheromone.

In 1976, shortly after the identification and synthesis of the principal pheromone component, we were asked to develop a pheromone-based trapping system to provide early warning against future tussock moth outbreaks. Existing monitoring methods were either too labor intensive to cover the host area adequately, or in the case of aerial surveys, provided information on outbreaks only after they were underway and it was too late for appropriate management planning and response. After two seasons of research to develop a prototype trapping system, we implemented an early warning trapping program in the late 1970's. This was accomplished only because of the assistance from cooperators representing multiple agencies. Among others, these included John Wenz, USFS, San Francisco and later, Sonora, CA, Leon Pettinger, USFS, Portland, OR, Ralph Thier and Julie Weatherby, USFS, Boise, ID, Ladd Livingston and David Beckman, ID Dept. of Lands, David Overhulser, OR Dept. of Forestry, Rick Johnsey, Bob Backman, and Dave McComb, WA Dept. of Natural Resources, and Steve Kohler, Montana Dept. of Natural Resources. Other key cooperators that assisted in later years include Lonne Sower, USFS, Corvallis, Don Owen, Jess Rios, and Frank Spandler, CA Dept of Forestry, Dan Marlatt , Bur. of Land Management, Karen Ripley, WA Dept. of Natural Resources, Phil Mocettini, USFS, Boise, ID, Iral Ragenovich and Kathy Sheehan, USFS, Portland, OR, and Jill Wilson and Carol Randall, Coeur d'Alene, ID.

An average of over 700 trapping locations have been maintained each year since 1979, with the most intensive trapping programs taking place in Oregon, Washington, Idaho, and California. A recent publication that describes the results of 10 case studies of outbreaks where trapping programs were in place, validated that the system is effective in providing 1-3 years warning of an impending outbreak, so long as traps are placed appropriately and follow-up sampling is performed once trap captures have reached key thresholds. I am especially grateful to co-author Kathy Sheehan, USFS, Portland, OR, for her fresh perspective, expertise, and considerable patience with her co-authors, all of which greatly facilitated completion of that publication. I am also very appreciative of the efforts of Iral Ragenovich, USFS, Portland, for her efforts in attending to the continuation of the early warning trapping and certain other pheromone-based applications for the tussock moth.

A very significant effect of the Tussock Moth Program was to provide funding for new positions. In 1976 Lonne Sower transferred to our pheromone research group at the Corvallis Laboratory from the USDA-Agric. Res. Lab. In Gainesville, FL. Lonne had considerable experience with pheromones of agricultural and stored products insects, and his expertise was a welcome addition to our research team. His research on Douglas-fir tussock moth greatly advanced development of the pheromone, and particularly for its potential for controlling populations by the mating disruption technique.

No discussion of tussock moth pheromone research would be complete without reference to related human interest stories. The principal component of the tussock moth pheromone, Z-6-heneicosen-11-one, is far less volatile than most pheromones, probably because of its long chain length. This no doubt is the explanation as to why clothing, pets, and other objects that have been contaminated by contact with the compound can remain attractive to male moths for a very long time. Thus the stories of entomologists being swarmed by rusty tussock moths (a related species commonly found in and around populated areas) in their yards, at football games, and the like. Similar stories abound for individuals working with gypsy moth pheromone being accosted by gypsy moth males in the eastern part of the US. I recall a field trip in interior BC hosted by

Roy Shepherd in about 1977 when we toured numerous spray test plots that had been treated with various pesticides. One treatment, possibly dimilin, was acclaimed as being especially effective in controlling the larval population. As we stepped out of the vans and started into the plot, however, we were soon greeted by dozens of tussock moth males zeroing in on yours truly, no doubt due to my being contaminated by the pheromone. Later that same evening we were relaxing in a park next to a river, in Kamloops, BC as I recall. I remember vividly that the surrounding vegetation was predominantly grassland with a few shrubs, and very few trees. In fact, there were no host trees evident as far as the eye could see in any direction. And yet, sure enough, across the river came a couple of very determined tussock moth males fluttering toward me, obviously following a pheromone trail. What is most unnerving to me about this phenomenon is that it still continues, even though I no longer handle the pheromone!

Western Pine Shoot Borer (1970's and 80's):

In the late 1970's, our group was approached by the Weyerhaeuser Company to work on the identification and development of the sex pheromone of the western pine shoot borer, *Eucosma sonomana.* This was of great interest to me because if ever an insect's biology were vulnerable to its population being controlled by a pheromone-based method, it would be this insect. Why! Because even where it is causing economic impacts, it is present in comparatively low densities, and it is therefore especially dependent on its chemical communication system for males to locate females to ensure that reproduction occurs. Thus, a pheromone-based system designed to interrupt male to female communication behavior should have an excellent potential for suppression of populations. Principal cooperators in the western pine shoot borer work included Lonne Sower and Charles Sartwell, USFS, Corvallis, Tom Koerber, USFS, Berkeley, Steve Cade and Dave Overhulser, Weyerhaeuser Co., Klamath Falls, OR, Jed Dewey, Missoula, Montana, Roger Kitterman of what was at that time Albany International Inc., Phoenix, AZ, and more recently, Philipp Kirsch and Darek Czokajlo of IPM Technologies, Portland.

We made excellent progress both in identification of the pheromone and in the initial steps needed to develop formulations for both ground and aerial applications of mating disruption treatments for ponderosa pine plantations. Our results were especially convincing as the disruption treatments resulted in damage reduction. Dave Overhulser was a key element in our team effort on this research. Dave cooperated on all our field efforts and was the lead scientist on one of the major field experiments. Two pheromone technology companies registered commercial formulations for shoot borer control in the early 1980's; however their return on investment did not meet profit expectations and their commercial registrations were allowed to lapse. More recently, interest in the mating disruption technique for control of this insect has been revitalized by a cooperative effort involving Nancy Gillette of the USFS PSW Research Station, scientists and staff from Hercon Inc., and foresters from private timber companies. Additionally, Darek Czokajlo and Philipp Kirsch of IPM

Technologies, Portland, OR, have successfully tested and registered their "attract and kill" formulation for commercial application to control the shoot borer. The IPM Technologies approach relies on droplets of a combined pheromone and pesticide formulation distributed over a plantation. This method has also been effective in reducing damage, and at this writing is attracting the interest of several timber companies for suppressing shoot borer impacts in their pine plantations.

The success of pheromone applications to control damage caused by western pine shoot borer stands as a classic example of successful pheromone-based insect control among all such efforts that have been tested, including those targeting numerous agricultural insect pests. I have no doubt that if the impact of the shoot borer was better understood and documented with comparative data, that greater interest would be forthcoming from land managers interested in growing ponderosa and Jeffrey pines in plantations. There is clearly a research opportunity for comparing growth on pine plantations where the insect has been somehow excluded or treated to prevent its impacts to tree growth, versus that occurring on similar plantations where insect activity has not been suppressed.

Spruce Budworm and Others (1980's):

A next logical step for pheromone identification work pointed to the western spruce budworm, *Choristoneura occidentalis*, and related *Choristoneura* species that feed on western conifers. Once again we worked in close cooperation with Doyle Daves of the Oregon Graduate Center, and a new member of his analytical team, Therese Cory. We were soon able to report successful chemical structure identifications of the sex pheromones for both the western spruce budworm and the Modoc budworm, *Choristoneura retiniana.* Field experiments using synthetic budworm pheromone formulations in mating disruption treatments were conducted for population suppression, and for development of population monitoring traps to predict defoliation. Study results were promising but for the most part inconclusive. It was about this time that Christine Niwa transferred from Missoula, Montana to join our Corvallis group. Chris participated in research on the budworm monitoring trap activities, eventually taking over the lead on that effort and advancing the concept and technique.

Chris was also the lead scientist in identifying the pheromone of the ponderosa pine tip moth, *Rhyacionia zozana.* Following the chemical structure identification, Chris conducted mating disruption tests that confirmed that the approach was effective for that species. One of the most notable findings from Chris's research was the validation that the pheromone treatments caused no adverse effects on two parasites of the tip moth.

It was in the late 1980's that I was privileged to work in western Montana with Pat Shea, USFS PSW Station, Davis, CA, and Mark McGregor, who had become a field representative for PheroTech Inc. working out of Missoula, Montana. We were establishing plots to evaluate the anti-aggregative effects of aerial treatments of verbenone against the mountain pine beetle, *Dendroctonus* *ponderosae*. Most of you who knew Mark will recall how much he enjoyed practical jokes, and also that he was very fond of firearms. On more than one occasion I watched as, with a big grin, he fired a round from a large caliber handgun into the air. I believe the handgun was a 357 magnum. Certainly its report was very loud, and, of course, Mark waited until Pat's attention was elsewhere when he touched it off. Pat's response was predictable, and the clear mountain air of western Montana would suddenly turn Technicolor! Mark's grin would just get wider, and you just knew he was already planning a repeat performance somewhere down the road. Those were memorable times, and we did complete a successful aerial treatment, although we would have preferred more conclusive results in terms of verbenone's suppressive effect on beetle behavior.

Re-emergence of the Douglas-fir Beetle (1990's):

The 1990's saw the USFS, PNW Research Station somewhat in turmoil. This was precipitated by the 1989 arrival of a new Station Director with an agenda to use the PNW Station as a testing ground for changing the U.S. Forest Service research organization. Over the next few years two of our field laboratories were closed, and the organizational structure of assistant Station Directors and Project Leaders was done away with in favor of Program Managers with responsibilities for research direction at multiple locations.

Within this scenario of organizational change, I was assigned to be the Acting Program Manager for Forest Health and Protection, and responsible for entomology and pathology research plus a few ancillary projects at three laboratory locations in Alaska, one in Washington, and three in Oregon. Clearly this was a full-time management position that would leave no time to conduct personal research activities. Interestingly enough, it was within this framework of events that I saw the opportunity to get back into bark beetle research. First of all, my research management assignment was to be temporary, and I envisioned a return to hands-on research within a year; secondly, our team's continuing work on lepidopteran pheromone development was in the capable hands of Lonne Sower, Charlie Sartwell, and Chris Niwa; and, thirdly, one Darrell Ross had recently been hired as a member of the Forestry Sciences Department Faculty at Oregon State University.

The opportunity to involve Darrell in pheromone research was evident, and I was fortunately able to scrape together a sufficient amount of funding for a cooperative project to immerse him in the fun and mystique of pheromone research on the Douglas-fir beetle. Darrell had limited experience in this line of research prior to 1992; however, as you all know, he is highly enthusiastic, and an exceptionally capable entomologist. You also know the rest of the story, because after a very short time Darrell became an expert on Douglas-fir beetle biology and ecology, and a pheromone applications specialist in his own right.

Teaming up with Darrell on cooperative Douglas-fir beetle research was especially fortuitous for me, as it turned out that my so-called temporary USFS assignment in management and administration was to continue until 1997. Consequently, I have often thought that my limited time working on our cooperative projects was a great help in maintaining my sanity during a difficult period of transition. In any case, I thoroughly enjoyed our opportunity to work together, and somewhat later the expanded studies on Douglas-fir beetle in Idaho and Montana that included cooperation with Carol Randall, USFS, Coeur d' Alène, ID, and Ken Gibson, USFS, Missoula, MT. Additionally, we enjoyed memorable times working with Steve Munson and others in studies to evaluate MCH and aggregation pheromone components for spruce beetle, *Dendroctonus rufipennis*, in Utah.

We enjoyed a number of research successes working with the Douglas-fir beetle, primarily due to Darrell's efforts. The use of the anti-aggregation pheromone, MCH, was unequivocally demonstrated to be capable of protecting live trees from beetle attack. Perhaps most significant were the research results with high-strength aggregation pheromone lures that demonstrated the potential for wide-area treatments to influence where tree mortality takes place on the landscape. This concept still calls for additional research, but I believe such an effort could be highly rewarding. I have to attribute this viewpoint to concepts learned as a result of the PNW Station reorganization. Influences of that reorganization focused greater interest and awareness on area-wide management approaches, as for example, stream drainages, sub-watersheds, and the like. Such a viewpoint makes good sense, but raises significant research challenges, as it is a complex issue to determine or predict where a bark beetle population might disperse over large landscapes.

Some additional bark beetle work involved program management activities in Alaska, and cooperation with Jerry Boughton and Ed Holsten, USFS, Anchorage, and Skeeter Werner, USFS (retired), Fairbanks (at the time). There had been an immense spruce beetle outbreak in the early 1990's with white spruce tree mortality spread over millions of acres. This occurrence set the stage for high fire risks, questions about wildlife habitat, site restoration, and a multitude of other related resource issues. We worked together in an attempt to package an R&D proposal that would attract more federal funding for restoration treatments to the affected area. Although our efforts to attract more financial support were generally unsuccessful, I learned a great deal about the area and very much enjoyed working with the Alaskans and getting to know some of their many cooperators.

What Now? (2000 +):

It was early in the new millennium that I began to seriously consider retirement. A number of events came together at that time to cause me to consider that perhaps I had spent enough of my lifetime in the office and chasing after bugs. Eventually I followed through with that consideration and retired on January 3rd of 2003.

Since 2000, both before and after retirement, my entomological career has primarily consisted of completing studies and manuscripts. Most gratifying to me during this period was the successful completion, and publication, of the 1979-2001 results of the operational Douglas-fir tussock moth trapping program for predicting outbreaks in the West. I realize that I mentioned this earlier in this presentation, but I am repeating myself as I feel very strongly about the assistance of both John Wenz and Kathy Sheehan in helping to complete this manuscript. Their efforts were outstanding, and essential for completion of the manuscript. The paper relates the results of numerous case studies of outbreaks and the related performance of the trapping for predicting those outbreaks.

Would I Change Anything? (In doing it again):

Were it possible to go back and change my career decisions, I doubt I would make very many. Certainly it has been a most rewarding career, and receiving the WFIWC Founders' Award makes it even more so. This will truly be a standout memory that I will treasure always. Also of great value to me is the knowledge that some of the research findings in which I had a role in development, are in operational use and playing a role in forest resource management. Of most significance to me, however, are the close associations with some of the people I have worked with over the years.

I have been truly fortunate and blessed with a very rewarding career that has been greatly enhanced by associations with many fine and talented people. In addition to the science progress that we made, we also had a lot of fun. Again, I am deeply honored and appreciative of receiving the Founders' Award. I thank all of you and offer my particular thanks for the thoughts and efforts of those who nominated me.

Panel Discussions

Panel 1. Going…going…gone: Supply and Demand for Future Entomologists

Moderator - Peter M. Hall, BC Ministry of Forests

Premise of the Panel:

1) Conference theme "Back to the Future" implies that we should be looking back to where we have come from and also having some vision of where we are going.
2) One of the issues that will arise in the coming (or "near-present") future is the age-class distribution of currently practicing entomologists in all levels of government, universities, and industry.
3) This is complex as many things are changing: evolving forest management objectives; evolving technologies; evolving and changing insect species of concern and "apparent" changes in dynamics.
4) How do we cope? Where are we going?

Presenters:

1) Deepa Pureswaran, NSERC postdoctoral fellow – a recent graduate just getting established in the field of forest entomology…..What were her expectations on beginning in the field, what are her future expectations as to challenges and opportunities?
2) Jim Wood, Director, Forest Resources Program, CFS – PFC – a program manager in a federal government forestry organization who "manages" professional entomology research scientists and technicians… where does CFS currently think they are going, what skill sets will be desirable in the future, how are things going to change?
3) Robert Coulson, Professor, Texas A&M University – a teacher of entomology and entomologists since 1973. Again, what skill sets would be needed in the future, how do we go about ensuring adequate skill and talent is available as older individuals retire and take their experience and expertise with them?

Deepa Pureswaran

Forest entomology: A changing field with changing people

The title of the panel refers to the future of forest entomology as a discipline in general and to the retiring generation of forest entomologists in particular. But is forest entomology really disappearing? In the past few months there have been several advertisements calling for students to study different aspects of forest entomology at the undergraduate, graduate and postdoctoral levels. There are also faculty positions available at universities.

There are over 30 species of forest insects that are classified as pests in the Forest Insect and Disease Leaflets of the USDA forest service. Bark beetles, weevils and spruce budworm are the top three pests of conifers. The top pests of hardwoods, the gypsy moth, longhorned beetles, and the emerald ash borer, are all exotic species. In light of these pest problems, there is a need for forest entomologists. We must understand the biology and natural history of these insects before developing detection and control methods to minimize the damage they cause, if not eradicate them. There is funding available from agencies in Canada and the United States for the study of forest insects. Every decade since 1945, the number of papers related to forest entomology published in refereed journals has more than doubled. Articles relating to forest insects are not restricted to entomology journals alone, but have also made their way into journals of general interest like Ecology and Oikos.

Forest entomology as a discipline is flourishing but as with any field, it is also changing. Several other fields have contributed to the evolution of the discipline and we have encouraged this by collaborating with scientists in those fields. The skills researchers need today and the challenges we face differ from those in the past. We now have access to new technology that we must keep up with in order to conduct our studies. The skills we need might be in molecular biology, computing, or geographic information systems. It is much easier to access remote forests and retrieve the information we need to conduct experiments. In the past, locating the insect in remote forests, to studying it and publishing must have been tedious and challenging. Forest entomologists used to focus on studying the natural history of their insect. Taxonomy and systematics were an integral part of the discipline. Even though there are graduate programs at universities today that still offer forest entomology courses, there are not as many students who do their studies at the organismal level. Not because there is a lack of interest in traditional forest entomology, but because there are so many more research options to choose from, that classical studies do not attract as many students. This is a potential problem for the future. What can we do to revive and maintain classical forest entomology? There is considerable interest from both faculty and students regarding conducting workshops or intense, short term courses in forest entomology. Graduate students from universities across the continent who work with forest insects and have no access to such a course, can be brought together for formal training in forest entomology.

So let's look at what we have here. Among my colleagues, we have a new generation of scientists who are curious and enthusiastic. Our research questions are relevant to science and pertinent to society. With new research problems and retiring scientists, there are currently jobs available. Funding agencies consider insects and their outbreaks important enough to allocate money for their study. There is plenty of technical expertise available in various disciplines if we seek them out and establish collaborations. And finally, forest entomologists are publishing more widely now than ever before. So personally, I think the opportunities are plenty and that the field is thriving and moving in new directions. The prospect for research careers in forest entomology is bright.

Jim Wood and Sophia Sudnikowicz

The changing role of entomologists in Natural Resources Canada – Canadian Forest Service

A key role for federal science and technology (S&T) in Canada is to support public decision making, policy and regulation development, as well as monitoring and public safety. It is well recognized that sound science is essential for policy and regulation development. The federal government approach to publicly funded S&T is changing. For example, there is a move toward greater integration with the creation of networks of federal, provincial and academic researchers to work together and share results and funding. In addition, funding to federal S&T departments is increasingly being targeted to specific high-priority issues and outcomes. Work of senior federal research scientists is being focused on the provision of sound scientific input to policy, the mentoring of junior scientists and the synthesizing of bodies of scientific knowledge to inform policy makers.

The Canadian Forest Service (CFS) is a sector within Natural Resources Canada. The CFS mandate is sustainability of the forest resource and competitiveness of forest sector. The CFS is a science-based policy organization with a national focus and strong regional delivery through the cross-Canada network of regional centres and nodes. As the leading national forest sector S&T organization, the CFS conducts research on climate change, sustainability of Canada's forests, forest-dependent communities and industry competitiveness. Within those larger research topics, a number of key issues such as invasive species, wildland fire, the boreal forest, aboriginal forestry and indicators of sustainability are being addressed.

Entomologists are employed by CFS in a broad range of capacities. For example, entomology-related job-posting data for CFS from 1997–2003 include: spatial data analyst, landscape decision support scientist, forest entomologist, biodiversity specialist, pest management specialist, pest impact technician and biocontrol technician.

The CFS is similar to many other Canadian S&T institutions, such as universities and provincial research organizations, in that a significant proportion of scientific, professional and technical staff can or will soon be eligible to retire. In the next five years, half the CFS entomologists in the scientific and professional classifications will be able to retire. The situation is similar in the technical classifications.

Areas of potential staffing of entomological expertise include: invasive species (risk analysis, GIS, policy/trade, economic impacts, taxonomists); natural disturbances (landscape-level modeling and risk assessments; impacts upon carbon, timber supply, community safety and stability); and collections (taxonomy, information systems, web applications). Actual staffing will be dependent upon regional as well as national priorities, and availability of funding.

Robert N. Coulson

Going, going, gone: The future of forest entomology

The future of forest entomology as a vital component of forest protection and forest science has been a topic of discussion and debate at the WFIWC for the past ten years, at least. In this panel discussion on the subject, the approach I have taken is (i) to consider forest entomology in the context of an institution cycling through a sequence of orderly successional stages and (ii) to consider the scope (content) and bounds (context) of forest entomology – a redefinition.

Holling (1992) developed a model of ecological succession where the process was envisioned to proceed in a cyclic fashion through four principal stages: exploitation, conservation, release, and reorganization. These stages roughly correspond to birth, growth, death, and renewal. Gunderson, *et al.* (1995) applied this model to institutions in general. I suggested that our "institution" of forest entomology is in the midst of reorganization and that the outcome will be an enterprise with a broader charge than in the past.

The scope (subject matter) and bounds (spatial and temporal scale) of forest protection have expanded with new concepts of management and technical knowledge of forestry and ecology. Although still an applied and directed component of forest management, the actual implementation of forest protection measures is guided by consideration of several practical realities. First, forests, world-wide, have been greatly modified by human activities. Second there are a number of different types of forest environments and their need for protection varies. Third, emphasis in forest management practice has shifted from a model that emphasized extraction of forest resources for human consumption to one that features maintenance of integrity, health, and sustainability of the forest environment, i.e., resource extraction is considered in context with the condition of the forest environment. Fourth, there are many causes for change in forest conditions and resources. Only a limited number can be modified or directed by human intervention. Finally, the impact of change in forest conditions and resources is manifested at multiple spatial and temporal scales.

Gunderson, L.H., C.S. Holling, and S.S. Light, eds. 1995. *Barriers and Bridges to the Renewal of Ecosystems and Institutions.* New York: Columbia University Press.

Holling, C. S. 1992. Cross-scale morphology, geometry, and dynamics of ecosystems. *Ecological Monographs* 62: 447-502.

Panel 2. Damaged Wood

Moderator - J. Daniel Lousier, Whisky Jack Forest Sciences, Cowichan Bay, BC

The extent, intensity and rapid rate of spread of the mountain pine beetle epidemic have produced one of the most, if not the most, difficult challenges in forest resource management British Columbia has ever encountered. We are witness to a natural disturbance event, which is taxing our ingenuity and capability to respond in the most effective manner. Sustainable forest management (SFM) involves balancing economic, social, and environmental needs and issues in support of the needs of people today, the needs of future generations, and the needs of the forest itself. SFM plans must be sound ecologically, make economic sense, and benefit human society, present and future. The current mountain pine beetle (MPB) epidemic in British Columbia, and the province's response to it, are putting the concept and principles behind SFM to the test. The past and current uplifts in AAC[1] are providing substantial direct economic and social benefits to the local forest industries, their employees and local communities, and indirect economic and social benefits to the province as a whole. Resource managers and resource-dependent communities have, however, identified significant knowledge gaps in the current MPB management strategy:

- What are the realistic markets for products from beetle-killed pine;
- What are impacts of the epidemic itself on all forest resources;
- What are the impacts (direct and cumulative) of management strategies and practices on all forest resources;
- Where will the future timber supplies to the local mills and communities come from;
- What are the impacts of management strategies and practices on current land uses (e.g., recreation and tourism, agriculture, subsistence lifestyles); and
- What is the long-term economic and social sustainability of the communities?

Within British Columbia, we have research programs and institutions (Canadian Forest Service (BC and Alberta), Forintek, FERIC, University of Northern British Columbia, University of British Columbia, McGregor Model Forest, forest companies, consulting companies) doing research in each area. Thus, we have presentations dealing with the economics of value recovery from beetle-killed timber, the ecological legacy of the mountain pine beetle and the harvesting activities (including salvage) we undertake, and the long-term sustainability

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[1] The uplifts were to deal firstly with trying to limit the growth of the epidemic through harvesting 'green attack,' and secondly with the salvage harvesting of the abundance of dead trees.

implications for the forest-resource-dependent communities in the British Columbia interior.

McGregor Model Forest Association. 2003. A sustaining vision. Sustainable forest management in BC's Omineca Region. Canadian Forest Service, BC Ministry of Sustainable Resource Management and Canadian Forest Products Ltd., Prince George, BC. 20 p.

Presenters:

1) Tony Byrne, Forintek Canada Corp., Vancouver, BC
2) Ann Chan-McLeod, Department of Forest Sciences, UBC, Vancouver, BC
3) John Parkins, Social Science Research Group, Canadian Forest Service, Edmonton, AB

Tony Byrne

Value recovery from mountain pine beetle-killed timber

Freshly killed trees are useable by the current industry because the trees have only bluestain, which seems to be manageable in the market place (or, at least the industry is trying to manage it). Cutting freshly infested trees ('green' and 'red' attack) has at least slowed the spread of the MPB but it has clearly not stopped it. The concentration of harvesting activity is now moving toward salvaging the dead trees ('grey' attack).

The older dead trees have drying checks and are more problematic in terms of processing. Processing and manufacturing costs increase as the dryness of the logs increases, and value recovery declines. Why don't we process more dead trees? Quite simply: our technology is not suitable because most mills are set up for green wood; there are still too many unknowns in the processing of such wood; profitability is lower; and, to date, we have few markets for the increased amount of 'falldown' products from lower quality logs. Dry logs are brittle and are liable to break each time they are handled, thus increasing logging and handling losses in the forest and mill yards. There is decreased lumber volume from dead logs, and lumber shows higher levels of degradation due to deterioration. Also, splits and checks in dry logs open up with handling. Dry log decks may be a higher fire hazard. Debarking is more difficult for dry logs; sheets of old, dry bark can readily jam debarkers.

Forintek's wood property tests show that freshly killed wood is as sound as wood from live trees. These findings refute literature evidence reported many years ago. Other research has shown that bluestain can be removed somewhat by bleaching (the effects are generally quite shallow), thus increasing the cost. Rotary peeling produces rough, partial veneer sheets for plywood manufacture, resulting in increased processing and handling costs. Usage of large amounts of beetle-killed wood in oriented strand board (OSB) manufacture may not hold much promise: increasing the amount of pine in the current process requires significant increases in the amount of resin utilized, thus significantly increasing the cost of OSB production. Research is underway to look at utilizing pure lodgepole pine for OSB. The North American market for medium density fiberboard (MDF) is already overstocked so there appears to be little viable opportunity for utilizing MPB-killed pine in MDF production.

Pine is a desirable species for furniture and appearance grade products. Gluing properties of ‘green’ and ‘red’ attack wood are the same as those for live wood. Bluestain can be disguised by particular darker finishes or enhanced by clear finishes. Beetle-killed wood has increased permeability to fluids; thus, we see an increased uptake of preservatives, glues and finishes. This has significant positive implications for the production of poles, fence posts, treated decking, and, particularly in the United States market, treated framing lumber.

The forest products industry has in place a research program to try to recover value from beetle-killed trees and overcome some of the problems in handling and processing dry logs. The key to doing that economically is reducing manufacturing costs and trying to diversify the product mix. Most research is underway on ‘green’ and ‘red’ attack wood. Much more information is required on ‘grey’ attack pine, e.g., shelf-life;’ and wood quality and milling properties; product possibilities; market potential.

Ann Chan-McLeod

Factors affecting the ecological legacy of post-beetle stands

The key question considered in this presentation is: “Is ‘damaged wood’ damaging to wildlife?” Information was presented on: (a) beneficial effects of MPB-killed stands on wildlife habitat; (b) negative effects of MPB-killed stands on wildlife habitat; (c) factors affecting the ecological legacy of MPB-killed stands; and (d) placing MPB-killed stands in the overall context of wildlife habitat management.

The beneficial effects of MPB-killed stands on wildlife habitat were identified as:

i) increased foraging substrate, particularly for those predators on the MPB and other insects associated with dead and decaying wood;

ii) increased nesting sites for wildlife species which utilise dead trees (e.g., cavity-nesters);

iii) increased number of perching sites, especially hunting and resting perches for the predatory (e.g. raptors) and scavenging (corvids) species;

iv) increased source of downed wood for those wildlife species inhabiting the forest floor; and

v) promotion of understory growth, due to open canopy increasing habitat cover and food for many species of wildlife.

The negative effects of MPB-killed stands on wildlife habitat were described as:

i) such stands have less habitat (amount and contiguity) for canopy and sub-canopy species of wildlife;

ii) elimination of habitat for closed-canopy wildlife species; and

iii) management of MPB-killed stands can result in the loss of existing wildlife trees (older snags) and the loss of future cavity trees.

Factors affecting the ecological legacy of MPB-killed stands include:

i) time since infestation and tree death – dead trees begin to decay and different decay stages of the trees present different habitat opportunities to a wide range of fauna;

ii) residual green component – at the stand level, the abundance and density of remnant trees and other vegetation substantially affect quality and distribution of wildlife habitat, especially for those species requiring habitat connectivity and continuity; and

iii) neighbourhood composition - at the watershed or landscape level, the composition, diversity, continuity and structure of the remnant stands play a critical role in determining wildlife habitat quality and quantity.

Thus, in the context of overall wildlife habitat management, the quality and quantity of wildlife habitat will be determined to a large extent by the beetle management activities (e.g., salvage harvesting) selected, and the areas in which these activities are implemented.

The conclusions specified in this presentation were:

i) post-beetle stands will have both positive and negative effects on wildlife habitat values;

ii) practitioners should refrain from salvage logging in locations where habitat values are highest; and

iii) beetle control/management measures, including salvage logging, are potentially more detrimental to wildlife and wildlife habitat than the beetle epidemic itself.

John Parkins

Socio-economic dimensions of community vulnerability to the pine beetle

The objectives of this project were to:

i) from the published literature, develop a comprehensive framework for a community vulnerability assessment to the mountain pine beetle outbreak;

ii) involve community members in determining key factors associated with vulnerability; and

iii) construct a baseline vulnerability assessment of thirteen study communities in British Columbia that includes primary and secondary data and report results in tabular and spatial formats.

The literature review involved:

i) evaluating international and national climate change vulnerability assessments, concentrating on climate science and social science;

ii) the following assessments for each of the study communities:

- hazard and disaster research;
- rural communities and climate change;
- community capacity; and
- health promotion: community capacity; and

iii) defining the institutional dimensions of risk.

The conceptual framework developed was found to offer a more pluralist approach to vulnerability assessment because: it incorporated physical, political, economic, and socio-economic dimensions; it combined physical information and public knowledge; and it built upon existing data. Such an approach emphasizes the latent capacity of communities to respond over the long term. Index scores were obtained for each dimension assessed for each community, and for an overall vulnerability index. It was found that changing from the physical assessment to the more holistic assessment could have significant impacts on community scores.

The policy implications of these assessments reveal that:

i) such an approach improves our understanding of community-level abilities to adapt;

ii) future policies and programs can be targeted more strategically to meet community needs. For example:

- some communities may require attention to the political dimensions of their response capacity, whereas others may require attention to economic or social dimensions; and

the focus of response planning should be on those ‘intangible’ assets that contribute to community capacity.

<u>Summary (Dan Lousier)</u>

With this panel, we have tried to address issues remaining after the mountain pine beetle has moved on to ‘greener pastures’. We have also tried to present as positive a spin on these issues, recognising that the beetle has provided an incredible opportunity for learning, innovation, and entrepreneurial ventures. Much research and knowledge transfer remains to be undertaken to capitalise on these opportunities.

Panel 3. What's in the Future?

Moderator - John Borden, Director Research and Development Phero Tech Inc., Delta, BC.

Contributors to this panel were asked to consider the future of forest entomology with respect to both the past and the present. The four panelists explored in succession exotic insects and regulatory policy, technological progress and development, urbanization of forest health, and the impact of climate change.

Presenters:

1) Troy Kimoto, Survey Biologist, Canadian Food Inspection Agency, New Westminster BC.
2) Jim Ellenwood, Remote Sensing Program Manager, USDA Forest Service, Forest Health Technology Enterprise Team, Fort Collins, CO.
3) Jerry Carlson, Research Scientist, Forest Health and Protection, New York State Department of Lands and Forests, Albany, NY.
4) Alan Carroll, Research Scientist, Pacific Forestry Centre, Canadian Forest Service, Victoria BC.

Troy Kimoto

Past, present and future of exotic forest insects in Canada

Troy set the historical stage by reviewing 12 historical introductions of forest insect pests into Canada, starting with the larch sawfly in 1882, and ending with the pine false webworm in 1961. The present status of regulatory policy was set in 1990, with passage of the federal Plant Protection Act, under which jurisdiction was given to the new Canadian Food Inspection Agency. This agency operates under directives that may be either commodity-specific, e.g. wood packaging, or pest-specific, e.g. the emerald ash borer. The future is uncertain, with implementation of the as yet untested International Standards for Phytosanitary Measures (ISPM No. 15) of FAO's International Plant Protection Convention, e.g. with respect to new standards for wood packaging materials. Although Canada's main trading partner remains the USA, trade with China and Mexico now represent 6.8 and 3.8 percent of Canada' imports, respectively, which poses huge challenges with respect to ensuring that all imports are free of potential exotic pests.

Jim Ellenwood

Past, present and possible future detection technologies

Using the Kaibab National Forest in Arizona as a setting, Jim followed the historical trend in pest survey methodology. Ground surveys in 1910 required 11 people working 244 days to lay in 195 miles of compass line on 412,000 acres at a cost of $9,163.30 ($174,843.17 in current dollars). Today the entire state is aerially surveyed at a cost of $1,710. Given explosive growth in technology, the future prospects are virtually unlimited. Future surveys will be highly technological and will integrate advanced sensor technology with sophisticated sampling techniques and data mining. A taste of the future is exemplified in the hyperspectral imagery now being implemented for surveys of the emerald ash borer and other critical pests.

Jerry Carlson

The urbanization of forest health

Jerry presented the complexity of forest health in urban environments, where there are multiple stakeholders, disparate landowner interests, and multiple agency mandates and authorities. Unlike a conventional forest environment, one must first locate the trees in an urban landscape that is 2-8 degrees F hotter than a rural environment. Management is confounded by conflicting opinions and emotions on what the purpose of urban trees is, and whether there should be more or fewer of them. An increase of 65 percent in container traffic through the port of New York City since 1998 has exacerbated the threat of introduction of exotics like the Asian longhorned beetle. Eradication efforts since 1996 in New York and 1998 in Chicago have been largely successful, but a more understanding public in Chicago has facilitated the program in that city. The more recent finding of the beetle in New Jersey exemplifies the need for continued vigilance and the challenges that will be faced in the future.

Alan Carroll

Changing the climate, changing the rules: Predicting forest pest impacts under global warming

Alan exemplified the impacts of climate change through four types of forest insect pests. The spruce beetle is a **native ubiquitous** pest. Under climate warming it should trend toward a one-year life cycle. When coupled with increased host stress, this should lead to more frequent outbreaks, with severe host mortality. The mountain pine beetle is a **native invasive** pest. Under observed and predicted climate change, the range of this species should expand, and outbreaks should occur in habitats that were previously climatically unsuitable. One **native innocuous** pest is the pinyon ips beetle. A warming trend coupled with drought should shift this species from 1-2 generations per year to 3-4, thereby increasing its impact on host mortality. Finally, the gypsy moth is an **exotic invasive** pest, which may survive and persist in western habitats because of a more favorable window for oviposition. Alan noted that significant climate change has already occurred, but cautioned that its effect may be confused with the effect of certain forest management practices. Within the next 50 years, native ubiquitous and native exotic pests should increase their impact through altered outbreak characteristics, while native and exotic invasives should increase their impact through range expansion.

Special Workshop: Analysing Climate Change

Sponsored by: Natural Resources Canada, Atlantic Forestry Centre

Moderator: David R. Gray

This one-day workshop brought together 8 scientists from government and universities of Canada and the United States to discuss the potential effects of climate change on insect pest dynamics at the landscape scale. Insect outbreaks are natural disturbances that operate at enormous spatial scales. As such these events are dominant factors in shaping the forest landscape. Climate change will potentially affect the geographic range (i.e., range shift, and/or range expansion) of insect pests, and the frequency, duration, severity and impact of their outbreaks. The objective of this workshop was to present analytical techniques suitable for investigating the relationship between climate change (spatially variable) and insect outbreaks (spatial events). The presenters were encouraged to discuss the techniques and methodologies they employed in their studies, and to highlight the perceived strengths/weaknesses, dataset limitations, and the assumptions inherent in their methods. Thus the focus was at least as much on techniques and methods of studying complex dynamics at a landscape scale as on the outcome of the studies themselves. Presenters discussed their approaches in each ½ hour presentation. A half hour discussion followed every two presentations.

Presenters:

1) David Gray, Canadian Forest Service, Atlantic Forestry Centre
2) Richard Fleming, Canadian Forest Service, Great Lakes Forestry Centre
3) Allan Carroll & Brian Aukema, Canadian Forest Service, Pacific Forestry Centre
4) James Powell, Utah State University, Department of Mathematics and Statistics
5) Barry Cooke, Canadian Forest Service, Laurentian Forestry Centre

6) Andrew Liebhold, United States Forest Service, Northeastern Research Station

7) Pierre Legendre, Université de Montréal, Département de sciences biologiques

Presenters' names appear in **bold** in the following abstracts.

The effects of climate change on insect outbreaks at the landscape scale - 2 insects – 2 questions – 2 techniques

David R. Gray

Canadian Forest Service, Atlantic Forestry Centre

Insect outbreaks can be characterized by a number of attributes, including (but not limited to) their geographic range, frequency, duration, severity and impact. Insect outbreaks are just one manifestation of the complex interactions between the pest and its environment, which include host(s), natural enemies and climate. And just as insect pests are likely to respond to climate change, so too are their hosts and natural enemies expected to respond.

I ask how climate change will affect the range of an introduced insect (gypsy moth) using a process-based technique; and I ask how it will affect the severity and duration of a native insect (spruce budworm) using a statistically-based technique. The reasons for choosing each technique are discussed, as are their respective strengths and weaknesses.

Question 1. How does climate affect the range of the gypsy moth (an introduced insect) in North America; and how will climate change alter the range?

The range of an insect is defined by its available host(s) and by the climatic conditions that are suitable for population persistence. Suitable climatic conditions will generate seasonality (life cycle events occurring at appropriate times of the year); and annual climatic fluctuations will not overwhelm the phenological processes that create stability (the condition whereby the state variable(s) (e.g. time of egg hatch) return to their initial conditions following a perturbation). A geographically robust phenology model can estimate the geographic range of an insect by estimating the probability that climatic conditions are suitable for population persistence. A geographically robust phenology model is a phenology model that performs equally well regardless of the location, and would usually be process-based and would not rely on arbitrary calendar dates for any decision-making.

I describe a geographically robust model of gypsy moth phenology that is process-based, and illustrate the potential range of this insect under historic and climate change scenarios. See Gray (2004) for a description of the model and results. Advantages of the technique are:

- it's process-based and therefore very robust geographically;
- it's easy to adapt to the desired spatial resolution; and

- it's intuitive and easy to interpret.

Disadvantages are:

- model development can be very laborious;
- the model doesn't account for natural selection; and
- the model doesn't account for other biological factors that may limit persistence.

Question 2. How does climate affect the outbreak characteristics (principally duration and severity) of spruce budworm outbreaks; and how will climate change affect the outbreak characteristics?

Outbreaks of the spruce budworm (SBW) occur within a complex ecosystem that includes at least 26 natural enemies and two principal hosts. Climate undoubtedly affects each of these elements of the system, and it does so in mostly unquantified ways. Thus, efforts to estimate the net result of climate change on outbreak characteristics through a process-based approach are unlikely to succeed in the near future. Instead I describe a statistically-based approach known as constrained ordination. Constrained ordination examines the relationship **Y**=**XM+E**, where (in the example described here) **Y** is a matrix of 9387 observations of 4 SBW outbreak characteristics; **X** is a matrix of 9387 observations of 9 climatic, 11 forest composition, and 9 spatial variables; **M** is a 29×4 matrix of regression coefficients; and **E** is a 9387×4 matrix of errors. Observations of SBW outbreak are from the last documented outbreak (1957 – 1992) in the eastern Boreal (east of the Manitoba – Ontario border) and Maritime (New Brunswick and Newfoundland) forests. A fuller description of constrained ordination can be seen in ter Braak (1994); results have been submitted to Climatic Change (Gray 2005). Advantages of the technique are:

- it's statistically robust and powerful in addressing a complex issue; and
- it suggests potentially important biological questions.

Disadvantages are:

- predictions rely on extrapolation;
- results may be scale-dependent;
- results are not intuitive;
- uncertain impacts of climate change on forest dynamics are not included; and
- the choice of climatic variables is somewhat arbitrary.

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Gray, D.R. 2005. The relationship between climate and outbreak characteristics of the eastern spruce budworm in Canada. Climatic Change (submitted).

ter Braak, C.J.F. 1994. Canonical community ordination. Part I: Basic theory and linear methods. Ecoscience 1:127-140.

Using CART to analyze climatic and forest influences on the large-scale defoliation patterns caused by spruce budworm in Ontario

Richard A. Fleming[1] and Jean-Noël Candau[2]

[1] Canadian Forest Service, Great Lakes Forest Research Centre, Sault Ste. Marie, ON

[2] Unité de Recherches Forestières Méditerranéennes, Institut National de la Recherche Agronomique, Avignon, France

Classification and regression trees (CART) (De'ath and Fabricius 2000) are introduced as a means for analyzing climatic and forest influences on the large-scale patterns of impact caused by certain insect defoliators. We use the spruce budworm (SBW) in Ontario as a case study. Tree ring studies show that the SBW has been outbreaking on a fairly regular 30-35 year cycle since the mid-1600s in Eastern Canada. This is long before humans had any substantial impacts on these forests. The SBW is embedded deep in a complex ecosystem with well over 30 natural enemies, and it is fluctuations in the effects of these natural enemies, which are widely considered as the driving force behind SBW population dynamics. This complexity currently precludes any comprehensive approach using process models (i.e., models derived from fundamental assumptions about basic population processes such as birth, death, immigration, emigration, and phenological development).

Spatially referenced defoliation, vegetation, and climate data were used to construct the CART models. The defoliation data are digitized versions of the province-wide aerial sketch maps produced annually by Ontario's Forest Health Survey (FHS) since 1941. The survey is quasi-systematic (flight lines 6-10 km apart) with mapping error generally under 500m (Sippell 1983). Ontario's Forest Resource Inventory (FRI) provided the vegetation data in grid cells varying between 5x5 and 20x20 km^2 (OMNR 1996). The FRI extends north and south beyond the defoliation coverage and provides aerial and ground based estimates of stand level characteristics. The climate histories are spatial interpolations for Ontario from 471 meteorological stations. They include monthly records of precipitation and minimum, mean, and maximum temperatures at 1 km resolution (Price et al. 2000).

We focused our analysis on the only completely recorded outbreak (1967-1998). The dependent variables were the frequency and occurrence of (moderate-severe) defoliation. [We ignored light defoliation (< 25%) because it is considered unreliable (Sippell 1983)]. From the FRI we extracted 12 forest variables for each grid cell. These were the % total basal area of 10 age classes (each 20 years from 0-180, and all ages beyond 180) and of the primary (balsam fir and white spruce) and 3 most common hosts (i.e., including black spruce). We composed 18 climatic variables, 13 related to temperature and 5 to precipitation, to represent key events in the SBW lifecycle. This number was a trade-off between comprehensively covering the lifecycle and minimizing the possibility of spurious results. The data for all 32 variables were saved in grid of 600,000 cells, each representing 1x1 km. To reduce this to a manageable amount of data for fitting models, we randomly selected 600 of these cells. This selection reduced redundancies in coarser (forest) variables, hopefully without causing excessive loss of information.

There are 3 main limitations to the data. The extent is limited in time to a single outbreak cycle, and in space to Ontario (so the eastern and western boundaries are political). On the other hand, using only Ontario data has the advantages of little confounding influences from spraying and consistent survey protocols. A second limitation is the lack of greenhouse gas data. Third, there are a number of complications to interpreting the FHS data (Sippell 1983).

A classification tree (CT) was developed to describe where defoliation occurred. The algorithm for 'growing' the CT involves splitting the data into ever smaller groups until a minimum group size is reached. At each split, the algorithm uses the predictor variable and its value that reduces the misclassification error the most. This typically produces a CT, which is 'over-fitted' to peculiarities of the data. To counter any 'over-fitting', a cross-validation procedure was applied to "prune" away unreliable splits. The original data at each split were randomly separated into 10 mutually exclusive subsets. Each subset was used once to independently test 'sub-trees' grown on the 9 other subsets and the most accurate sub-tree structure retained.

Collinearity among predictor variables is less of a concern in CART than in most other multivariate modeling. Nonetheless, collinearity can cause instability in CTs in which alternative predictors provide splits almost as good as the ones selected. This implies that small changes in the data can lead to the adoption of different predictors. The usual solution in multivariate analysis is to remove the predictors most responsible for multicollinearity, but this reduces the ability of the CT algorithm to find the best predictor at each split and overlooks the fact that the degree of multicollinearity likely varies in different subsets of the data. Instead, we applied a Random Forests procedure (Breiman 2001), which involved building 200 CTs from different random sub-samples of original randomly selected 600 spatial grid cells. At each split, the procedure finds the most important among 10 randomly selected predictors. (Predictor importance is calculated as the decrease in accuracy when that predictor's values [alone] are shuffled).

The development of regression trees (RTs) parallels that of CTs. As a basis for developing our regression tree for describing where different frequencies of defoliation occurred, we randomly selected 600 grid cells from areas where some defoliation had been recorded at least once during the last outbreak. The algorithm for 'growing' the RT involves splitting the data into ever smaller groups until each one is acceptably homogeneous. At each split, the algorithm uses the predictor variable and its value that reduces the variance in defoliation frequency the most. Figure 1 shows the difference between how classical regression and regression trees analyze data. Without additional information, it is not clear which approach better suits the illustrated relationship. As in the development of CTs, the process of growing the RT typically results in 'over-fitting', so again we used a cross-validation routine to "prune" away unreliable splits.

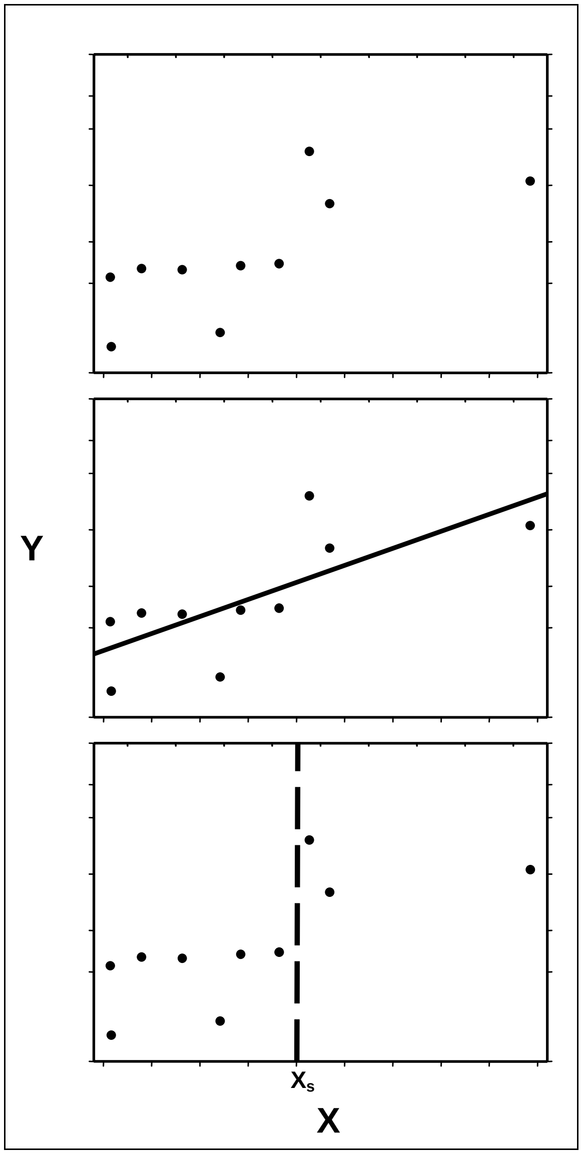

Figure 1. Comparison of the classical regression and regression tree (RT) approaches. (a) Scatter plot of data (adapted from Fleming et al. 1999, Fig. 4). (b) Classical regression fits the least squares line. (c) The first split in fitting a RT separates the data at the dashed, vertical line (where $X = X_S$). For all $X < X_S$, the RT's predicted value of Y is the mean Y-value of all points to the left of the dashed line, and for $X > X_S$, of all points to its right. The RT algorithm may select further splits to describe the data more precisely.

CART has advantages over traditional multivariate approaches. One need not assume: (1) Gaussian relationships between dependent and predictor variables, (2) uniform effects on the dependent variable of the predictor variables and their interactions over their entire ranges, and (3) constant interactions among predictors over their entire ranges. CART can capture non-linear and non-additive behavior and complex conditional relationships. In addition, CART can accommodate continuous and categorical predictor variables without transformation. A drawback of CART is that it can sometimes produce extremely complex trees. There are alternative approaches (e.g., MARS – multivariate Adaptive Regression Splines) available for such situations (Muñoz and Felicísimo 2004).

Since this paper was part of a climate change symposium focused on methodology, we did not detail the results of applying CART to Ontario's aerial survey records of SBW defoliation. These results are presented elsewhere (Candau and Fleming 2005).

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Intellectual Capital

Allan L. Carroll[1], **Brian H. Aukema**[1, 2], Yanbing Zheng[3], and Jun Zhu[3]

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[3] Department of Statistics, University of Wisconsin-Madison

Given the unprecedented size and severity of the ongoing mountain pine beetle epidemic in western North America, questions have been raised regarding the potential role of climate change. These questions can be critically evaluated by exploiting the long-term data sets collected and maintained by public sector research and monitoring agencies. For example, until 1996, the Canadian Forest Service, Forest Insect and Disease Survey conducted annual aerial assessments of the distribution and abundance of forest pests across Canada. Together with data from long-term weather stations operated by the Meteorological Service of Environment Canada, various techniques can be used to quantify the impacts of changing climate on the spatio-temporal dynamics of mountain pine beetle populations.

We present two techniques for studying spatio-temporal dynamics of biological populations. The first is a construction of a non-parametric spatial covariance function to examine spatial synchrony. The second is a Bayesian implementation of an autologistic model examining abiotic and biotic factors influencing spread of an outbreak. For illustration, we implement both techniques on aerial survey data of mountain pine beetle-caused mortality to pines, overlaid on 12 x 12 km grid cells. However, both techniques can be applied to other organisms.

Non-parametric spatial covariance functions examine how distance affects synchrony of biological populations. In brief, the function is constructed by graphing pairwise correlations between time series as a function of distance between cells, and then fitting a smoothed function through the correlations. Confidence limits about the line can be constructed using bootstrapping techniques. The function was applied to cells during two different time periods in the current outbreak of mountain pine beetle in British Columbia. During incipient years (1990-1996), correlations decayed to zero, the provincial average, within 200 km. During outbreak years (1999-2003), regional synchrony was always positive, even at distances spanning 900 km. Non-parametric spatial covariance functions are advantageous because they are descriptive and can be used to examine time series. A disadvantage is that the populations must be spatially referenced in the same place each year.

A Bayesian implementation of an autologistic model was used to examine factors affecting spread of mountain pine beetle during the 1972-1985 outbreak on the Chilcotin Plateau, British Columbia. Our model contained various climatic covariates derived from the Safranyik model, as well as terms for second order spatial and first order temporal autocorrelation. In Bayesian approaches, model parameters are considered random variables rather than fixed point estimates, as in frequentist statistics. The probability distribution for each regression parameter is derived from the product of a sampling distribution (i.e., the likelihood) and a prior probability distribution (i.e., the prior), divided by a normalizing constant (i.e., the marginal probability density of the data across all possible hypotheses). In implementing our model, we used vague priors so that inference was based entirely on the sample data. A Metropolis algorithm was used to generate posterior densities. Initial results demonstrate that mean annual temperature and neighbouring outbreak populations of mountain pine beetle in space and time influence the probability of any given cell suffering an outbreak. Bayesian models are advantageous because they provide the entire distribution of each model parameter, instead of point estimates, and can easily be used for forecasting.

Modelling the development of insects, including variability of both environment and phenotype

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One of the common traits of insects (and many other exothermic organisms) is that maturation from egg to adult is comprised of several separate, discrete phases, which must be completed at rates strongly dependent on environmental temperature. Ample experimental evidence shows that developmental speed varies nonlinearly with temperature. Additionally, rates of development are the phenological expression of a variety of genes, meaning that in a population of organisms, rates of maturation must be viewed as distributions.

To describe the distribution of developmental milestones (e.g. the hatching of a population of eggs, or emergence of adults from pupae) an extension of the McKendrick-von Foerster equation is derived. Temperature variation manifests as variable developmental speeds while phenotypic variability appears as a diffusive term. Completion of an insect life cycle is modeled by coupling several such equations together; discontinuities in parameters provide mechanisms, which control the timing and synchrony of insect populations.

One particular biological example is considered in depth. Mountain pine beetles (*Dendroctonus ponderosae*) serve an important ecological role in western US pine forests, which have evolved with bark beetle disturbance as an integral part of an adapted system. The reproductive strategy of mountain pine beetles requires new hosts each year, and pines under attack defend themselves strongly. There is thus strong selective pressure for dispersed populations of beetles to mature and emerge simultaneously (synchrony), and at an appropriate time of year (seasonality). In the absence of phenotypic variability development becomes a simple circle map. In combination with seasonal temperature swings a natural consequence of this simple model is that oviposition and emergence will occur in fixed, attractive cycles corresponding to one, two, or half generations per year. The dynamic properties of the thermal habitat are therefore characterized by regions of adaptive, synchronous seasonality separated by regions of maladaptive, asynchronous seasonality, which (with host availability) set the limits of mountain pine beetle habitat. Phenotypic variability (diffusion in the extended McKendrick-von Foerster equation) serves as an evolutionary bet-hedging strategy. Predictions of this model compare favorably with field data.

Climate change impacts on forest insect outbreak dynamics: the comparative/process approach

B. J. Cooke

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The North American climate is warming, and certain forest insect species, in some areas, are doing more damage than ever before. However, this is not true of all species everywhere; so is there really a causal link? There are actually very few forest insect species whose biology and range-wide dynamics are sufficiently well understood that solid inferences can be made regarding past and future responses to climate change. Although nearctic insects in general would likely prosper under warmer temperatures, population models of our most important and well-studied boreal defoliators, such as the tent caterpillars and conifer-feeding budworms, suggest that **a generalized positive response to climate warming at the level of the organism does not necessarily translate into a positive response at the regional scale of metapopulations** and outbreaks. The devil in this paradox lies in the details of the complex feedback structures thought to regulate population fluctuations. I illustrate with a simulation model, along with some specific examples where climate change forecasts for range ***expansion*** or range ***shift*** - two starkly different outcomes - depend sensitively on some very basic assumptions about the insect's underlying dynamics. Some of the most problematic cases, it turns out, involve some of the most damaging sub-boreal species of Lepidoptera whose northern and southern range limits are found in Canada and the US respectively. If we want to be able to distinguish between likely cases of range expansion vs. range shift under climate change, then more research is required, along with greater cooperation between Canadian/American and eastern/western climatologists and insect ecologists.

Forest insect population dynamics and predicting the effects of climate change

Andrew "Sandy" Liebhold

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With ever-increasing evidence that the world's climate is changing as a result of elevated CO_2 emissions and other causes, there is increasing interest as to whether these changes might affect the frequency and intensity of forest insect outbreaks. The question of how weather affects insect population dynamics is not a new question; for many years, population ecologists have debated the relative importance of endogenous (e.g., natural enemies, disease, etc) vs. exogenous (e.g., weather) factors as causes of changes in insect densities. Currently, there is a general agreement that dynamics are usually affected by both sources and this is often represented mathematically by X(t+1) = f[X(t), Xt(-t), X(…)] + e(t) where density at time t is X(t), f(X) is a density-dependent (endogenous) function and e(t) represents density independent (exogenous) effects. Historically, most studies of the effect of weather on insect dynamics have concentrated on e(t). For example, the theory of “climatic release” states that outbreaks are preceded by specific weather events (represented by e(t)) that elevate populations above some threshold density such that they are no longer regulated at low densities. While this theory has considerable appeal, there is not good evidence for it as a cause of most forest insect outbreaks. First, empirical analyses do not consistently record temporal associations (either directly or lagged) between outbreaks and weather. Furthermore, there is little evidence that these exceptional weather patterns that have been proposed as causes of outbreaks occur in a temporally periodic fashion and thus this hypothesis is unable to explain the periodic nature of insect outbreaks, which is ubiquitous in nature. As a more realistic alternative, periodic insect dynamics are primarily the result of numerical interactions with either higher or lower trophic levels but weather may cause slight deviations from these density-dependent population trajectories.

In 1953 Moran proposed a theory that explained synchronous fluctuations of populations as being the result of very minor but synchronous effects of weather on a population system primarily driven by endogenous (e.g., predator-prey dynamics). Recent work indicates that the Moran effect may be a cause of the seemingly ubiquitous spatial synchrony seen in most forest insect populations. One assumption of this theory however is that the density dependent properties (f(X)) affecting populations are identical among geographically disjunct populations. However, there is mounting evidence that variation in the habitat (e.g., forest type) leads to geographic variation in density dependent processes. Simulation models illustrate that this type of variation can shape the extent of spatial synchrony at the regional scale.

These results have some interesting implications for the study of the effects of climate change on insect dynamics. These results indicate that if we are to observe the effects of climate change on insect dynamics, those effects are not only limited to impacts on density-independent (exogenous) factors. But additionally, changes in climate are likely to change the forest habitat and this can be expected to lead to changes in density dependent processes and, in turn, affect dynamic characteristics.

Recent results indicate that weather affects forest defoliators primarily via the Moran effect and examples of “climatic release” are rare or non-existent. Based upon these observations, I conclude that direct effects of climate change on defoliator outbreak dynamics are likely to be subtle. While climate change may have dramatic direct effects on forest composition and this may affect insect populations indirectly in a predictable way, direct effects on defoliator populations may be impossible to predict.

What are the important spatial scales in an ecosystem?

Pierre Legendre

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Spatial heterogeneity of ecological structures comes either from the physical forcing of environmental variables or from community processes. In both cases, spatial structuring plays a functional role in ecosystems. Ecological models should explicitly take into account the spatial organization of ecosystems.

A canonical (regression-type) modeling method has been developed, which allows the decomposition of the variance of a multivariate (e.g., species abundance) data table into four components: (a) a non-spatially-structured component explained by the environmental variables in the model, (b) a spatially-structured component of environmental variation, (c) a spatially-structured fraction which is not explained by the environmental variables and possibly results from community dynamics, and (d) a residual fraction. The first three components can be mapped separately, providing new insights into community dynamics.

In previous work, we used a polynomial function of the geographic coordinates of the sampling sites to represent broad-scale spatial variation. We have now found a way of representing spatial structures at all scales in these analyses. This is obtained by eigenvalue decomposition of a truncated distance matrix among sampling sites. The behavior of this method has been investigated using numerical simulations and real data sets. When sampling occurred along a transect or a regular grid, this modeling method allowed the estimation of the variance associated with each spatial scale in the observation window. A graph of the resulting *F*-statistic against scales is called a Scalogram. It indicates the significant spatial scales present in the multivariate data under study — for example, a community composition data table.

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Workshops

Regeneration Issues/Seed and Cone Insects

Moderator – Robb Bennett

About twenty conference participants attended this workshop. Formal and informal presentations were made on the evolution of the cone and seed pest management program in British Columbia, the effect of imidacloprid injections on *Contarinia oregonensis* (Douglas-fir cone gall midge), the systemic effects of emamectin benzoate and fipronil on *Dioryctria* coneworms and *Leptoglossus* and *Tetyra* seed bugs in loblolly pine, and recent exciting progress with *Dioryctria abietivorella* (fir coneworm) and *Conophthorus* cone beetle chemical ecology. In spite of a late start and domination of the workshop by the moderator's lengthy presentation, good discussion was generated by all presentations.

Cone and seed pest management in British Columbia

Robb Bennett - BC Ministry of Forests

In the past decade, the BC provincial government's cone and seed pest management group has dwindled to two full-time staff handling all relevant activities (research, development & extension, and operational support). This has led to inadequate delivery of services and research. In response to this, in late 2002 the Forest Genetics Council of BC established a Pest Management Technical Advisory Committee to oversee development of a provincial cone and seed pest management research business plan and annually administer a limited amount of contract research funding. Devastating crop losses to *Dioryctria abietivorella* in 2004 demonstrated that delivery of the pest management program was still inadequate and the FGC directed the PM-TAC to develop a proposal to address the issue. Based on TAC recommendations, current provincial staff will now focus efforts on development and extension work with seed production staff taking over responsibilities for all operational activities (including regular monitoring, assessment and decision-making tasks previously done by pest management staff). Research will be the responsibility of an entirely new program led by a research scientist with salary, operational, and research funds provided through the FGC. Interviews will be conducted in summer 2005 and the new research program should commence in the fall.

In collaboration with various research institutions, current research efforts are primarily concentrated on chemical ecology (*Contarinia oregonensis*, *Mayetiola thujae*, and *Dioryctria abietivorella* sex pheromones, *Leptoglossus occidentalis* pheromones and acoustic signaling), basic biology and taxonomy (*Megastigmus* spp.), and new pesticides testing (systemic effects of acetamiprid and imidacloprid).

Discussion centered on operational details of the PM-TAC, provincial conifer seed supply issues, and status of *Conophthorus* cone beetles and research in BC. The PM-TAC is comprised of representatives from provincial and federal government, the industrial and provincial seed production community, university research, and the FGC. It meets regularly through the fall and winter each year to refine its business plan, monitor research progress and developing pest management issues, and present reports and budget requests to the FGC. The activities of obligate cone and seed insects largely are the cause of the inability of seed orchards to meet projected production targets for “A-class” seed. The overwhelming amount of mortality recently in lodgepole pine stands (caused by bark beetles) and the concomitant need for vast amounts of lodgepole seed has exacerbated the problem. *Conophthorus* remains at high endemic levels in certain natural stands of western white pine in the province (e.g. on Texada Island) but has not yet become a problem in BC’s seed orchards. No research has been conducted on BC *Conophthorus* since collaborative work conducted on Texada Island in the mid-1990’s.

Systemic insecticide injections for control of cone and seed insects in loblolly pine seed orchards

Don Grosman - Texas Forest Service

Single systemic injections of loblolly pine with emamectin benzoate (Arise®) in 1999 resulted in reductions in *Dioryctria* coneworm damage ranging from 55 - 94% over a 6 year (1999 – 2004) period. Double injections did not improve efficacy over the single treatment. Injection treatments containing emamectin benzoate significantly reduced *Leptoglossus* and *Tetrya* seed bug damage during the first two years of the same study, but efficacy faded thereafter.

A second trial, initiated in 2003, evaluated injections of emamectin benzoate (Denim®) or fipronil (experimental). The initial efficacy of both chemicals was reduced during the first year due to drought conditions. Emamectin benzoate and fipronil both provided excellent protection against coneworms in the second year after injection; reducing damage by 96% and 80%, respectively, compared to check trees.

Evaluation of trunk-injected imidacloprid for control of the Douglas-fir cone gall midge

Dave Overhulser - Oregon Department of Forestry

The systemic insecticide imidacloprid was injected into the bole of grafted Douglas-fir trees at the J.E. Schroeder Seed Orchard to test its effectiveness at controlling seed damage by the Douglas-fir cone gall midge (*Contarinia oregonensis*). The insecticide was applied using Mauget-Micro-Injectors® containing 0.333 grams a.i. of imidacloprid placed at 10 cm intervals around the circumference of the trees. Injections were made on two different dates: 1) 30 days before reproductive bud break, and 2) at the time of reproductive bud break. The earliest treatment significantly reduced galled scales, and increased the seed extracted from cones and the percentage of filled seed. The early treatment also reduced the percentage of *Dioryctria* infested cones. The late treatment reduced galled scales and increased the seed extracted from cones, but it did not increase filled seed or reduce *Dioryctria* damage. Neither of the imidacloprid treatments reduced the amount of seed infested by the Douglas-fir seed chalcid (*Megastigmus spermotrophus*). Treatments with imidacloprid did not affect levels of conelet abortion, empty seed, or seed germination when compared to the check. A report on this study, designated Pest Management Report February 2003, is available from the Oregon Department of Forestry.

An effective sex pheromone lure for the fir coneworm

Ward Strong - BC Ministry of Forests

In response to a growing problem with feeding by *Dioryctria* in conifer seed orchards in BC, with support from the Forest Genetics Council of BC the Seed Pest Management group of the BC Ministry of Forests has spearheaded a research program. Identification of the culprit was pursued with Felix Sperling and Amanda Roe at University of Alberta. Using morphological and molecular techniques it was determined that *Dioryctria abietivorella* was the species responsible for seed destruction. Spray trials were conducted with the organophosphate dimethoate, the only insecticide registered for this use until more environmentally benign controls can be created. Two sprays timed six weeks apart were found to provide season-long control, but skipping either spray resulted in unacceptable seed loss. Collaborative work in 2004 with Jocelyn Millar at University of California-Riverside, and Gary Grant at the Canadian Forest Service in Sault Ste-Marie, resulted in the determination of a sex pheromone for *D. abietivorella*. Two chemical components delivered in a 1:10 ratio provided good trap catches. We are currently trying to improve this by examining additives for increased attractiveness and improved field longevity. We will also use the preliminary pheromone mixture at a variety of coastal and inland localities in southern BC throughout the field season in 2005 to gather *D. abietivorella* flight period data. We hope to use the pheromone for further phenological data gathering, timing of spray applications, and possibly mating disruption as a means of non-insecticidal control.

Dimethoate is currently the only systemic insecticide in Canada with broad registration for control of cone and seed insects. However various conifers as well as specific uses against particular insects are not covered by the current registration (e.g. control of *Mayetiola thujae* in western redcedar, double spray for *Dioryctria* control). Provincial seed pest management staff is attempting to have the label amended to give broader coverage for cone and seed insect control. This effort is hampered by the current review of organophosphate registrations by Environment Canada – it may be several to many years before a label amendment will be considered.

Recent work with cone beetle chemical ecology

Nancy Gillette - USDA Forest Service; **Peter de Groot**, Canadian Forest Service

Although Nancy's lab no longer has a cone and seed insect research mandate, she continues to pursue research on sex pheromones of, and effects of limonene and host volatiles on *Conophthorus*. With Andrea Brauner, Peter continues to research the potential synergistic effects of various compounds (especially pityol, α and β pinene, and limonene) on the behaviour of *Conophthorus coniperda*. Results to date suggest β pinene reduces trap catches, limonene enhances catches of males with some increase in males, and that there is some synergism between limonene and α pinene. Limonene + pityol may have significant positive effects on trap catches of females. In 2005, mating disruption trials will be carried out and the potential for trap-out using limonene + pityol will be examined.

Impact of Treatments on Non-targets

Moderator - Ken White, BC Ministry of Forests, Smithers, BC

Imre S. Otvos - Canadian Forest Service, Victoria, BC

Bacillus thuringiensis subsp. *kurstaki* (*B.t.k.*) is a naturally occurring, spore forming bacteria that has a world-wide distribution. It is commonly found in soil and on the leaves and needles of trees. While it is commonly found in nature, epizootics caused by this bacterium have rarely been found; they occur most often in enclosed places such as grain elevators. *B.t.k.* was first discovered in 1901 by Ishiwata in Japan, re-discovered in 1911 by Berliner in Germany, and finally re-isolated and cultured in 1927 by Mattes.

Over 70 subspecies of *B.t.* are currently recognized by the Institut Pasteur in Paris. Most of these subspecies are highly specific and only attack certain groups of organisms, primarily insects, nematodes and gastropods. Of these subspecies, the most commonly used for biological control are *B.t.* subsp. *kurstaki* and *aizawai* vs. Lepidoptera, subsp*. morrisoni* (aka *tenebrionis* and *san diego)* vs. Coleoptera, and subsp. *israelensis* vs. Diptera (specifically mosquitoes).

B.t. is the insecticide most widely used to control forest defoliators in Canada. Over the last 25 years, the size of defoliator infestations has ranged from a high of 27 million ha in 1985 to a low of 2.5 million ha in 1996. Only a fraction of these infested stands were treated, from a peak of 10.5% in 1984 (of which 22% was treated with *B.t.k.*) to a low of 2.6% (of which 84.1% was treated with *B.t.k.*) in 2002. Over the years, the proportion of stands treated with *B.t.k.* has increased, from 0.1% in 1974, to 22% in 1984, 65.2% in 1990, 99.7% in 1996, and back down to 84% in 2002. A majority of the treatment conducted throughout the last 30 years have been against the three species of *Choristoneura* (*fumiferana*, *pinus* and *occidentalis*), *Lambdina fiscellaria fiscellaria*, *Malacosoma disstria*, and *Lymantria dispar*.

Examination of peer-reviewed publications based on field experiments showed that *B.t.k.* applications almost always reduced species richness and density in the year of application, and up to 2-3 years following treatment. Three conditions have to be met for the non-target Lepidoptera to be affected by the *B.t.k.* application: the non-target Lepidoptera must be present in the feeding stage during and within 3-6 days after the treatment (the ½ life of *B.t.k.* in the field), the feeding stage must feed on exposed foliage (rather than mining leaves or buds), and the stomach chemistry must be alkaline to dissolve and activate the crystalliferous toxin. All the studies that monitored the field populations of non-target Lepidoptera showed that all but the rare species recovered within 2-4 years of the application.

The timing of the *B.t.k.* applications is critical in impacting on the natural enemies of the target organisms. Some publications have reported no negative impacts on the natural enemies, while others have reported an apparent increase in parasitism.

Laboratory, semi-field and field experiments commissioned by the International Organization of Biological Control (IOBC) have shown that *B.t.k.* applications are "harmless", slightly toxic or short-lived to 18 of 19 beneficial arthropods tested (syrphid flies were mildly affected). It was concluded that the use of *B.t.k.*, in accordance with the label requirements, can be recommended for Integrated Pest Management without any restrictions.

Cost versus benefits of *B.t.k.* applications should always be carefully considered prior to application. *B.t.k.* side effects should be weighed against the benefits. The benefits are usually economic and are relatively easy to measure. The environmental costs, such as impact on rare or endangered species, or the ecological consequences of the introduction of an exotic species (such as gypsy moth) and its impact on native species once it becomes established is more difficult to evaluate, i.e. put a dollar value on.

Implications of a mountain pine beetle epidemic and forest harvesting on caribou forage lichens in west-central British Columbia

Patrick Williston - Gentian Botanical Research

Deb Cichowski - Caribou Ecological Consulting

Terrestrial lichens are an important component of the diet of Tweedsmuir-Entiako caribou herd. The winter range of this herd centres in the Entiako and Tetachuck Lake region of the Nechako Plateau, which has been severely affected by a mountain pine beetle epidemic. This paper presents interim results from a multi-year study documenting the influence of canopy mortality related to mountain pine beetle attack and forest harvesting on the understory plant community, focusing specifically on terrestrial lichens. We examined seven site series belonging to four subzones (SBPSmc, SBSdk, SBSmc2, and ESSFmc) of the provincial Biogeoclimatic Ecosystem Classification system. We photographed more than 700 lichen colonies in permanent sample plots and quantified their surface area using image analysis software. These colonies were remeasured two years later. Trends suggest that in most site types, lichens are declining in beetle-attacked stands (as much as 6% in two years). Lichens are also in decline in many harvested sites, though in a few sites such as the submesic (01c) SBSmc2, lichens are increasing as substrate becomes available due to the death of feathermosses. Terrestrial lichens are slow growing (about 6 mm/yr) and are generally poor competitors. They are most abundant where conditions are too demanding for other species, such as the dry habitats found over glaciofluvial landforms. Competitive interactions among understory plants are strongly influenced by the availability of soil moisture and light. Soil moisture measurements in canopy gaps, under tree canopies, and in cut blocks show that the greatest moisture occurs in canopy gaps. Gaps also have higher light availability. Our results indicate that the canopy gaps created by the beetle epidemic foster conditions favourable to the growth of kinnikinnick and to a lesser extent feathermoss, which replace terrestrial lichens. In harvested stands the understory response varies, certain sites (i.e. the subxeric (03) SBSdk) support a near-monoculture of kinnikinnick, while others (submesic (01c) SBSmc2) show lichen expansion where feathermosses have died back. In general, harvesting resulted in a decrease in lichen abundance over glaciofluvial landforms, and an increase over morainal till landforms. Though still preliminary, our study suggests that the mountain pine beetle epidemic in west-central British Columbia is causing a decline in the abundance of terrestrial lichens, while forest harvesting, under specific conditions, may encourage lichen expansion.

Beetle Outbreaks – How did we get here?

Moderator - Allan Carroll

Participants - **Les Safranyik, Ken Gibson**

The objective of this workshop was to focus on the ongoing mountain pine beetle epidemic in western North America. Formal presentations were limited to Drs. Les Safranyik and Ken Gibson, who were asked to provide an overview of developments in research and management of the beetle in Canada and the United States during the past century. A list of knowledge gaps derived from the presentations by Drs. Safranyik and Gibson was used to structure an open discussion following their presentations (see Table 1).

The discussion was far-ranging, lively and encompassed the majority of attendees. Interestingly, there was very little debate regarding the knowledge gaps as listed (i.e., there was general consensus as to the need for research to address the gaps). Instead, attendees focused mainly on gaps not included on the list. More specifically, the lack of knowledge regarding the ecological, economic and social impacts of such an extensive outbreak. It was concluded that, despite the significant research efforts devoted to the mountain pine beetle, much more research is required to enable the mitigation of the impacts of future outbreaks.

Table 1. Current knowledge gaps restricting effective management of the mountain pine beetle in western North America.

Beetle Biology	Epidemiology	Management
• Regional variation in development thresholds/rates of the brood stages. • Temporal and regional variation in brood productivity in trees of different sizes and ages. • Regional variation in cold-hardiness of the various brood stages. • Stage-specific mortality and mortality factors in endemic and incipient epidemic populations. • Factors of long-range dispersal and role in infestation spread.	• Endemic-epidemic phase transition. • Regional and landscape level variation in rates of population change during outbreaks and effects on tree mortality. • Incidence of attack and mortality of non-host species, such as jack pine, and younger pine age classes during outbreaks. • Effect of climate change on beetle range and damage.	• Accuracy of standard ground and aerial surveys for assessment of red attack, infestation trend, and control efficiency. • Improved semiochemical-based tools for aggregation and anti-aggregation applications. • Decision-support tools and treatment options for hosts other than lodgepole pine. • Tests of the effectiveness of direct control for suppressing incipient infestations. • Improved models for predicting landscape level and regional infestation trend and impact of management operations.

Forest Health Monitoring- No borders in western North America

Moderator – Tim McConnell

Forest health monitoring in BC

Tim Ebata - BC Ministry of Forests, Victoria, BC

Forest health monitoring activities in BC can be grouped into four distinct categories:

- Damage conditions reporting
- Treatment planning
- Impact assessment
- Effectiveness evaluation

Damage conditions reporting is achieved through the annual aerial overview survey and is equivalent to the USDA Forest Service Detection Monitoring Program. This activity is accomplished using the annual aerial overview survey (fixed wing sketch mapping) and limited ground sampling. At this time, we have not adopted the Canadian Forest Service's Forest Insect and Disease Survey "Three Tree Beating" sampling plots into the overview survey process. The annual damage conditions report also includes the results of ad hoc surveys that are conducted to evaluate new damage – e.g., *Dothistroma* damage. It also provides an opportunity to provide updates on ongoing monitoring, operational trial and research project results.

Overview survey records began in 1914 (with very patchy ground based coverage), with reliable data only becoming available in the late 1970's. The data has been valuable for analysis of trends in outbreak frequency and distribution, which has been very useful in describing the effects of climate change.

Treatment planning monitoring in BC is equivalent to the USDA Forest Service Intensive Site Monitoring but with an operational (treatment) objective. Types of monitoring include:

- Defoliator population monitoring – egg mass sampling, bud mining sampling – detailed population monitoring to determine when treatment thresholds are met
- Over-winter mortality surveys – particularly for MPB
- Detailed aerial surveys and ground surveys for bark beetle management – not really monitoring unless used to examine licensee performance

Impact assessments are a form of monitoring with the USDA Forest Service equivalent being partially included in "Evaluation Monitoring". These assessments are usually conducted using permanent sample plots to compare damaged to undamaged growth and yield. For example, impact assessment plots have been established for WSBW / 2 yr budworm, and for other pests (i.e., *Petrova*, Warrens root collar weevil, spruce weevil, other pine pests). Most of these installations are established on a non-systematic, ad hoc basis and are usually established in areas of known damage.

The province's Ministry of Sustainable Resource Management (MSRM) supports and maintains a network of inventory (Vegetation Resource Inventory – VRI) and growth and yield plots and works closely with the Ministry of Forests Research Branch. VRI plots can be used to do longer term change monitoring of forest conditions.

Effectiveness evaluation is a new monitoring regime established to support BC's recently adopted Forest and Range Practices Act and regulations. Forest policy in BC has shifted dramatically from focusing on "command and control" to "results based" legislation. The goal of effectiveness evaluation monitoring is to determine if the current policy is working at achieving desired outcomes (i.e. meeting government's objectives). Current emphasis on this monitoring program is to establish baselines (i.e., pre-policy implementation) to compare to post-implementation. Post-implementation monitoring may not occur for several years, even decades from now. Sampling protocols and measurable indicators to answer specific questions need to be developed for forest health. A pilot project has been initiated this year.

In summary, forest health monitoring in BC has not been formalized as it has in the US. Numerous survey methods have been developed to quantify damage and incidence levels in various publications (e.g., Forest Practices Code forest health guidebooks) but the data collection has not been deployed on a forest health monitoring grid like the USDA Forest Service. BC is currently undergoing a significant forest policy shift to a more results based regime that requires an effectiveness evaluation monitoring protocol to be developed.

Forest health program in Mexico: Pest survey and detection

Carlos Alberto Magallon – Conafor National Forestry Agency)- Mexico –

In Mexico, the total forest cover is about 55 million hectares, 28% of the total landbase. Forests are mainly distributed in four ranges (Eastern Sierra Madre, Western Madre, Southern Sierra Madre and trans-volcanic belt) where land property is dominated by ejido (80%). Despite the importance of forests in Mexico, both because of coverage and usefulness for rural people, the governmental structure to ensure a sustainable use of forest resources was erratic until new federal administration took place in 2001. The new administration created the National Forestry Agency (CONAFOR), promoted new forestry legislation and raised the budget allocated to forestry. The forest health protection program of CONAFOR has reorganized the pest survey and detection program at the federal level.

With no federal budget allocated to forest pest survey and detection prior to 2001, systematic information was seldom gathered. At that time, most of the information came from private consultants reporting on pest problems in managed forests. Survey and detection in unmanaged forests was only done when a certain pest alerted the attention of local authorities. New legislation mandates CONAFOR to set up a permanent program of survey and detection of forest pests. A set of causal agents is in permanent observation include bark beetles, defoliators, dwarf mistletoes, root diseases, cone and seed insects, and shoot and stem borers. Local causal agents are under consideration when performing surveys as well as non-native insects and diseases. From 2001 to 2004, survey and detection was performed on a state by state basis with a ground checking approach. Ground checking surveys were done by either CONAFOR personnel, private consultants or by local universities through specific contracts with CONAFOR. Potentially large-scale problems were surveyed through satellite imagery. LANDSAT troubles and the higher cost of other remote sensing products have sped up our plans to perform a systematic aerial survey program beginning in 2005.

Previous to the aerial survey program be launched professional training was offered to CONAFOR technicians by USDA Forest Service specialists Tim McConnell and Erik Johnson. The training was expanded to two Mexican locations and more technicians in order to be ready to perform aerial survey in 2005.

The aerial survey program in 2005 has to include 12 out of 32 states in order to do calibration efforts with completed ground checking.

In 2006, aerial surveys will support the ground surveys for detecting potential insect and diseases outbreaks. However CONAFOR also has the responsibility of attending to specific requests from ejidos, private owners or state forestry departments to diagnose potential forest pests.

Therefore we have launched 2005 an electronic control system called “e-sanidad” that will provide on-line support to users reporting suspected forest pests. This is a two-way system that enables the user to get either a direct answer for a simple problem or to be qualified for a technical visit to diagnose a potentially more complex problem.

Detection and survey of forest insect pests in Alberta

Sunil K. Ranasinghe - Department of Sustainable Resource Development, Edmonton, AB

Forest management is a provincial responsibility in Alberta where most forested land is publicly owned. Forest pest detection and survey is a responsibility shared between the Crown and forest industry in Alberta. However, aerial surveys of pest infestations are solely carried out by the Crown and cover the forested Crown land.

Aerial detection and general overview survey of pests involve chartered flights with either rotary- or fixed-wing aircraft. The flight paths are pre-determined based on existing infestations, high risk areas as indicated by pheromone traps, predictive models or reports of pest sightings. These surveys are carried out either by trained forest health officers or contractors to map severity and extent of infestations. Defoliator and bark beetle pests are surveyed annually. Recently Tablet PCs in combination with GPS units were introduced in Alberta to increase the accuracy and shorten the processing time of aerial pest survey data. All aerial survey data are submitted to the provincial headquarters to be processed according to the provincial data standards. Digital maps of survey results are posted on the Forest Health Website (www3.gov.ab.ca/srd/forests/health/p_reports.html) making them available to forest industry and other clients.

Special overview aerial surveys are carried out for operational purposes, e.g. to prepare digital maps of spray blocks for spray programs. Usually GPS-equipped rotary-wing aircraft are used for these surveys.

The use of aerial photography or remote sensing to record pest infestations has been attempted in Alberta without much success.

Either pheromone- or lure-baited traps or baited trees are used in ground surveys to detect and survey forest insect pests. Use of pheromones and lures is regulated by the Crown to ensure that follow up action is taken to treat baited trees that become infested. The pheromone-baited traps are used to monitor and predict trends in defoliator populations and pheromone-baited trees are used to monitor bark beetle populations. Lures are used to detect and survey exotic pests and woodborers.

Other ground surveys include walk through, and systematic surveys used to detect and survey the mountain pine beetle, overwintering larval surveys to estimate survival of bark beetles, and ground truthing surveys to confirm the causal agent of defoliation detected from the air. Specific ground surveys are also carried out to predict severity of pest occurrence (e.g., spruce budworm egg mass or second instar larval population surveys), and to estimate pest populations before and after treatment programs.

In addition, other surveys such as the regeneration survey, “free to grow” survey and pre-harvest survey are used to record occurrence of pests. As well, pest occurrence is recorded during surveying of a network of permanent sample plots scattered across the forested Crown land. Depending on the age class and species, these plots may be surveyed either every five or ten years.

Forest health monitoring in the United States

Keith Sprengel – USDA Forest Service, Sandy, OR

The Forest Health Monitoring (FHM) program in the US was initiated in 1990 to provide information on the status, changes, and trends in forest health and sustainability. This program provides information on all forest lands to land-managers and policy makers that affects, directly or indirectly, all citizens of the US.

Forest health monitoring objectives include:

- Establish a monitoring system throughout the forests of the United States to determine detrimental changes or improvements that occur over time.
- Provide baseline and health trend information that is statistically precise and accurate.
- Report annually on status and changes to forest health.

One of the ways we work toward meeting these objectives is through the convening of annual FHM work group meetings designed to provide a productive forum for open discussions regarding our country's most important forest health issues. Unique aspects of these annual meetings are focus groups that address program components and develop resolutions that are carried forward to the Management Team (MT). Focus group resolutions are almost always accepted (as they are usually developed through consensus or sometimes majority by the assembled specialists in the focus group) and acted on by the MT, which results in a dynamic process of improvement.

Major forest health monitoring program components developed with the intent of meeting program objectives include: Detection Monitoring (DM); Evaluation Monitoring (EM); Research on Monitoring Techniques (ROMT); and Intensive Site Monitoring (ISM). These components are inter-related and dynamic. Another major FHM activity not listed is analysis and reporting. There's a strong emphasis in the program to synthesize information from various data sources to produce issue driven reports at multiple scales.

Detection Monitoring consists of a nationwide grid of permanent plots, off plot surveys (aerial surveys, satellite imagery) and special surveys (both ground based and remotely sensed).

Some of the special surveys have resulted in the **detection of exotics** such as Sudden Oak Death (SOD) in Oregon. Risk based surveys are also being developed in cooperation with the Forest Health Technology Enterprise Team (FHTET) for some recent introductions including European spruce beetle (*Ips typographus*), a wood wasp *Sirex spp.* and an 'alder phytophthora'. Currently, to my knowledge, risk-based surveys for SOD are being conducted in 36 States. Both aerial and ground-based surveys are employed.

Internationally, we are working with Mexico to expand a special survey, mapping pinyon pine mortality into the States of Sonora and Baja. Work on risk mapping is also being coordinated with Canada. Overall, we are seeing a trend toward increased coordination and cooperation with our neighbors to the north and south.

Since 1999, FHM ground plots have been integrated with Forest Inventory and Analysis (FIA) plots.

Phase 2 – Tree Measurements (~125,000 plots, each representing ~6,000 ac.)

Phase 3 – Health Indicators (~8,000 plots, each representing ~96,000 ac.)

Each plot is measured once every 5 to 10 years.

This plot design gets at the objective of providing baseline information that is statistically accurate and precise at the scales for which it is intended. Currently there are 44 States in the annualized program (76% of all forest cover). The Presidents' budget as submitted to Congress for 2006 shows an increase for FIA to allow for full implementation of the annualized plots in all 50 States (albeit, a scaled down version for Alaska).

Evaluation Monitoring is based on "problems" identified through detection monitoring, either plot based or off-plot, monies are granted, competitively, to determine the extent, severity, and likely causes of undesirable changes in forest health.

The third component of FHM is ***Research on Monitoring Techniques***. An excellent example of ROMT is in the area of Urban Forest Health Monitoring (UFHM). Work done has clearly demonstrated the feasibility and utility of UFHM and is moving to the next stage of national implementation with the assistance of Urban and Community Forestry. FIA will be implementing Stage 1 sampling in 2005 in CO and TN with funding derived from State and private sources. Funding has also been sent to the Southern Research Station to set up a task force to move this from research to an operational mode.

Another good example of ROMT in an earlier stage of development includes riparian monitoring. A pilot study completed in Oregon is examining sampling designs. A cooperative project in WY with the Remote Sensing Applications Center in WY is using image-based assessments of "riparian areas". Part of this project also involves working with National Forest System Washington Office Watershed staff to define "riparian". This is a problem that needs to be solved so we know what the population is that we're supposing to sample. The WY project will also investigate the effectiveness of the existing P2 grid at sampling riparian areas.

Intensive Site Monitoring (ISM) studies are set up to provide in depth monitoring of indicators to determine detailed information on key components and processes of selected ecosystems. The ISM sites are co-located with detailed process level research studies.

The studies attempt to enhance our understanding of cause-effect relationships. Ideally, these are set up in a variety of 'representative ecosystems'.

Conclusions:

- Continue to stress key strengths of FHM - Relevant, partnership-based, comprehensive, innovative, and proactive.
- Be real time - timely detection, analysis and reporting of adverse changes in forest health to facilitate effective management response.
- Look beyond the grid - look back: analyze trends and integrate diverse data sources; look forward: forecast future conditions, analyze risks; design new approaches for invasives.

FHM website – http://fhm.fs.fed.us

Gypsy Moth Status and Eradication

Moderator - Dave Bridgewater

History of gypsy moth in Idaho

Ladd Livingston - Entomologist, Idaho Department of Lands

Since the gypsy moth has such potential for causing damage, we monitor for introductions of this exotic insect every year. We have been conducting surveys since 1974. We have chosen to be more aggressive in our annual survey program (trapping at 4 traps / square mile) than called for in the national plan (one trap / four square miles) as we feel that by doing so we will be more likely to discover introductions before they become established populations. To date, we feel that this approach has been fruitful for us.

Our first NAGM was caught in 1986. We were suspicious that this moth represented more than we were aware of and with implementation of a standard grid trapping program, in 1987 we caught many more moths in Sandpoint and in Coeur d'Alene. This lead to egg mass surveys and eventually to ground and aerial eradication projects in these two towns. For all eradication projects, we have used formulations of *B.t.k*. as the pesticide of choice.

Over the years we have found many single moths and several times multiple moths in our survey traps, but without finding established populations. However, in 1997 we once again found multiple moths in a single trap, this time in Post Falls. Further surveys found fresh egg masses, pupal cases and shed larval skins. Investigation found that egg masses had been introduced in ornamental bird houses that came from New York. The following year, 1998, we conducted another successful eradication project. In all cases, our public meetings have stimulated very little interest, with the main concern being, “Please make sure you get the moths that might be at our place.”

This year, 2005, we are conducting an eradication treatment for Asian gypsy moth in response to finding one AGM in a regular NAGM trap in Northern Idaho. We will also conduct intensive monitoring of the area for the next two or three years, trapping a five-mile radius around the catch site at 25 traps / square mile.

How did an AGM arrive in North Idaho? Our best guess is that it came on one of the thousands of shipping containers that pass by the capture site each day being transported on the local railroad, which comes directly from the ports of Washington and Oregon. DNA analysis by APHIS did establish that the moth came from Asia.

History of gypsy moth in Washington State

Brad White - Pest Program Manager, Washington Department of Agriculture

The average trap catches of male gypsy moths from 1974 to present has been 168 per year. In the last 10 years, this catch rate has been reduced to an average of 67 per year.

While many of these catches have been single moths in a single trap, there have been instances where multiple catches have been recorded in either a single trap or in a cluster of traps. From our experience, when we catch a single moth in a trap, about 22 percent of the time that site will repeat catches the following year. If the traps catch two to three at a site, the site repeats about 25 percent of the time. When four to five are caught, the repeat rate climbs to 55 percent, and if six or more are caught the repeat rate is about 79 percent.

In our detection trapping, we normally use 1 trap per square mile. If we have caught a single male at a location the year before, we increase the trap density to 24 traps per square mile. If we have caught multiple moths the year before, we increase the trap density to 64 traps per square mile.

In 2004, Washington caught a total of 68 moths at 24 sites. Multiple trap catches were at Shaw Island in San Juan County (9), Evergreen Ridge in Kitsap County (1 in 2003 and 20 in 2004), and two sites in King County, Roanoke (Seattle) (3 scattered singles in 2003 and 5 in 2004, with 3 in one trap) and Madrone Park (Seattle) (6 with 3 in one trap). One Asian gypsy moth was caught in Idaho 1.5 miles from the Washington State line.

Eradication sites in 2004: Port Ludlow (12 acres) where 14 moths were caught in 2003 and none caught in 2004; Bellevue (11 acres) where 17 were caught in 2004 and none trapped in 2004, and Mayfield (7.5 acres) where 8 were trapped in 2003 and one was caught in 2004.

Eradication sites proposed for treatment in 2005 are: Roanoke in Seattle (12 acres), Evergreen Ridge in Kitsap County (120 acres). The positive site at Madrone Park in Seattle will be intensively trapped and have additional ground inspection. The positive Shaw Island site is pending. The owner may elect to treat their site. The portion of the two-mile intensive trapping area around the Asian catch site in Idaho that falls within Washington will be trapped at 25 traps per square mile.

Gypsy moth In British Columbia

Peter Hall - Entomologist, BC Ministry of Forests (Chair, Gypsy Moth Committee)

British Columbia employs a Gypsy Moth Committee to review trap catches and make recommendations for action the following year. The committee is made up of representatives for BC Ministry of Forests, Canadian Forest Service, Canadian Food Inspection Agency, and WLAP.

In 2003, 55 moths were caught on the lower mainland, with 43 of them in one location. There were also 15 egg masses found in the high trap catch area. On Vancouver Island, 45 were caught with 33 in one location and 2 egg masses in the high catch area.

Traps with single moth catches will be monitored by CFIA utilizing the standard trap density for first year finds (16 traps per square mile for a one mile radius around positive trap site). This is recommended course of action for the following 2003 positive sites: Abbotsford, Chilliwack, Burnaby, North Vancouver, Richmond, Vancouver, Campbell River, Nanaimo, Oak Bay (Victoria), Sooke, and View Royal.

More aggressive treatments are recommended for Gabriola Island, Langley, Duncan, Delta and Gordon Head (Victoria). Gabriola Island: mass trap the area at a density of 9 traps per acre in a strip extending ¼ mile on each side of the road and ¼ mile beyond the last of the 2 traps and an additional ½ mile radius trapping at 36 traps per square mile. Langley and Duncan should have traps set at a density of 9 traps per acre for ¼ mile radius around positive trap finds. An additional zone of ½ mile beyond that should be trapped at 36 traps per square mile. Large numbers of moths and viable egg masses found in the core area indicates the failure of the mass trapping program in Delta. The recommendation is to aerially spray with *B.t.k.* (Foray 48B) 3 times at a rate of 50 BIU per ha. At Gordon Head, aerial application of *B.t.k.* (Foray 48B) 3 times at a rate of 50 BIU per ha. The area of treatment would be approximately 250 ha.

2004 spray treatments were completed in Saanich (Vancouver Island) and North Delta. The Saanich treatment area was approximately 390 ha in the vicinity of Mount Douglas Park. The North Delta treatment was 20 ha. Zero moths were captured in North Delta indicating successful eradication. The area will be monitored in 2005 at 16 traps per square mile over the treatment area and buffer. Several moths were captured in proximity to the Saanich treatment area. We believe that the 2004 spray boundaries were too conservative and missed the southern end. In 2005 it is proposed that we mass trap with 9 traps per acre centered on cluster of positive traps and delineation trapping at 36 traps per square mile around single moth catches.

Mass trapping treatments were carried out in Abbotsford, Duncan and Gabriola Island. No moths were found in the Abbotsford mass trapping site indicating no populations were present. Increased detection trapping in the area in 2005 was recommended (16 traps per square mile). Moths were trapped in the Duncan and Gabriola sites. The recommendation for 2005 at both sites is mass trapping with 9 traps per acre centered on clumps of positive catches and positive finds in the buffer area.

Elsewhere in the province, 30 moths were caught. In effect, there is insufficient information at any site to make a recommendation for other than increased detection surveys or mass-trapping. Should further information become available, such as the discovery of viable egg masses, the above recommendations will be revisited.

Gypsy moth in Oregon

Kathleen J. R. Johnson - Supervisor, Insect Pest Protection and Management, Oregon Department of Agriculture

A NPDES permit is required for pollutants from a point source entering waters of the US, because of a 9th Circuit Court ruling in Nov. 2002 on the US Forest Service's Environmental Impact Statement for a Douglas fir tussock moth project. The court ruled that a spray nozzle on an aircraft is considered a point source and pesticides being applied are pollutants and require a permit. USDA interprets this ruling on a project similar operationally to the one proposed to mean that a NPDES permit is required; in the west, USDA is bound by this court's ruling. The lack of a NPDES permit would also make the project vulnerable to lawsuits seeking an injunction. It should be noted that EPA and Oregon DEQ do not require an NPDES permit for these situations. DEQ issues NPDES permits in Oregon (by agreement with EPA).

Since the late 1970's there have been eradication projects in Oregon almost every year. Sixteen have been aerial applications, and some have been ground applications or a combination of both. Some of the differences between the two methods of treatment are: In aerial applications we use undiluted *B.t.k.* at a low volume with small droplet size, and we employ three applications. Usually this method is chosen when dealing with larger acreages or limited or no access. This often uses less *B.t.k.* per acre. In ground applications, *B.t.k.* is diluted with water and a spreader-sticker is added. This uses a high volume with large droplet size, and two applications. This method is used when dealing with small acreages and good access. This often uses more *B.t.k.* per acre.

The prevention of gypsy moth introductions remains one of our most important activities. Traditionally, outdoor household articles have been the source of introductions into Oregon. However, there are new concerns about untreated spruce and other nursery stock from infested areas following the introduction on spruce nursery stock from Canada. Logs and firewood also remain of concern for widespread introductions. There is a new commitment by the Eastern Region of the USDA, APHIS-PPQ to review current processes with regulatory officials from uninfested areas. However, there is little support for an international review of processes.

Our more recent eradication projects are ones in Eugene, Gresham, and Clackamas. In Eugene, a household moved from Connecticut to Eugene 2001. We trapped 1 male in area in 2002. In 2003, 17 GMs trapped. The source was a utility trailer and live female GMs laying eggs was found 2003. A 183 acre eradication area was treated in 2004. No moths were trapped in 2004.

In Gresham, three gypsy moths were trapped in and near a high tech manufacturing company's parking lot in 2001. In 2002, two gypsy moths were trapped there. By 2003, only one gypsy moth was trapped in the parking lot. In 2004, the company treated the trees and shrubs in the parking lot with *B.t.k.* (Foray 48B), and later in 2004 no gypsy moths were trapped in area.

In Eagle Creek, Clackamas County, 1 moth was caught in 2002. In 2003, 6 were caught in 4 traps. In 2004, in a delimiting grid of 5 square miles around each positive site with 25 to 49 traps per square mile resulted in 3 males in two traps. Both of the sites were repeats from 2003. Subsequent egg mass searching resulted in finding gypsy moth egg masses and pupal cases on spruce nursery stock from Canada. We propose for 2005 to make three applications by helicopter of *B.t.k.* (Foray 48B) on 268 acres. The first application will be in late April, then 7 - 14 days apart.

New Management Directions – Wood vs. View

Moderator - Michael R. Wagner, Regents' Professor, School of Forestry, Northern Arizona University

Presenters:

1) Patience Rakochy - University of Northern British Columbia / Private Consultant
2) John Pousette - University of Northern British Columbia / BC Ministry of Forests
3) Rick Dawson – BC Ministry of Sustainable Resource Management, Williams Lake
4) Rich Hofstetter - Northern Arizona University, School of Forestry
5) Michael R. Wagner - Northern Arizona University, School of Forestry

The goal of the workshop was to examine how forest insect outbreaks impact a full range of forest values from conventional wood fiber to recreation and forest environmental services such as biodiversity. The panel offered two broad contrasts; timber vs. non-timber values and geographic variation between British Columbia and Arizona.

Current attention in British Columbia is focused on the massive mountain pine beetle outbreak. This outbreak has the potential for substantial disruption in the longer term wood supply, while short term impacts include a substantial increase in available timber through salvage harvests. The landscape scale of the outbreak also raises issues for wildlife management. Habitat requirements of many wildlife species are dependent on a range of forest overstory conditions that can be met with appropriate timber harvest scheduling and modifications of salvage operations to avoid complete removal of dead trees that provide habitat for some important species.

A recent pine bark beetle outbreak in Arizona has impacted a large part of the commercial forests in Arizona. This outbreak is occurring at a scale not seen in the Southwest for at least a century. The impact of this outbreak on timber values is a strong contrast to the situation in British Columbia. Because of the deteriorated state of the forest products industry in Arizona, the capacity for utilization is very low. In contrast, tourism and recreation are major industries in Arizona. Forest insect impacts on recreation use were shown to be substantial and capable of reducing tourism to even the international tourist destination- the Grand Canyon National Park. Recognizing the broad role that forest insect outbreaks can play on traditional and non-traditional forest products is important to consider in forest pest management decisions.

Preventing the Next "Big" Outbreak

Moderator - Ken Gibson, US Forest Service

Iral Ragenovich – USDA Forest Service, Portland Oregon

Introduced forest species have caused significant impact to the ecosystems of North American forests. Examples include: Chestnut blight, European gypsy moth, white pine blister rust, and hemlock woolly adelgid. More recently, Asian long-horned borer, sudden oak death, and emerald ash borer have become established and agencies have been working hard to eradicate them or limit their spread. Others that we do not want are: Asian gypsy moth and European wood wasp.

Unlike native insects, there are things that we can do to prevent establishment and “outbreaks”: 1) Prevention, 2) Early Detection, and 3) Rapid Response.

Prevention includes: Regulatory/Quarantines, Inspections/Interceptions, Inspections at foreign ports. A second part of prevention is to identify potential pests and their pathways (risk assessments) and where these organisms have the potential to cause the most impact should they become introduced and established (risk maps). USDA Forest Service and APHIS have at least 6 risk assessments. A risk assessment for solid wood packing material (SWPM) is also in draft. SWPM is the primary source of introduction for scolytids and wood borers.

Detection includes: Some level of detection trapping has been in place, but only for specific insects, such as gypsy moth. Efforts have been made, through the Early Detection/Rapid Response (EDRR) program, and the APHIS CAPS (Cooperative Agricultural Pest Survey) surveys to include general trapping for potential exotic bark beetle and wood borer introductions. To date, with most of the new finds, such as *Scolytus schevyrewi and Orthotomicus erosus*, indications are that these insects have been here for several years and likely came in on SWPM. We did not find them before, because we were not looking for them. As we expand the EDRR/CAPS programs we will have more opportunities to intercept these new introductions. Fairly new introductions that have been detected in CAPS traps are *Xylosandrus crassiusculus* in The Dalles, OR and *Sirex noctilio* in New York. Even with an expanded program, we cannot detect everything and we need to take advantage of the public’s eyes, as well.

Rapid Response includes: additional survey/delimit trapping, eradication, and internal quarantines and regulations.

Successful eradication projects include European gypsy moth in the West, both in the US and Canada; Asian gypsy moth, Asian longhorned beetle in Chicago, and citrus longhorned beetle in Washington.

Prevention, detection and rapid response are actions that can result in preventing establishment of an introduced pest. However, there is still much to be done, before these actions can be effective. We still need to:

1) Tighten-up regulatory activities. There are still too many things getting through, both externally and internally.
2) Get more stringent SWPM regulations in place. Also get SWPM Risk Assessment published and require more stringent SWPM standards.
3) Expand and fully implement the EDRR and CAPS programs and continue to identify more efficient and effective detection tools such as better lures and traps.

Title VI of the Healthy Forests Restoration Act of 2003 – The Early Warning System for Forest Health Threats in the United States - includes the Forest Service response to both exotic and native forest threats. The EDRR and much of our regular detection and surveillance program are all wrapped up into the Early Warning System.

Terry Shore – Canadian Forestry Service, Victoria, BC

Outlined the population dynamics of the mountain pine beetle (MPB) and pointed out the key elements as they relate to the possibilities for control. At 97.5% mortality levels, MPB populations can remain static, so even a small increase in survivorship can quickly move the population into an exponential increase. The proportion of infested trees required to maintain a static population or to effect a reduction in an infestation is directly related to the rate of increase, and can quickly outstrip the resources available to treat trees.

With over 7 million ha (18 million acres) of MPB-infested forest currently in British Columbia, there are a decreasing number of locations where direct control is a possibility. One area where we will be attempting to stop the next big infestation is the Peace District near the British Columbia/Alberta border. Here we hope that the partial protection of the Rocky Mountains to the west and less favourable climate to the east will provide an opportunity for direct control.

Ladd Livingston - Entomologist, Idaho Department of Lands

Two examples of outbreak prevention work used on a regular basis in Idaho (Idaho Department of Lands) were presented. The first was with introduced populations of gypsy moth; the second, operational procedures for reducing mortality caused by Douglas-fir bark beetle.

Since the gypsy moth has such potential for causing damage, we monitor for introductions of this exotic insect every year. We have been conducting surveys since 1974 and have detected and eradicated three established populations. Also, this year, 2005, we are conducting an eradication treatment for Asian gypsy moth in response to finding one AGM in a regular NAGM trap in Northern Idaho. We have chosen to be more aggressive in our annual survey program (trapping at 4 traps / square mile) than called for in the national plan (one trap / four square miles). We believe by doing so we will be more likely to discover introductions before they become established populations. To date, we feel that this approach has been fruitful for us.

The Douglas-fir beetle (DFB) is one our most destructive bark beetles. While the mountain pine beetle in lodgepole pine may kill more trees from one year to the next, the value of Douglas-fir (DF) is normally far greater than of lodgepole pine. Accordingly, we are very aggressive in our approach to managing for and against DFB. Since outbreaks are usually precipitated by catastrophic events that produce a large amount of susceptible host, e.g. windthrow. We are very aggressive in salvaging fresh windthrow. Other management tools that we use on an on-going basis to manage DFB include:

1) Stand hazard rating for prioritizing management activities based on large tree size, old age, high stand density and high percent DF in the stand.

2) Aggressive salvage of infested trees through direct and salvage sales, even using gypo loggers that monitor areas of state ownership for infested trees. Our aim is to have DFB removed from the forest along with the logs.

3) Commercially thin overly dense stands of DF. Thinned stands are typically less susceptible to attack. This technique is not used in areas with substantial levels of root disease as harvesting activities in these sites can exacerbate the root disease problem.

4) Time harvest activities to provide trap trees. By cutting during the flight period, beetles are trapped and then killed when the logs are processed. Timing is everything.

5) Bait trees to contain populations, with the infested trees later being removed by harvest operations.

6) Use of MCH to protect threatened stands.

We feel that the implementation of these practices helps us keep losses to the DFB to a minimum. MANAGEMENT DOES MAKE A DIFFERENCE.

Detection/Aerial Survey – Methods and Standards

Moderator – Tim Ebata

Theme - What's New in Aerial Survey Methods?

The workshop was well attended by local contractors and government agency staff involved in aerial surveying. The purpose of the workshop was to provide an update on the most current aerial survey techniques, and in BC's case, to determine if digitally assisted sketch mapping could be applied in the province.

Tim Ebata BC Ministry of Forests, Victoria, BC

Tim began the workshop by describing the methods used to conduct aerial surveys in BC. There are two types of aerial surveys: the traditional aerial overview sketch mapping survey common to most forested jurisdictions; and detailed operational surveys for directing treatment operations. The new methods used in BC have been the introduction of paper maps that have been customized with current Landsat imagery and various other map information that surveyors find useful for navigating. Standards changes include the introduction of two new severity classes Trace (<1%) and Very Severe (>50%) to better quantify very light and very heavy infestations, respectively. An open discussion was held on the pros and cons of digitally assisted mapping technologies. Experience with such systems, primarily by the USFS, shows that they work quite well but rely on good technical support, training and reliable hardware. Another new detection method applied operationally in 2004 was the use of conventional colour aerial photographs (1:30,000) to produce "measle maps" depicting the precise location and number of bark beetle killed trees. This information was used to direct treatments in areas where suppression of the population was recommended.

Keith Sprengel - USDA Forest Service R-6

Keith described the cooperative aerial overview survey conducted by the USFS/ Washington State Dept. of Natural Resources and Oregon State Dept. of Forestry. This region has had a systematic aerial survey since 1949 covering 49 million acres of forest land. As in BC, the survey uses a standard grid pattern or contour/ridge flying. Two observers are on board, each looking out over 2 miles flying at 120 mph. Observations are recorded using the digitally assisted sketchmapping system. Special surveys, such as Swiss needle cast and Sudden Oak Death are conducted as needed, and usually the surveys are designed to capture single agent events. Automated flight following is used to enhance safety and also minimize "cockpit noise and confusion". The survey is supported by regional and national standards for data collection, training, GIS, metadata and safety. Different from BC is that each recorded polygon or point of activity can receive up to 3 separate activity or agent (pest) codes. Each activity code for a polygon receives a modifier indicating the numbers of trees affected or the relative severity of the effect. Up to 82 separate disturbance /host type combinations have been mapped over the last 30 years. The digital mapping system uses scanned 300 dpi 100K USGS maps and the Brovey merged Landsat 7 imagery. The system navigates with Geolink software using accurate GPS data which allows accurate mapping of disturbance polygons, but still relies on the observer's ability to interpret signatures and their relative position while flying at over 100 mph. Future base maps using higher resolution images will be possible when hardware improves. Draft maps are made available in pdf format on the web within a day or two of completing each 30' x 60 ' quad area. Although positional accuracy of the mapped disturbances has greatly improved, errors continue to be found in identifying the causal agent – a problem inherent to sketch mapping. Maintaining accuracy and consistency is a challenge that can be dealt with by training, maintaining permanent staffing, mentoring, improved technology and more ground checks. Along with the traditional damage reporting and salvage planning uses, numerous non-forest health uses for the data have been ranging from wildlife habitat type identification and fuel loading estimates to input variables for an avian productivity model.

Erik Johnson - USDA Forest Service R-1

Erik described a project he has been working on in Brazil that uses aerial sketch mapping of the rain forest to assess the accuracy of vegetation classifications from satellite imagery. Erik described the process and the “confusion matrix” that was used to quantify the accuracy.

Are Insect Outbreaks Increasing?

Moderator: Vince Nealis

Vince Nealis - Canadian Forestry Service, Pacific Forestry Centre

Vince introduced the session by citing recent examples in which scientific institutions made public claims that outbreaks of several species of forest insects were all increasing in response to climate change. There was concern that such blanket statements, unsupported by critical scientific evidence, could misinform public policy at several levels. Speakers were asked to address the statement and provide their own opinion and evidence for their position.

René Alfaro - Canadian Forestry Service, Pacific Forestry Centre

René took a comparative approach to the analysis of evidence, focusing on common indicators: extent, frequency, intensity, and duration of the outbreaks. He stressed the importance of scale and asked that we examine critically the causes as well as the patterns of outbreak behaviour. Evidence in favour of the hypothesis that outbreaks are increasing was strongest for bark beetles although in mountain pine beetle, the pattern of increase appeared to be scale-dependent. The evidence for increases in outbreaks of defoliators was more ambiguous.

Jesse Logan – USDA Forest Service, Rocky Mountain Research Station

Jesse felt there had definitely been an increase in all aspects of the outbreaks of several western bark beetles. Moreover, these increases were strongly associated with observed changes (*i.e.* warming) of climate in the recent past. He provided clear examples where trees formerly outside the historic climatic range of bark beetles, or at least of recorded bark beetle outbreaks, were now being attacked and killed by bark beetles.

Barry Cooke - Canadian Forest Service, Laurentian Forestry Centre

Barry said the notion of increasing outbreaks predates climate change concerns and is an important hypothesis to test. More critical examination of the patterns for spruce budworm, however, revealed that trends might be somewhat different in different regions or climatic zones. A simulated random population series illustrated the dangers of concluding the existence of a pattern from a short time series and stressed the inadequacy of the current historical record. Ultimately, understanding population processes would be required to gain the necessary evidence.

Sandy Liebhold – USDA Forest Service, Northeastern Research Station

Sandy argued that, contrary to scientific opinion, outbreaks of the gypsy moth were actually increasing and not decreasing. The recent impacts of a disease would not interrupt a 10-yr periodicity of gypsy moth outbreaks. In the case of gypsy moth, the relatively recent introduction of this insect (140 yrs) and its continuing invasion of new habitats make definitive conclusions on trend difficult.

Richard Fleming - Canadian Forest Service, Great Lakes Forestry Centre

Richard related an experience in which one of his scientific papers on climate change and insect outbreaks had been cited to add apparent scientific credibility to an otherwise sensationalist extrapolation of results. The appropriate scientific rebuttal to this misuse of information, however, posed a dilemma. On the one hand, it was irritating to have the context of one's carefully qualified speculations misrepresented but, on the other hand, popularizing the fact that forests and their insect disturbances will change under climate change scenarios was not, in itself, a negative thing.

Questions from the audience indicated that no one disagreed with the reality of climate change or that this change would influence insect disturbance patterns. Everyone also recognized that few generalizations, other than the current paucity of data, were available and that species-specific dynamics had to be considered. Parallel changes in forest land-use patterns, application of various intensive forestry practices make it difficult to separate climate-induced vs. anthropogenic causes of observed change.

Environmental impact studies: how do we analyze the effects of our actions, and how do we present them to the public?

Moderator - Connie Mehmel

Mitigating the effects of forest defoliator suppression on the mardon skipper butterfly (*Polites mardon*)

Beth Willhite - USDA Forest Service, Forest Health Protection, Sandy, OR

A field study conducted near Glenwood, Washington, during late June 2000, assessed the potential of two methods to prevent or mitigate deposition of aerially-applied *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*) on Idaho fescue growing in a forest meadow environment. Native bunchgrasses, including Idaho fescue, are the larval host plants of the meadow-inhabiting mardon skipper butterfly, which is currently listed by Washington State as Endangered, and as a federal Candidate species. This study examined the ability of a physical barrier (aluminized plastic film) to prevent *B.t.k.* spray deposition on host plants, and also tested the effectiveness of using sprinkler-applied water to wash spray deposition from the foliage of host plants. Both treatments were applied within spray blocks during operational aerial application of *B.t.k.*, and for at least two hours following the completion of spraying. A wash solution, taken from fescue grass blade samples collected in control and treatment plots before and after spraying, was prepared and cultured for presence and relative abundance of *B.t.k.* Other collected data included maximum/minimum temperatures for ground cover treatments, measurements and photo records of vegetation response to ground cover treatments immediately following cover removal and 24 hours later.

Ground cover treatments resulted in post-treatment levels of *B.t.k.* that, while averaging slightly higher than most pre-treatment levels, were extremely low. Temperature extremes were moderated by the ground covers compared to adjacent uncovered plots. Most of the forbs in the covered plots were of medium to short height and showed no deleterious effect from the treatment. The majority of the tall grass seed heads present on the plots recovered their height within 24 hours after cover removal. One very tall flowering yarrow plant in a covered plot that had been bent over parallel to the ground during treatment did not recover its original height by 24 hours following treatment.

The high-pressure sprinkler method used in this study was less successful than the cover method in mitigating *B.t.k.* deposition. Although a large difference (magnitude of 6) in the amount of *B.t.* cultured was observed between the sprinkled and unsprinkled samples, considerably more *B.t.* remained on the foliage following the sprinkler treatment than remained following the ground cover treatment, probably due to backsplash of contaminated soil. A sprinkler system using misting emitters to apply water less forcefully might more successfully mitigate spray deposition. Testing such a system is the next logical step toward further evaluating this method.

Public perception of bark beetle spray projects in Arizona: A contrast in demographics

Joel McMillin - USDA Forest Service, Forest Health Protection, Flagstaff, AZ

The southwestern United States experienced a landscape-level bark beetle outbreak in ponderosa pine forests between 2002 and 2004. The combination of extended drought (reduced precipitation and increased temperatures) and unprecedented high tree density across the landscape led to extraordinary tree losses throughout the Region. As a result of this outbreak, numerous USDA Forest Service maintained recreation sites have experienced severe impacts caused primarily by *Ips* species (*I. lecontei*, *I. pini*, *I. calligraphus*) and to a lesser degree western pine beetle (*Dendroctonus brevicomis*). Therefore, vegetation management plans, including preventive spray programs, were proposed for campgrounds and picnic areas to protect high-value ponderosa pine in 2003 and

2004. The results of proposed and actual spray projects were discussed in relation to the demographics of each project area.

All proposed spray projects spraying five to 10 candidate ponderosa pine trees per individual use site with 2% carbaryl (Sevin SL). Guidelines included treating the entire bole and large branches of candidate trees, the use of a lift to treat trees greater than 60 feet in height, 200-foot no spray buffers around any moving or standing water, post-treatment application of Neutrasol to picnic benches and structures, and completion of spray applications by mid April to precede *Ips* flight periods. This timeframe posed several problems related to weather (Arizona springs are windy, have freezing overnight temperatures and periodic snow/rain storms), funding (in some cases prevention/suppression funds were not in place by the desired spray time window), and completion of NEPA prior to spraying.

In 2003, the Prescott and the Apache-Sitgreaves National Forests (NF) proposed spray projects for the spring 2003. The proposed projects were similar in the number of trees to be sprayed (<5,000), but differed demographically. The Prescott area has a much larger population base and a large Multiple Chemical Sensitivity community, while the project area on the Apache-Sitgreaves is relatively sparsely populated. Because bark beetle-caused impacts did not become apparent until November 2002, both Forests were not able to initiate the NEPA process (i.e., public and agency scoping) until late 2002/early 2003. Based on the number of issues raised during scoping on the Prescott NF, it was determined that an EIS was needed and this proved to be time-prohibitive. Therefore, this project was dropped for consideration in 2003. In contrast, public scoping on the Apache-Sitgreaves NF did not result in any significant issues and a 1-year Categorical Exclusion (CE) was signed after consultation with the US Fish & Wildlife Service. A similar NEPA decision occurred in 2004; however, a multi-year CE was signed. Results of this project have been very successful with protection rates of sprayed trees ranging from 99.5 to 99.9 percent despite high levels of mortality surrounding the spray trees.

Public perceptions of bark beetle control activities on public lands in Colorado

Tom Eager - USDA Forest Service, Forest Health Management, Gunnison, CO

As custodians of public lands, it is incumbent upon land management agencies to determine what the desires of the general public are. However, this is much more easily said than done. There are a number of potential sources of information regarding public attitudes, each having associated good and bad points.

For this session, two case studies were presented. The first example is that of the “County Line Project”. This is a vegetation management activity proposed on the southern Rio Grande National Forest. The proposed action is to be conducted in typical spruce / fir stands at an elevation of 10,000 feet. These stands are designated timber management units and have experienced endemic spruce beetle activity since 1998. In 2002 there was a huge increase in spruce beetle-caused mortality, with several thousand mature spruce being killed over a 1,500-acre area. Stands to the immediate north were much less impacted, possibly due to stocking reduction cuts that took place in the 1970's. The proposed action entails sanitation / salvage removal of infested trees in the highly affected area and a sanitation / trap tree / thinning operation in the northern units. Work in the general area would allow the de-commissioning of 2 miles of road, as well as reforestation efforts in the form of planting.

Opposition by special interest groups to any management activity in this locale was almost immediate and information was placed on the Internet that was misleading and false. The special interest groups labeled the operation a "clearcut" when in reality only dead trees were to be removed in salvage units and thinned stands were targeted for 100 ft^2 BA / acre of residual living trees. The misinformation campaign was followed up by an Internet driven comment submission program. Visitors to the special interest group website were instructed to "Simply Click Here" to send a "form letter" style comment to the Draft Environmental Impact Statement. Over 400 identical comments were submitted from "interested parties", from every corner of the nation.

Does public response to NEPA proposals constitute a realistic depiction of the "general public's" desires regarding management of public lands? First-hand experience with local residents at public meetings and in field meetings would indicate otherwise. In these interactions, support for the US Forest Service to "do something" is almost unanimous.

The second "case study" presented a way to gauge public perceptions by directly asking questions of the public in a typical "public opinion survey". However, there are two major pitfalls to this approach. The first is that it is difficult to craft incisive questions that get to the heart of a matter. At some point a certain degree of understanding of forest ecological processes and management must be assumed. In reality there is a very wide range of individuals' grasp of these concepts. Some individuals have only a rudimentary understanding of management and ecological issues. This gap in knowledge can be a formidable challenge when questioning what must be assumed to be a fairly uniform population.

The second major issue when directly questioning the public is that the "Paperwork Reduction Act" of 1995 severely limits the ability of Federal employees to "gather information" from the public. The standard rule is that if identical questions are asked of 10 or more individuals from the general public, special permission must be obtained from the Office of Management and Budget. The process of obtaining permission to survey the public requires that a formalized process be undertaken and this procedure takes between 6 and 8 months. It is evident that any such survey work needs to be planned well in advance, and that "quick" surveys are no longer a possibility.

If we as public servants are to best serve our "clients", it is important that we have a good understanding of the needs and desires of society. However, it is often difficult to ascertain what these needs actually are.

Verbenone/MCH/Mass-trapping/Non-host

Moderator - Leo Rankin

Some new inhibitory semiochemicals (and one "old" inhibitory semiochemical) for the southern pine beetle, *Dendroctonus frontalis*

Brian T. Sullivan[1], William P. Shepherd[1], Deepa Pureswaran[2], Mark J. Dalusky[3] and C. Wayne Berisford[3]

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The semiochemistry of southern pine beetle, *Dendroctonus frontalis* Zimmermann (Coleoptera: Curculionidae: Scolytinae) was studied intensively from the late 1960s through the 1970s, and five compounds with a range of behavioral activities were identified as pheromones for this species. However, evidence suggests that the pheromone system of this insect has not been adequately characterized. We applied research tools not available to the original researchers, including coupled gas chromatography-electro-antennographic detection (GC-EAD) and chiral/capillary gas chromatography-mass spectrometry (GC-MS), to a reexamination of the pheromone system of *D. frontalis*. GC-EAD analyses of extracts of adult beetles revealed ten compounds not previously identified as pheromones for this species that elicited antennal responses in conspecifics. Eight of these were identified by GC-MS and were subsequently found to alter *D. frontalis* responses to traps baited with an attractant. Acetophenone, fenchyl alcohol, myrtenal, 2-phenylethanol, and *cis*- and *trans*-myrtanol reduced attraction of one or both sexes while cis-verbenol enhanced attraction of females. Several of these newly-discovered attractant antagonists may have potential for use in tree protection and/or spot disruption since they reduced the numbers of beetles responding to attractant by more than eighty percent. The low release rates required and the relatively low price per kilogram for some of the inhibitors suggest that they could potentially be a cost-effective substitute for semiochemical inhibitors currently registered for *D. frontalis*.

In addition, we have been using these same research tools to reexamine the role of the male-produced semiochemical *endo*-brevicomin in the biology of *D. frontalis*. The original semiochemical studies of *D. frontalis* conducted in the late 1960s and 1970s characterized *endo*-brevicomin as a mixed-function pheromone – an attractant at low concentrations but an aggregation inhibitor at high doses.

In the mid-1980s, it was discovered that the pure (-)-enantiomer was inhibitory while the (+)-enantiomer was attractive to *D. frontalis*, leading to the hypothesis that the "mixed-function" activity attributed to *endo*-brevicomin was the result of mixing the enantiomers. Recently, we used chiral capillary GC-EAD analyses to examine enantiomeric discrimination of *endo*-brevicomin by *D. frontalis*, and found that the (+)-enantiomer elicited antennal responses at concentrations five orders of magnitude lower than the (-)-enantiomer. Chiral GC-MS analyses of aerations/extracts of individual males both in the lab and in the field indicated that they produce only the (+)-enantiomer. Using headspace rather than the more traditional gut extraction techniques, we also discovered that paired male *D. frontalis* produce large quantities of *endo*-brevicomin, contrary to earlier reports suggesting they produce only minute quantities. We suggest that (+)-*endo*-brevicomin is a male-produced aggregation pheromone component that complements female-produced frontalin. However, in direct conflict with this hypothesis, at least two previous studies indicate that bolts with paired *D. frontalis* are no more attractive than bolts with solitary females. Our aeration data suggest that this may occur because females decrease their production of frontalin when joined by *endo*-brevicomin producing males, and hence there may be a net parity in attractant levels. Field experiments with gram quantities of the purified enantiomers are planned for this coming field season.

Systemic insecticide injections for single tree protection against southern pine bark beetles

Don Grosman and William Upton - Texas Forest Service, Lufkin, TX

The efficacy of systemic insecticides dinotefuran, emamectin benzoate, fipronil, and imidacloprid were evaluated in 2004 for preventing attacks and brood production of *Ips* engraver beetles (Coleoptera: Scolytidae) and wood borers (Coleoptera: Cerambycidae) on standing, stressed trees and bolt sections of loblolly pine (*Pinus taeda*) in east Texas. Emamectin benzoate was found to be highly effective in preventing engraver beetles and associated wood borers from successfully colonizing both stressed trees and pine bolt sections. Fipronil was nearly as effective as emamectin benzoate at three and five months after injection and moderately effective in reducing insect colonization of bolts one month after injection. Fipronil also was highly effective in preventing bark beetle-caused mortality of stressed trees. Imidacloprid and dinotefuran were ineffective in preventing bark beetle and wood borer colonization of bolts or standing, stressed trees. Plans to further test emamectin benzoate and fipronil in 2005 for single tree protection against several *Dendroctonus* spp. were described.

Verbenone flakes: Aerial and ground applications for bark beetle control

Nancy Gillette[1], Donald R. Owen[2], John D. Stein[3], Nadir Erbilgin[4], David L. Wood[4], Jeffrey N. Webster[5] and Connie Mehmel[6]

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Verbenone is an anti-aggregation pheromone for many beetle species, including most *Dendroctonus* spp., which are the most devastating bark beetle pests in most western forests. Use of verbenone to protect forest stands, however, has been limited by a lack of effective release systems to disperse the pheromone in forest stands. To date, the most widely available formulations have been bubble caps, pouches, and beads. The first two release systems require laborious hand application using a long-handled hammer, and thus have limited utility for area-wide control. The last formulation, the bead, consists of 5 mm plastic beads with verbenone adsorbed onto the outside of the beads. This formulation has shown inconsistent efficacy when applied for control of other *Dendroctonus* spp., perhaps because the release rate from the beads was not optimal.

We tested a new formulation of verbenone, the Verbenone "Disrupt" Flake[2[1]] (Hercon Environmental, Emigsville, PA), for protection of both individual trees (ground applications) and forest stands (aerial applications) from bark beetle attack. This flake consists of a 3 X 3 mm plastic laminate "sandwich," where the outer layers are impermeable and the inner layer contains the active ingredient, verbenone. The pheromone thus is released only at the perimeter of the flake, possibly resulting in more favorable release characteristics (longer duration and more consistent release over time). A similar flake formulation has been used successfully for many years in mating disruption in the Gypsy Moth "Slow-the-Spread" program, but this is the first such formulation of a bark beetle pheromone. The verbenone flake was tested as an aerial application for control of *Dendroctonus brevicomis*, the western pine beetle, in a ponderosa pine stand in the Big Valley Mountains, Lassen County, California and for individual tree protection against the mountain pine beetle, *Dendroctonus ponderosae,* attacking lodgepole pine at Whaleback Ridge, in Siskiyou County, CA.

Aerial Application: Aerial application was made using fixed-wing aircraft fitted with a hopper and metered dispensing system to disperse the flakes evenly over five 50-acre plots, with five 50-acre untreated plots serving as controls. The verbenone was applied at the rate of 150 grams of active ingredient/acre, or one kilogram of flakes/acre. In order to challenge the anti-aggregation effect of the flakes, we baited 4 trees per plot and placed eight Intercept traps/plot, also baited with western pine beetle aggregation pheromone lures. Efficacy of the flake was assessed using several variables, including numbers of beetles trapped/plot, number of *D. brevicomis* attacks/tree/plot, and tree mortality. We also took the opportunity to assess efficacy for protection of trees from attack by *Dendroctonus valens*, a secondary pest that has also been shown to use verbenone as a behavioral chemical.

[2[1]] Mention of a commercial product does not constitute endorsement of its use by USDA

Individual tree application: Ground applications were made at the rate of 15 g/AI/tree, with a suspension of the flakes in water with sticker, using a trailer-mounted hydroseeder. The formulation was applied in a single band on only one side of the tree to a height of seven meters. All trees were baited with *D. ponderosae* aggregation pheromone immediately after treatment. Forty trees were selected for the study, and twenty were chosen at random for treatment with the remainder serving as controls. The basal area, DBH, and live crown ratios of control trees and treated trees were not significantly different. Efficacy of the individual tree protection strategy was measured by number of *D. ponderosae* attacks/tree, number of *D. valens* attacks/tree, numbers of pitch tubes producing dry frass, and tree mortality one year following treatment.

Results - Aerial application: Aerial application of verbenone flakes resulted in significant reduction in numbers of *D. brevicomis* trapped on treated plots for up to sixteen weeks following application. Baited trees on treated plots showed significantly lower rates of fading at twelve weeks following application, with 75% of control trees fading compared to only 20% of trees in treated stands.

Results - Ground (individual tree) applications: Treated trees showed significantly fewer attacks by both *D. ponderosae* and *D. valens*. At eight weeks following treatment, the numbers of *D. ponderosae* pitch tubes with dry frass was significantly lower in treated trees than in control trees, indicating that survival of treated trees is likely to be significantly higher than that of control trees. The site remained inaccessible as a result of deep snow pack, but final tree mortality assessments will be made in mid to late summer. Two parallel studies testing this strategy for protection of ponderosa pines from attack by *D. brevicomis*, however, failed to provide protection, despite the success of the aerial application strategy targeting *D. brevicomis*.

Conclusions: Verbenone flakes show promise for aerial applications targeting *D. brevicomis* (western pine beetle), *D. valens* (red turpentine beetle), and possibly *D. ponderosae* (mountain pine beetle). Verbenone flakes are also promising for individual tree protection from *D. valens* and *D. ponderosae*, but not *D. brevicomis.*

Methyl jasmonate elicits defenses in Norway spruce (*Picea abies*) and interferes with host colonization by the bark beetle *Ips typographus*

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The terpenoid resin and phenolic constituents of conifers have been implicated in protecting trees from infestation by bark beetles and phytopathogenic fungi, but it has been difficult to prove these defensive roles under natural conditions. We used methyl jasmonate, a well-known inducer of plant defense responses, to manipulate the biochemistry and anatomy of mature *Picea abies* (Norway spruce) trees and test their resistance to attack by *Ips typographus* (the spruce bark beetle). Bark sections of *P. abies* treated with methyl jasmonate had significantly less *I. typographus* colonization than bark sections in the controls and exhibited shorter parental galleries and fewer eggs deposited. The numbers of beetles that emerged and mean dry weight per beetle were also significantly lower in methyl jasmonate-treated bark. In addition, fewer beetles were attracted to conspecifics tunneling in methyl jasmonate-treated bark. Stem sections of *P. abies* treated with methyl jasmonate had an increased number of traumatic resin ducts and a higher concentration of terpenes than untreated sections, whereas the concentration of soluble phenolics did not differ between treatments. The increased amount of terpenoid resin present in methyl jasmonate-treated bark could be directly responsible for the observed decrease in *I. typographus* colonization and reproduction.

The use of population reduction trapping for pine engraver beetle, *Ips pini* (Say)

John Ball[1], Ray Sowers[2] and Coe Foss[3]

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[3] Assistant State Forester, South Dakota Division of Resource Conservation and Forestry

Pine engraver beetle populations in the Black Hills of South Dakota have risen dramatically in the past few years. An isolated 14 ha stand of mature ponderosa pines became infested resulting in a lost of 298 trees. These trees were harvested during the winter of 2002-2003 but most were placed in ten slash piles scattered throughout the stand. During 2003, three Lindgren funnel traps baited with a commercially available attractant containing lanierone and ipsdienol were placed aside of each slash pile. A total of 30 traps were set. The traps captured 72,136 pine engraver beetles during 2003. Only nine trees became infested during that season and were removed that winter. Funnel traps were employed in identical locations during 2004 and captured only 1315 pine engraver beetles. These results suggest that trapping at slash piles may be an effective means of reducing mortality within the stand.

Urban Forest Pest Issues

Moderator - Jerry Carlson

Managing forest health in environments of multiple influential stakeholders, disparate landowner interests with multiple agency mandates and authorities.

Jerry Carlson - Forest Health and Protection, New York State

Jerry presented information on the development of forest health management programs in New York State. The major discussions during this presentation focused on the differences and similarities between forest health management in the heavily developed New York environment and the less heavily developed west. The discussion centered on the varying concepts of what forest health means to the multiple and varied stakeholders in the urban environment. The central issues of managing forest health in the urban environment were resource inventories, health status, tree values, unique urban barriers to reforestation, exotic invasive species, varying agency authorities and public awareness. The port of New York City and New Jersey is one of the largest in the world and it delivers exotic, imported goods to over 80 million people within a 24-hour truck drive. The arrival and establishment of invasive, exotic species has recently forced many changes to the process and development of urban forestry programs in the east. This presentation and discussion then worked its way through the examples of Asian longhorn beetle, hemlock woolly adelgid and emerald ash borer as projects that have strained and forced the redesign of urban forestry programs in NY. Jerry gave examples of the risk and hazard modelling, mobile mapping and GIS technologies developing to deliver urban forest health management in New York.

When mountain pine beetle comes to town

Nicole Jeans-Williams - ForHealth Consulting Blind Bay, BC

Nicole's presentation and the lively discussion centered on the impact of mountain pine beetle infestations in forests adjacent to urban centres. Specifically, the group discussed the impacts on Mission Creek Park in Kelowna BC. The talk showed how the city and its urban forest management have been impacted by this pest-wildland forest association. Nicole talked about the sources of infestation being undetected attacks, logyard imports, firewood, and infestations in adjacent protected areas. The discussion then moved to the interaction between pest management objectives and urban forest management objectives and the sources of conflict and resolution. Nicole then discussed the various treatment options available for MPB and their compatibility or lack thereof with urban forestry. One of the largest problems was the management of debris following treatments. The emphasis of the urban forest programs in the example cities of Kelowna and Prince George have evolved from a reactive, emergency phase to a more long term proactive and preventative phase and the concurrent management risk from wildland fires moving into the urban area. Nicole concluded with a discussion of the education and outreach needs for urban forest health and risk abatement emphasized by the future risks of emerald ash borer, sudden oak death and bronze birch borer. Nicole expressed appreciation for the contributions of

Ron Sharp & Ken Johannson, City of Kamloops

Ian Wilson, City of Kelowna

Brenda Slade, City of Prince George

TDB Consultants Inc.Stacey Harding, Central Okanagan Regional District

Urban and resort communities – new pest management tools required

Jennifer Burleigh, Joe Meating - BioForest Technologies

Jennifer's talk opened with a discussion of the unique challenges faced by forestry professionals in moving from a forest protection strategy to one of single tree. Discussions centered on the lower damage tolerances, safety concerns, higher tree values and multiple and varied external influences on management objectives. Jennifer talked about her work with Blair Helson, CFS, on developing improved formulations of NEEM (azadirachtin) and its efficacy on the following:

- Spruce budworm
- Gypsy moth
- Forest tent caterpillar-
- Pine false webworm
- Cedar and birch leafminers. and
- Its repellency on MPB

The discussion centered on the ability to protect foliage on white spruce threatened by spruce budworm and the importance of maintaining groves of these trees in urban forests. Jennifer then presented information on the development of systemic injection tools and their efficacy in delivering protective doses to high value urban trees. Jen specifically talked of the development and efficacy of the ECOJECT SYSTEM and the criteria influencing its design;

- Minimize the risk of exposure to users
- Reduce or eliminate risk of environmental contamination
- Rapid set up time for injection (< 15 sec)
- Light weight and easily transportable
- Variable volume canisters (8 to 30 ml per unit)
- Effective in hardwoods and conifers

- Moderate, constant pressure for rapid injection times
- Reduced damage to trees

Jennifer presented information on the new imidicloprid formulation developed by Blair Helson and the discussion included uptake throughout the tree, toxic residues in tree tissues and the efficacy on EAB larval and adult controls. Jennifer acknowledged the following as contributors to her presentation:

- Industrial Research Assistance Program (I.R.A.P.)
- Blair Helson, Dean Thompson, Allan Carroll – CFS
- Taylor Scarr – Ontario Ministry of Natural Resources
- Rory McIntosh – Saskatchewan Environment
- Nelson Carter – New Brunswick

Emerging Technologies in Forest Entomology

Moderator - Dezene Huber

From pulaski to PCR – tools of the trade in forest pathology

Kathy J. Lewis (and graduate students) - University of Northern British Columbia, Prince George, BC

The study of forest pathogens, their ecology, and their relationships with forest management, involves a wide range of scientific methods, some of which have been adopted and modified from other disciplines. These methods vary in training, technical, and equipment requirements. Our lab uses methods that require little more than a Pulaski and Petri dishes, and some that are more technically demanding. For example, we have adopted methods in molecular analysis to examine patterns of establishment and spread of a root rot pathogen, *Inonotus tomentosus*, and have determined that basidiospores are an important means of spread of this pathogen. We have also adopted methods of tree ring analysis to quantify the role of small-scale disturbances in stand dynamics of sub-boreal forests and to link the agent of disturbance with the impact on stand structure over time.

A case study of the needle pathogen, *Dothistroma septosporum*, was presented to demonstrate how multiple approaches could be combined to study complex problems. This fungus is currently causing widespread mortality in young and mature pine in northwestern BC at a rate and scale that is unprecedented in recorded history. The epidemic may be the result of changes in host availability, changes in weather that are more conducive to reproduction and spread by the pathogen, and/or modification of the pathogen itself into a more virulent strain. We are using PCR-based molecular analyses to examine the population structure of this pathogen in several ecosystems and management regimes. We are using tree ring analysis to determine the outbreak history of *D. septosporum* in managed and unmanaged areas, and in conjunction with tree ring-based climate reconstructions, to determine the role of climate change in epidemiology of this fungus.

Bark beetle functional genomics

Christopher I. Keeling - Michael Smith Laboratories, University of British Columbia, Vancouver, BC

Functional genomics allows researchers to examine the gene expression and biological function of many genes at once. At the University of Nevada, Reno, the research groups of Drs. Claus Tittiger and Gary J. Blomquist use functional genomics to study pheromone biosynthesis and juvenile hormone regulation in bark beetles such as the pine engraver beetle (*Ips pini*). In this species, the male is the pioneering sex and attracts conspecifics to the host tree with an aggregation pheromone. Upon feeding and regulation by juvenile hormone III (JH), the pheromone component, ipsdienol, is biosynthesized *de novo* via the mevalonate pathway in the male midgut. Identifying and characterizing genes in the midgut that respond to feeding or JH-treatment may provide information on the regulation of pheromone biosynthesis and may also yield new targets for novel pest management strategies as well as new information on the mode of JH action during host colonization and reproduction. An expressed sequence tag (EST) project recovered 574 tentatively unique genes from JH-treated *I. pini* male midguts. cDNA microarrays and quantitative real-time PCR were used to examine gene expression in midgut tissue of fed, JH-treated, and control beetles of both sexes. Several genes were significantly regulated by JH-treatment or feeding, including known mevalonate pathway genes, other known genes, and unknown genes. Transcript levels in the midgut of both sexes respond to JH and feeding, although there were sex differences in both basal transcript levels and sensitivity to JH that were consistent with sex-specific pheromone biosynthesis.

Human exposure and health surveillance during aerial applications of B.t.k. for gypsy moth control

David B. Levin - Department of Biology, University of Victoria, BC

There is considerable evidence that *Bacillus thuringiensis* (B.t.) is neither toxic, nor pathogenic to mammals. None-the-less, application of B.t. spray in populated urban centers often generates considerable public concern about the impact of exposures to B.t. on human health. Aerial applications of Foray® 48B, which contains B.t. subspecies *kurstaki*, strain HD1 (B.t.k. HD1), were applied to control the European gypsy moth (*Lymantria dispar*) in Victoria, British Columbia, Canada, in 1999. An assessment of the health impact of Foray® 48B was also conducted during this period. Environmental and human samples, collected before and after aerial applications of Foray® 48B, were analyzed for the presence of B.t.k. HD1-like bacteria. Molecular methods were used to determine the identity of over 11,000 isolates from environmental and human samples. Several health indicators, including an assessment of the impact of the spray on asthmatic children, were measured. Results of the studies suggested that B.t.k. HD1-like bacteria were present both in the environment and in the human population of Victoria prior to aerial applications of Foray® 48B and that the spray had no detectable adverse effect on the human population.

Future Role of Silviculture in IPM

Moderator - Peter de Groot, Canadian Forest Service, Sault Ste. Marie, ON

About 50 people attended the workshop (seated, standing along the walls and outside the door) to hear three presentations on silvicultural management of the eastern and western spruce budworms and mountain pine beetle, and how tree resistance was used in integrated pest management. The following are abstracts of their presentations.

Silvicultural spruce budworm management in intensively managed forests

David A. MacLean - Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, NB

Eastern spruce budworm is a dominant insect pest in Canada, having caused an estimated two-thirds of the 710,000,000 ha of moderate-severe defoliation or beetle-killed trees in Canada from 1975-2000. I will review and discuss silvicultural strategies and tactics to reduce spruce budworm damage, related to: 1) reducing occurrence of the most damaged trees within stands, 2) reducing occurrence of the most damaged stands within landscapes, 3) creating stand characteristics that enable trees to better withstand and recover from defoliation, 4) creating stand or landscape characteristics that alter budworm population dynamics, and 5) integrating silviculture with targeted insecticide protection to keep trees alive. I will describe the effectiveness of aggressive budworm-amelioration strategies used by J.D. Irving, Ltd. on the privately owned Black Brook District in northern New Brunswick, by comparing stand and forest composition after fifty years of intensive forest management aimed, in part, at reducing budworm damage.

Potential of tree resistance in integrated pest management

Dan Quiring - Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, NB

Tree improvement programs that strive to select more commercially valuable trees exist throughout Canada and in many other countries, yet tree resistance to insects has only been incorporated into a small minority of such programs. The principal reason for the lack of integration of tree resistance into most tree improvement programs may be the paucity of studies demonstrating the heritability of resistance of conifers to common pests. I will discuss the costs and benefits associated with selecting trees resistant to insect pests using recent studies carried out in New Brunswick on jack and white pines resistant to the white pine weevil; white spruce resistant to four different insect pests; and on black spruce resistant to yellow-headed spruce sawfly.

Using silviculture strategies to lessen impacts of western spruce budworm and mountain pine beetle in our future forests

Lorraine Maclauchlan – BC Ministry of Forests, Kamloops, BC

The mountain pine beetle and western spruce budworm are two of the most important insect pests in British Columbia. The mountain pine beetle currently infests over 7 million hectares of lodgepole pine forests and is infesting and threatening many of our young stands as well. The western spruce budworm at its peak in 1987 covered almost 850,000 ha of interior Douglas-fir forests in southern BC and is again on the increase, with over 500,000 ha affected. Silviculture, from the pre-harvest planning of harvesting method and regeneration, through stand tending treatments and direct control measures, is imperative to lessen the future impacts from these insects. Planning future silviculture strategies, including mixed species planting, higher density stocking, pushing historical elevational and latitudinal ranges of species, spacing, pruning and thinning, and changing expectations of rotation age and products is all part of the new recipe. I will describe some ideas on how to manage and manipulate stands and landscapes to make them more resilient to these insects. In particular I will detail results from a study of budworm in different ecosystems and stand structure regimes and how harvesting practices can aggravate or lessen impacts. I will look ahead at the next mountain pine beetle outbreak and discuss silviculture options to lessen hazard and risk.

Decision Support Systems – Development

Moderator - Terry Shore, Canadian Forest Service, Victoria, BC

The workshop was attended by approximately 25 people. Terry Shore gave a short introduction to the subject in which he described which decisions forest insect decision support systems are developed to address. He gave a brief overview of a typical flowchart showing the integration of data about the host and the insect into various models. Next he introduced three speakers to discuss the development and implementation of decision support systems for several forest insect pests.

Developing a decision-support system for management of landscapes with mountain pine beetle

Andrew Fall - Gowlland Technologies Ltd. Victoria, BC

Mountain pine beetle (MPB, *Dendroctonus ponderosae* Hopk.) outbreaks present a number of challenges for decision-makers, including (i) complexity of interactions between the forest, MPB and management, (ii) uncertainty in system knowledge and inherent stochasticity (e.g. beetle locations and densities, weather patterns, and potential management policy), and (iii) multiple, conflicting values. Nonetheless, decisions must be made regarding appropriate resource allocation, such as level of management effort to apply (e.g. allowable annual cut and single-tree budgets), and where to focus harvest and fell and burn treatments. We have collaboratively developed a decision-support system (MPB DSS) to help inform decision processes regarding MPB. Our goal is to create a strategic tool to explore likely trajectories and spatial impacts of a MPB outbreak under a range of management options. The conceptual basis is a simulation model that integrates MPB population dynamics, forest growth and management. The MPB component scales stand dynamics to the landscape by effectively running the stand-level MPBSim model in each 1-ha cell, and captures local and long-distance dispersal between cells as a function of MPB pressure, hosts, distance, wind, and pheromone diffusion. The harvesting component is a strategic spatial forest estate model based on recent timber supply reviews, enabled with beetle management options that influence how harvest is targeted based on detectable red and green attack, salvageable volume, and risk / susceptibility estimates. The single-tree treatment component directs fell and burn allocations. The integrated model was implemented in the Spatially Explicit Landscape Event Simulator (SELES) spatial modelling tool. Verification tests included (i) matching timber supply review results, (ii) calibrating MPBSim to each study area based on local weather and stand conditions, and (iii) comparing landscape scale MPB trajectories against known patterns from earlier in the present outbreak.

We have applied the MPB DSS in Lakes timber supply area (TSA), Morice TSA, Kamloops forest district, a portion of Williams Lake forest district, and Foothills Model Forest, Alberta, with ongoing work in Dawson Creek and Banff National Park. These cover a gradient of conditions from very high susceptibility and MPB attack in Lakes to low in Foothills. Outcomes in terms of spatial and temporal patterns of volume and area affected have broadly indicated a low potential for management to influence the MPB progression in Lakes, a modest potential in Morice and a high potential in Foothills. In each application, we communicated results to forest health experts (provincial, regional, district), government and industry foresters, some interested public and ENGOs. We provided information for further analysis of (i) economic values to Min. of Forests, Economics and Trade Branch, (ii) forest operations to the Forest Practices Board, (iii) ecological values to Oikos Consulting, and (iv) provincial scale implications to Min. of Forests, Research Branch. The degree to which DSS information influenced decisions that assimilated many inputs is hard to quantify. One indicator of the utility of the MPB DSS is the interest and support for further application and extension. In a complex domain, a decision-support tool must continue to evolve as system understanding increases and as management questions diversify.

Integrating insects into forest management planning: the spruce budworm decision support system

David A. MacLean - Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, NB

From 1975 to 2000 in Canada, forest insects caused 709 million ha of moderate-to-severe defoliation plus areas of beetle-killed trees. To put this in perspective, of the 234 million ha of commercial timber in Canada, about 0.4% are harvested annually and 0.5% are depleted by fire and insects annually. This presentation reviewed efforts in eastern Canada to include spruce budworm (*Choristoneura fumiferana* Clem.) defoliation effects on trees and stands into forest management planning, through development of the Spruce Budworm Decision Support System (SBWDSS). This GIS-based system uses a defoliation-based stand growth model and a timber supply model to predict the timber supply benefits of protection or forest restructuring at the scheduled time of harvest. The SBWDSS has been implemented for all forests in New Brunswick and for test areas in Alberta, Saskatchewan, Ontario, and Quebec. Scenarios for the 5.0 million ha of budworm-susceptible forest in New Brunswick indicated that potential losses were 82 million and 203 million m^3 of timber for ‘normal’ and ‘severe’ outbreak scenarios. Several applications of the SBWDSS were described, including prediction of changes in forest composition and wildlife habitat, natural disturbance simulation, and designing insecticide programs to protect timber and sequester carbon.

The development of decision support systems for forest tent caterpillar and spruce budworm in Saskatchewan, Canada.

Jennifer Burleigh - BioForest Technologies Inc., Prince Albert, SK

BioForest Technologies is collaborating with various agencies in the development of two new decision support systems. To help forest managers protect one of Canada's most important deciduous tree species, trembling aspen, from damaging agents such as forest tent caterpillar, a project was initiated to develop an Aspen Management Decision Support System. The project focuses on the essential ingredients of a prototype decision support system similar to the spruce budworm decision support system's protection planning system. The project is based on a 90,000 ha study area in Saskatchewan's Bronson Forest region. Using relationships described in the literature, preliminary analysis models the effects repeated outbreaks of forest tent caterpillar could have on trembling aspen radial growth.

The second decision support system under development is for jack pine budworm. Jack pine budworm is the most important pest affecting the jack pine resources in Ontario and several other provinces. In November 2004, a project was initiated by the Canadian Forest Service to complete the development of a Jack Pine Budworm Decision Support System. Relationships between jack pine budworm cumulative defoliation and growth loss were examined. STELLA® modeling software was used to build a cumulative defoliation model and a hypothetical back feeding function was tested. While relationships between cumulative defoliation and growth loss were strong (R^2: 0.64 - 0.84) further data will be analyzed due to low sample sizes.

Decision Support Systems – Applications

Moderator - Marvin Eng, BC Ministry of Forests

Development of a decision-support system for maintaining the gypsy moth-free status of British Columbia

Vince Nealis - Canadian Forest Service, Victoria, BC

The gypsy moth, *Lymantria dispar* L., is an invasive insect now established in northeastern North America. Periodic introductions have occurred in British Columbia since 1978 but have been successfully eradicated. These eradication programs, however, often involve the use of pesticides in urban areas and so come with considerable public cost and concern. A series of particularly contentious programs in 1979, 1992, and 1998 have increased constraints on how eradication programs are conducted. The result is that to maintain the gypsy moth-free status of British Columbia, resource managers must provide very credible evidence of the location of new introductions, the risk of the population persisting and, if pesticides are recommended, when and where they should be used. In the case of pesticide use, decisions are required that, at once, minimize the area treated and at the same time maximize the likelihood of achieving eradication in one campaign. Targeting is critical.

Many decisions regarding risk and targeting are aided by simulating the seasonal development (phenology) of gypsy moth in any climatic zone, in any year, in British Columbia. These simulations are accomplished by integrating information-rich, temperature-dependent physiological processes of the gypsy moth and site-specific normal and ambient temperatures via BioSIM, a modeling interface developed by J. Régnière of the Canadian Forest Service. The model has been used at the landscape level to map areas within the province most climatically favorable to the gypsy moth and increase the efficiency of the detection trap network. At this same scale, the model is also used to judge the risk of newly detected introductions to establish and increase, and therefore to guide decisions regarding options. At a more local scale, the model has become part of the operational program. It is used to predict the time of egg hatch and larval development and hence facilitate the logistics and timing of the application of pesticides. The success of this application of the model has led to its use in evaluating past eradication programs before the model was employed. This historical analysis suggests that, with the improved targeting capability offered by the model, the number of pesticide applications per season could be reduced without reducing the likelihood of success.

Use of southern pine beetle survey data for forest management decision support: SPB map/text reporter

Robert Coulson, Jaehyung Yu, Hyunsook Kim, Maria Tchakerian, and Forrest Oliveria

Knowledge Engineering Laboratory, Department of Entomology, Texas A&M University and USDA Forest Service, Forest Health Protection

Survey and monitoring activities are generally undertaken to identify where and to what extent insects and diseases are impacting resources and conditions of the forest environment. Often, the usefulness of a survey is directly related to how quickly the data collected can be organized, interpreted, and viewed. In this presentation we describe the development of a software system designed to facilitate real-time operational use of text and map information derived from SPB surveys. The goal of this project is to facilitate real-time operational use of southern pine beetle survey information for suppression, prevention, and evaluation purposes. The specific objectives of the project are (i) to develop a computer application (the SPB Map/Text Reporter – SPB-M/TR) that organizes and summarizes southern pine beetle survey information for operational use by forest managers and (ii) to develop an ArcIMS® application to deliver real time summarized maps and text reports of SPB survey information on the INTERNET.

As a preface to the project, we interviewed Forest Service personel on the Davy Crockett National Forest, who were experienced from previous outbreaks of SPB, and they provided a definition of the types of reports and maps needed by forest managers for operational IPM. Given this background, the principal development has been to extract and integrate needed tabular data (from SPBIS) and spatial data (from ArcGIS) and build the reports and maps. ArcSDE (Spatial Database Engine) is being used as the development tool with Arc Objects and C programming language. Once the maps and reports are built, the next task will be to deliver them to the INTERNET using ArcIMS application server. ArcXML, Java scripts, and HTML programming languages will be used to customize the INTERNET interface. Access to SPB-M/TR users on the National Forests will be controlled by passwords.

Provincial-level projection of the current mountain pine beetle outbreak in British Columbia: supporting decisions or just washing windows.

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A Provincial-Level Mountain Pine Beetle Model for British Columbia was developed as part of a two-year project to assess the impacts of mountain pine beetles (MPB), forest management, and interactions between these factors across the province. Detailed methodology and results can be found at http://www.for.gov.bc.ca/hre/bcmpb.

The results of the project have been used in a variety of applications. Notable examples include:

- communication of the possible implications of the outbreak in a variety of governmental and non-governmental venues.
- “planning” efforts, in a broad context:
- “Forest stewardship in the context of large-scale salvage operations”(http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr019.pdf),
- 2005 – 2010 Provincial MPB Action Plan (http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/actionplan/2005/actionplan.pdf);
- the development of a Treasury Board submission on reforestation;
- an assessment of MPB impacts on BC parks

- the expedited allowable annual cut determination for the Lakes, Quesnel and Prince George Timber Supply Areas (2004/10/01); (http://www.for.gov.bc.ca/hts/aactsa.htm) and,
- the development of the Emergency Bark Beetle Management Area Strategic Planning Map (http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/maps/ebbma/EMU_ltr_Feb_05.pdf).

Based on the experience of providing support for these applications we conclude that:

- One of the most important requirements for successful support of decision-making processes is the involvement of the right participants at the right place and time.
- Communication of the explicit consequences of assumptions is among the most valuable outcomes of modeling.
- Natural resource management decisions are rarely, if ever, based on solely science but they can benefit from being informed by science.

We note with caution that, "scientific apparatus offer a window to knowledge, but as they grow more elaborate, scientists spend ever more time washing the windows." (Isaac Asimov).

Regional Trends

Moderator - Don Grosman, Texas Forest Service, Forest Pest Management, Lufkin, TX

British Columbia

Tim Ebata – BC Ministry of Forests, Victoria, BC

By far the most common disturbance agent was the mountain pine beetle. The beetle epidemic is the largest in recorded history and is found primarily in the central interior of the province where there are vast areas of mature lodgepole pine. Beetle infestations are now expanding its northern range and have been found in alarming numbers east of the Rocky Mountains in the Peace Forest District. If climate continues to improve for the beetle, this infestation has the potential to spread eastward into the jack pine forests that are found throughout Canada's boreal forest. Overall expansion of the beetle infestation changed from just over 4 million hectares in 2003 to 7.1 million hectares in 2004. The outbreak is projected to peak in 2008 resulting in up to 80% of the susceptible volume being killed. In the heavily attacked areas in Quesnel and Vanderhoof forest districts, young pine stands – particularly those with large investments in spacing and pruning – have suffered significant mortality due to mountain pine beetle and pine engraver (*Ips pini*). In some cases, damage was exacerbated by drought conditions.

Other bark beetle damage increased or decreased depending on the species. Spruce beetle populations have dropped considerably in most of the province to 124,723 ha. Hotspots of activity are in the East Quesnel and Horsefly areas. Douglas-fir beetle numbers have risen by 10,000 ha from 2003 to 33,705 ha in 2004. This change is probably the result of increased drought stress, which weakens the trees. Western balsam bark beetle continues to be one of the largest contributors of chronic levels of mortality in sub-alpine fir stands. 1.7 million ha of very light mortality was mapped in 2004, which represents an increase of 300,000 ha since 2003.

Insect defoliators were active throughout the province. On the decline from last year were the eastern spruce budworm (*Choristoneura fumiferana*) (29,648 ha) and the western hemlock looper (*Lambdina fiscellaria lugubrosa*) (5,750 ha). Neither species were caused significant damage. The spruce budworm decline was similar to the decline reported in Alberta. Western spruce budworm (*Choristoneura occidentalis*) defoliation increased in the interior Douglas-fir zone in south central BC to cover an area of 627,000 ha.

Drought conditions in the summers of 2003 and 2004 resulted in 11,000 ha of dead trees in the Southern Interior and Coastal Forest Regions. This is a significant increase in damage over past years. Another climate related pest was *Dothistroma* (redband) needle blight that was found defoliating and killing immature lodgepole pine throughout the northwest portion of the province. Disease incidence is favored by warmer spring temperatures that could be the result of climate change. The Northern Interior Forest Region has initiated more detailed helicopter and ground surveys to further delineate the most severely damaged areas and prepare them for rehabilitation. Other damaging agents of note were redbelt (9,926 ha), fires (223,772 ha) and the aspen and poplar shoot blight, *Venturia* sp. (51,227 ha).

A more detailed report can be obtained from the BC Ministry of Forests Aerial Overview Survey web site at:
http://www.for.gov.bc.ca/hfp/FORSITE/overview/overview.htm

Alberta

Hideji Ono – Alberta Sustainable Resource Development, Public Lands and Forests Division, Edmonton, AB

In 2004, most of the forest pests that are routinely monitored in the province declined.

The populations of the spruce budworm, which is the main defoliator of spruce forests in Alberta, collapsed in northwestern Alberta in 2004. This collapse was widespread and may have been caused by the actions of a combination of biotic and abiotic agents. The total defoliated gross area declined from 158,258 hectares in 2003 to 30,721 hectares in 2004. This is an 80% decline. The severity of defoliation declined similarly.

Similarly, the large aspen tortrix populations collapsed across the province. However, the forest tent caterpillar populations increased, especially in the northwest. The aspen defoliation was scattered over a gross area of 632,810 hectares, compared to 5,414,276 hectares in 2003. This is an 88% decline in affected area.

The mountain pine beetle infestations continued but were kept at bay by the aggressive management action spearheaded by the Department of Sustainable Resource Development (SRD). The number of green-attack trees outside the National Parks declined from 1,316 in 2003 to 408 in 2004. However, this pest continues to pose a serious threat to the lodgepole pine resource in Alberta. In 2004, beetle attack was detected near Crowsnest Pass in southwestern Alberta, the first such detection during the current outbreak. Mountain pine beetle infestations in Alberta are expected to increase in 2004, since increased mountain pine beetle activities are being reported from adjoining jurisdictions of British Columbia and Montana in areas close to the borders with Alberta. The SRD is working in close cooperation with their counterparts in these jurisdictions to minimize the risk of beetle infestations in Alberta.

Alberta Invasive Species Council formulated an Invasive Plant Strategy in 2004. The provincial invasive plant management is composed of education and awareness, and surveys and control programs. Several hundred sites were surveyed. Biological, chemical and mechanical means were used to control these pests.

The Forest Health Section produced posters, brochures, and a mountain pine beetle management guide to increase awareness. The forest health web site was updated to include maps, newsletters, reports, survey data and a web-based forest pest damage diagnostic system. A forest health teacher’s guide was produced as well. The regional forest health officers provided training and technology to help the industry and other personnel in forest health-related subjects. A field study on impact of woodborer damage was completed and another on Armillaria root disease was formulated in 2004.

More information is available at http://www3.gov.ab.ca/srd/forests/health/index.html

Regions 1 & 2: Montana, Colorado, Wyoming

Ken Gibson – USDA Forest Service, Forest Health Protection, Missoula MT

Bark beetles remained the most damaging group of insects in the Northern Region in 2005, and among those, the most extensive and destructive, by far, was mountain pine beetle. Mountain pine beetle populations have been increasing dramatically for the past 7 or 8 years, increasing to more than 700,000 acres in 2004. Most were in lodgepole pine stands in west-central Montana and northern Idaho; however, significant amounts of whitebark pine have also been infested within the past several years. Ponderosa pine stands in central and eastern Montana have also been affected. Population increases are being enhanced by warmer- and drier-than-normal conditions.

Douglas-fir beetle populations have returned to nearly endemic conditions in northern Idaho, but are still at outbreak status in many stands in western and southwestern Montana. Many stands affected by wildfires in 2000 and 2003 still harbor epidemic populations and outbreaks are being extended because of the unusually dry conditions we have been experiencing in the past 4-5 years. Currently, Douglas-fir beetles are found infesting more than 101,000 acres, Region-wide.

Fir engraver-infested acres reached an all-time high in 2004, extending to slightly more than 298,000 acres. Most infested stands were found in northern Idaho. Virtually all mortality is drought related.

Many high-elevation subalpine fir stands are being impacted by a combination of drought effects, root diseases and bark beetles. Most outright mortality has been attributed to western balsam bark beetle. An estimated 371,000 trees were killed on 175,300 acres in 2003 (recorded as faders in 2004).

Western pine beetle infested acres declined somewhat in 2004, despite continuing dry conditions. Just over 10,300 acres were infested in 2004. Most of those infested acres were in northern Idaho.

Acres of ponderosa pine on which pine engraver-caused mortality was found in 2004, increased to more than 17,000 acres. Most was recorded on second-growth ponderosa pine stands in western Montana.

Spruce beetle was found at endemic levels throughout the Northern Region. An outbreak, covering more than 8,700 acres still exists in Yellowstone National Park.

Western spruce budworm populations are once again on the increase in the Northern Region. During most of the 1980s, infested acres exceeded several million each year. Budworm populations collapsed to endemic levels during most of the 1990s, but began increasing about 3 years ago. In 2004, defoliation was recorded on more than 236,000 acres. That was an increase from just 142,000 acres in 2003. Populations are expected to continue to increase in 2005.

Populations of Douglas-fir tussock moth have declined to endemic conditions in northern Idaho—down from 142,000 acres in 2001. A small outbreak, covering about 5,800 acres was recorded in western Montana in 2004. That population is expected to decline in 2005.

Since first being discovered in northern Idaho in the early 1980s, balsam woolly adelgid populations have increased almost yearly. In 2004, more than 50,000 acres were infested—up from 24,000 acres recorded in 2003. In many of those infested areas, subalpine firs are being killed, whereas grand fir is being stunted or suffering growth loss.

Region 3: Arizona, New Mexico

Terry Rogers – USDA Forest Service, Albuquerque, NM

Although the Southwest's long-term drought continued through the 2004 growing season, it was not as extreme as the previous two years. This contributed to the overall decrease in conifer mortality from bark beetles, detected on 426,680 acres in 2004 compared to 2,700,000 acres in 2003. The most dramatic decrease in 2004 was the decrease in piñon mortality by piñon Ips. New mortality was detected on only 146,145 acres. This figure is not directly comparable to the 1,914,345 acres detected in 2003, since not all the same acres were surveyed, but it is still a significant reduction.

Ponderosa pine mortality was attributed to Ips engraver beetles (84,595 acres), western pine beetle (58,160 acres), roundheaded pine beetles (525 acres), and mountain pine beetle (5 acres). Note that Ips activity was significantly reduced from the 695,130 acres observed in 2003. Although the number of acres affected by western pine beetle decreased by 5,000 acres across the region, there was a slight increase in mortality on the Gila National Forest and on State and private lands in New Mexico.

Bark beetle-related mortality in high elevation forests increased in 2004. In the mixed conifer and spruce-fir cover types, trees were killed by spruce beetle (21,205 acres), fir engraver beetle and western balsam bark beetle (25,700 acres), and Douglas-fir beetle and/or *Scolytus monticolae* and *Pseudohylesinus nebulosus* (87,965 acres). Mortality to true firs and Douglas-fir represent two fold and three fold increases, respectively, over observations in 2003.

Defoliation by western spruce budworm increased in 2004, with 248,895 acres detected *vs*. 167,325 acres in 2003. Spruce aphid (*Elatobium abietinum*) defoliation occurred on 28,730 acres in 2004, which was down from 121,060 acres in 2003. New Mexico fir looper activity decreased to 5,915 acres in the Sacramento Mountains of southern New Mexico.

Aspen defoliation or dieback was observed on 54,275 acres across the region in 2004. There are differences in the type of damage between the two states. In New Mexico, over 25,000 acres were defoliated by the western tent caterpillar. In Arizona, nearly 29,000 acres of mortality and dieback of aspen were observed. This event was initiated by weather-related events over the past 5 years.

Region 4: Rocky Mountains

Brytten Steed – USDA Forest Service, Forest Health Protection, Ogden, UT

The following summary is based on aerial detection surveys and assumes that the total acres flown were similar in years (with the exception of piñon-juniper woodlands). States covered in this summary of the Intermountain Region include Utah, Nevada, southern Idaho, western Wyoming and the small section of the Humbolt-Toiyabe National Forest in California.

The Intermountain Region saw an increase in 2004 in most bark beetle activity on National Forest lands. Mountain pine beetle activity in the Region rose from ~1.6 million trees killed in 2003 to ~3.4 million in 2004. Of these 3.4 million trees, approximately 1.2 million trees were killed in Idaho on the Salmon-Challis and Sawtooth National Forests; more than 800 thousand trees were killed on the Bridger-Teton National Forest in Wyoming; greater than 600 thousand trees killed occurred in Utah on the Ashley and the Wasatch-Cache National Forests.

Douglas-fir beetle tree mortality increased from almost 168 thousand trees dead in 2003 to more than 356 thousand in 2004, continuing an increasing mortality trend that began in 2002. High areas of activity in 2004 included more than 82 thousand trees on the Bridger-Teton National Forest in Wyoming and more than 53 thousand on the Ashley National Forest in Utah.

Spruce beetle activity in Engelmann spruce increased from over 123 thousand in 2003 to over 318 thousand in 2004, above the 2001 peak of ~270 thousand trees killed. High activity areas in 2004 included more than 40 thousand on the Dixie National Forest in southern Utah and more than 33 thousand trees on the Manti National Forest in Utah.

Piñon Ips activity increased on National Forest lands in 2003 due, in part, to increased survey in these areas and possible late detection of 2003 mortality. When all land ownerships are considered, tree mortality decreased in 2004. Mortality on National Forest lands increased from 0.5 million trees in 2003 to 3.1 million in 2004. However, on all ownerships, piñon mortality decreased from 4.4 million trees in 2003 to 1.1 million trees in 2004.

Defoliator activity in the Intermountain Region decreased in 2004 from spikes in activity in 2003. Douglas-fir tussock moth activity decreased to less than 5 thousand trees in 2004, after a small spike of activity in 2003 when ~10 thousand trees were affected. Western spruce budworm had a spike in activity in 2003 and declined in 2004. In 2003, approximately 105 thousand trees were defoliated in the Region with over 88 thousand occurring on the Boise National Forest. Levels in 2004 were less than 29 thousand trees affected, with over 15 thousand of those occurring on the Dixie National Forest.

Gypsy moth was first detected in 1988 with eradication projects in the 1990's and continuing yearly detection trapping. In 2004, four moths were captured; three at two sites in Utah and one in Wyoming. One Utah site is high elevation spruce-fir vegetation and is not of concern. Delimitation trapping will occur in 2005 at the sites in Salt Lake City and Park City, Utah and Jackson, Wyoming.

Region 5: California

Danny Cluck – USDA Forest Service, Forest Health Protection, Susanville, CA

Western pine beetle-caused increased slightly in all areas except for Southern California, where outbreak populations have declined. Areas of high mortality include the Warner Mountains (Modoc NF) and the McCloud Flats (Shasta-Trinity NF).

Mountain pine beetle caused high sugar pine mortality in the central and southern Sierra. Scattered mortality of lodgepole pine occurred throughout the Sierra Nevada. Some ponderosa pine mortality in the Warner Mountains is attributable to MPB.

Other bark beetle activity included: (1) Jeffrey pine beetle caused a gradient of elevated tree mortality from north to south except for a new outbreak in the Tehachapi Mountains (Los Padres NF), (2) fir engraver-caused mortality of both red and white fir remains high throughout the state; and (3) red turpentine beetle attacks on fire-injured Ponderosa and Jeffrey pine in prescribed and wild land fires throughout the state.

The Mediterranean pine engraver is a new beetle to our region (most likely from solid wood packing material). It was first detected in May 2004 in Fresno, CA and is now found in five southern Central Valley counties. Overwintering populations were found in dead Aleppo pine and Italian stone pine, and old galleries were found in Monterey pine. This beetle may carry spores of fungal pathogens already present in the US or other pathogens from other unknown origins. Further trapping and studying fungal associates will occur this year.

Lodgepole needleminer continued in Yosemite NP with 25,000 acres of high-level defoliation reported. Jeffrey pine needleminer caused roughly 600 acres of very light defoliation near Lake Tahoe, This same area experienced defoliation in 1996.

High trap counts of Douglas fir tussock moth last year in central and southern Sierra resulted in some light defoliation. Trap catches combined with egg mass surveys revealed the potential for higher levels of defoliation in 2005. The southern Sierra may be headed towards an outbreak.

Fire-injured red and white fir on the 1999 Bucks Fire (Plumas NF) are beginning to fail with full green crowns creating hazardous stand conditions and fuel accumulations. These trees suffered high levels of basal girdling without corresponding crown scorch. Woodboring and ambrosia beetles may be facilitating the spread of decay fungi through damaged cambium. Decay has spread rapidly in five years leaving little functional xylem, yet crowns remain green.

Sudden oak death (*Phytophthora ramorum*) was confirmed in Lake and San Francisco Counties. Fourteen counties are now infested. Confirmations of the disease increased within known infested counties. The number of host plants susceptible to *P. ramorum* increased to 64. *P. ramorum* was detected in 53 nurseries in California in 2004.

Region 6: Washington, Oregon

Iral Ragenovich – USDA Forest Service, Portland, OR

Native Insects. Bark beetles continued to be the primary forest insect concern in WA and OR in 2004, with drought and overstocking continuing to be the primary underlying reasons for the activity. The main defoliator problem is western spruce budworm.

Mountain pine beetle primarily occurred in lodgepole and whitebark pines in north and north central WA on the Okanogan and Wenatchee NF's. Western pine beetle activity occurred in many areas, such as central Oregon. Other bark beetles that increased include *Ips*, western balsam bark beetle, spruce beetle, and fir engraver. Only Douglas-fir beetle continued in a downward trend.

Western spruce budworm defoliation increased from 143,000 acres in 2003 to almost 200,000 acres in 2004, with almost all of the activity occurring in the Wenatchee/Okanogan/Yakima area. Douglas-fir tussock moth remains at endemic levels. Special surveys were conducted in 2002 and 2004 for Pandora moth. In 2004, over 87,000 acres of defoliation were mapped within the Winema reporting area, compared to about 25,000 acres in 2002.

Non-native Insects. In 2004, both larch casebearer defoliation and visible balsam wooly adelgid damage, decreased by about 60%. Gypsy moth has been trapped for several years in the Eagle Creek area east of Portland. A small treatment project about 280 acres is planned. In addition, ODA captured trapped over 150 specimens of granulate Asian ambrosia beetle, *Xylosandrus crassiusculus,* for the first time, during their CAPS woodborer survey.

Region 10: Alaska

Dustin Wittwer and Mark Schultz - USDA Forest Service, Juneau AK

A variety of insect populations continued to increase in Alaska.

There was a 40% increase in active spruce beetle infestations, primarily in the Seward Peninsula. Northern spruce engraver populations increased four-fold in 2004, especially in interior Alaska. Western balsam bark beetle is responsible for sub-alpine fir mortality in the Skagway River watershed, northeast of Skagway.

Spruce budworm and larch sawfly defoliation increased in 2004 in interior Alaska; and black-headed budworm increased in southeast Alaska.

Spruce aphid defoliation in southeast Alaska declined by 75%. The largest outbreak of aspen leaf miner on record in Alaska continued to expand; 584,405 acres were mapped. Leaf miner activity continues in the Yukon Flats National Wildlife Refuge, and has expanded in the Fairbanks and Upper Tanana River Valley. Birch leaf roller infestations decreased by 80%, with the largest infestation north of Tyonek in south-central Alaska.

Due to continued mild weather conditions, insect defoliator populations increased around the Anchorage area with noticeable damage to alder species. The primary defoliator of the thin-leaf alder was the introduced alder woolly sawfly. Amber-marked birch leaf miner populations increased 138,000 acres (over 4x's 2003 acres) of heavily defoliated birch. This introduced insect has now spread north and south of Anchorage to Soldotna, on the Kenai Peninsula. Ground surveys detected leaf miner activity in Haines and Skagway in southeast Alaska.

Release of a hymenopteran parasitoid to control the insect is underway. Other introduced insects of interest in 2004 were: (1) one male European gypsy moth was trapped near Fairbanks, (2) western tent caterpillars, and (3) the European pine shoot moth was introduced on ornamental Scotch pine. Exotic insect monitoring continued with placement of traps for amber marked leaf miner, gypsy moths, nun moths, and exotic bark beetles and woodborers.

Exotic Introductions

Moderator - Dave Holden

The threat of the ambrosia beetle, *Platypus sulcatus (=mutatus)* to world poplar resources

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We described the life cycle, hosts and damage caused by the ambrosia beetle *Megaplatypus mutatus* to poplar resources of Argentina. This insect, native to the subtropical area of eastern South America, has extended its range in Argentina, reaching as far south as Neuquén in the Argentinean Patagonia. The damage is caused by the adults, which bore large gallery systems into living poplars, *Salix* and many other broadleaf species, including fruit trees such as walnuts and avocados. The galleries not only degrade the lumber, but weakened trees often fall during windstorms. A recent introduction to Italy, demonstrates that this insect can move long distances, from country to country, and therefore, presents a threat to poplar cultivation world-wide. We present preliminary results of research aimed at developing a pheromone-based detection and control system.

Invasive forest insects, what's bugging us in Ontario

A.A. Hopkin – Canadian Forest Service, Great Lakes Forestry Centre, ON

The concentration of introduced forest pests is likely higher in the Great Lakes Basin (GLB) than anywhere else in Canada. There are numerous reasons for this: the GLB is a centre for manufacturing and about 70% of imported industrial materials arrive in the area, often associated with solid wood packing material. The Detroit border crossing is one of the busiest crossings in the US. There is a high diversity of hardwood and conifer species in the basin, increasing the chance that a forest pest, from Europe or Asia, is able to find a suitable host.

There is a long history of introduced insect pests in the GLB. The gypsy moth (*Lymantria dispar*) has been established in Ontario since the 1970's. Presently, insect populations are under control due to the introduction of an alien fungus *Entomophaga maimaga*. Other well established alien insects include the larch sawfly (*Pristiphora erichsonii*), the European sawfly (*Neodiprion sertifer*), birch leaf miner (*Fenusa pusilla*) and of course the European Spruce sawfly (*Gilpinia hercyniae*).

Most recently the emerald ash borer, (*Agrilus planipennis* EAB), was in Windsor Ontario in 2003. Based upon evidence collected from dead green ash, it was concluded that it has been present in Michigan for at least five years. This insect is native to Asia, and was likely transported to North America in solid wood packing material, or in logs that are used to stabilize cargo within containers during shipping. The insect has spread about 60-80 km from Windsor since its discovery. The larvae feed on the phloem and outer sapwood for several weeks creating S-shaped feeding galleries that meander back and forth and may extend over an area of 20 to 50 cm in length. The numerous larval tunnels cause the bark to split and soon girdle the stem, killing a tree in as little as two to three years. All native and cultivated species of ash are at risk of attack. The emerald ash borer is capable of attacking stressed and healthy, urban and forest trees of all sizes. The EAB, if not effectively controlled, has the potential to spread across the entire range of ash.

Subsequent to the discovery of the EAB in southwestern Ontario, the Asian longhorn beetle (*Anoplophora glabripennis*) (ALB) was discovered in the Toronto/Vaughan area in September 2003. This insect was first discovered in New York (1996) then Chicago (1998) and subsequently in New Jersey (2002). Unlike the EAB, the ALB attacks many hardwood species in Canada, including maple, elm, poplar, birch and sycamore. There are currently no known natural enemies for the ALB in North America.

The pine shoot borer (*Tomicus piniperda*) has been present in Ontario since at least 1993. It affects pines, though primarily Scots pine. There is presently concern about a northward expansion of this insect due to a possible outbreak of the jack pine budworm which will provide potential hosts by stressing jack pine in areas adjacent to the *T. piniperda* populations, potentially an interesting interaction between a native and alien pest. The insect has also been discovered to vector exotic blue stain fungi in Ontario, which like the insect, originate from Europe. Other important alien insects include the pine false webworm (*Acantholyda erythrocephala*) and the beech scale (*Cryptococcus fagisuga*).

The list of introduced insects in Ontario causing economic damage to forest tree species in the GLB is currently in excess of 30. The recent introduction of the EAB and the ALB has refocused our attention on an old problem.

Knowledge gapes: What we don't know about invasive alien species

Leland Humble – Canadian Forest Service, Victoria, BC

As the title implies, there are significant gaps (gapes) in our understanding of invasive alien species and their global movement. The global movement of pests and pathogens associated with wood packaging is used to illustrate these knowledge gapes.

The recent establishments of European pine shoot beetle, brown spruce longhorn beetle, Asian longhorn beetle, and emerald ash borer in Canada have served to focus research, regulatory and policy attention on invasive species in forestry. The problem is however, global in scale. North American species such as red turpentine beetle and *Ips grandicollis* have established in Asia and Australia respectively; multiple species of European origin including *Sirex noctilio* and species of *Hylastes*, *Hylurgops* and *Orthotomicus* have been transferred to pine plantations in the southern hemisphere; and species indigenous to the southern hemisphere have established in Europe (*Megaplatypus mutatus*) or in both Europe and North America (NA) (*Phoracantha* spp.).

The predominant pathway for many of the recent species transfers is presumed to be untreated (green) wood packaging used to package and or brace commodities in international trade. Bark and wood-boring pests are routinely intercepted during phytosanitary inspections, and can be present in significant numbers as well as complete development long after the arrival of the commodity. As less than 2% of all imported commodities are generally inspected it is difficult to determine the overall risk posed by this pathway. In addition, inspections generally provide no information on the abundance or diversity of species associated with individual shipments as only species occurrence is documented. And finally, because inspection of wood packaging is both difficult and labour intensive, all species present in wood packaging are generally not enumerated during inspection. Thus, databases derived from pest-interception records quantify the frequency of occurrence of the most easily detected species, rather than the richness and diversity of species associated with the packaging.

Difficulties in identifying the species moving in association with wood packaging further exacerbate the ability of regulatory agencies to determine which species threaten Canadian forests. These difficulties arise from a combination of factors including the inability to identify immature life stages, varying levels of taxonomic knowledge for intercepted taxa, inadequate knowledge of the regional flora and fauna in the countries of origin and lack of systematic expertise. As a consequence of these limitations the proportion of fully identified species can vary widely among the intercepted taxa.

Better resolution of the richness diversity of species associated with wood packaging can be obtained through the rearing of intercepted wood packaging. In contrast to inspections, rearings provide quantitative data on the abundance and diversity of all taxa present, as well as adult specimens for definitive identifications. Thus one can determine not only what species are present, but also their abundance, which is of interest in estimating the potential for a species to establish. We currently lack definitive data on the size of populations of the species moving with trade, and thus cannot evaluate the potential for their establishment.

Offshore surveillance for pests associated with tree species or genera growing in the forests from which wood packaging is produced may be useful in determining which pest species should be targeted for surveillance activities in Canada. Current problems with *M. mutatus* attack on hybrid poplar in South America and its incursion into Italy (see Alfaro in this session) suggest that it should be considered as a potential target for surveillance activities in Canada. Knowledge of the species that have shifted to North American tree species grown as ornamentals or in plantations in other regions of the world is of use in determining the range of taxa of potential quarantine concern to North American plant protection organizations.

Over the past decade, multiple research studies have demonstrated that at least 50 non-indigenous Scolytidae are known to have established in NA. While for the majority of these alien invasive species, the continent or region to which they are indigenous is known, the origin of an introduction cannot always be ascribed to the region in which the species occurs naturally as many of the alien species are now naturalized in multiple regions beyond their native range. Besides being unable to determine the origin of the populations, one is also unable to determine whether the establishments were the consequence of single introductions and subsequent range expansion or whether they have resulted from multiple introductions from the native range and/or other established non-indigenous populations. Determination of the origin(s) of populations will require the use of molecular DNA analyses of the populations from around the world. Such studies should be undertaken to obtain the data necessary to evaluate the effectiveness of national and international regulatory efforts to prevent the spread of such non-indigenous species.

The use of molecular tools for determining the origins of populations of non-indigenous pests and pathogens of quarantine concern can provide useful insights into the pathways of movement(s) of such organisms in international trade. Molecular analyses of the population structure of the fungus *Amylostereum areolatum*, vectored by *Sirex noctilio*, revealed that the vector/pathogen populations in the southern hemisphere likely originated from redistribution of populations across that region following its original establishment in New Zealand rather than from multiple independent introductions from Europe. These results suggest that more efforts are needed to identify the pathways of movement of this and other vector/pathogen associations to prevent further global movements.

The implementation of surveillance programs for the detection of non-indigenous introductions in forest ecosystems has led to the discovery of a significant diversity of recently established non-indigenous bark- and wood-boring beetles in multiple jurisdictions in North America. These programs have demonstrated the inadequacy of the current knowledge of the species composition, the pathways of introduction and their distribution in North America. In BC alone, species of

Asian, European and North American origin have established in coastal forests. With the exception of *Trypodendron domesticum*, which responds to the aggregation pheromone of a related Holarctic species, *T. lineatum*, each of the remaining 5 species detected during surveillance was recovered from traps baited with non-species specific kairomones.

Of the current lure combinations used in surveillance programs (α-pinene, ethanol and an *Ips typographus* lure [racemic ipsdienol, cis-verbenol & methyl-butenol]) only the latter is based on an aggregation pheromone of a species of recognized quarantine concern. Further development of surveillance programs is hampered by an inadequate knowledge of the chemical ecology of the targeted species. Semiochemicals have not been identified for many species of quarantine concern, and, in instances where the semiochemicals are known (e.g. *I. typographus*), cost considerations have resulted in the production of lures with less specificity than that of the actual pheromone. We also lack information on the efficacy of lures in detecting species other than the targeted taxon. Rectification of these limitations will require both testing of lure systems used in these detection programs in regions of the world from which non-indigenous species of concern could originate and development of new lure systems for species for which current systems are inadequate.

Significant knowledge gaps also exist in the range of organisms associated with species of quarantine concern and their potential for establishment in Canada's forests. Twenty-two species of fungi not currently present in NA were vectored by nine of the species of Scolytidae intercepted during quarantine inspections in Canada. On average, more than 45% (range 33% - 87%) of the fungi associated with individual species are currently not present in NA. In addition to fungi, plant pathogenic nematodes and mites are vectored by bark- and wood-boring taxa. Current phytosanitary detection efforts (inspections and surveillance programs) do not encompass vectored organisms, which in themselves can pose serious threats to forest ecosystems. Indeed, evaluations of the organisms vectored by the majority of recently established non-indigenous bark- and woodborers have not been undertaken to determine either their diversity or impacts.

While significant knowledge gaps related to various aspects of the pathways of movement, diversity, distribution, detection and impacts of non-indigenous species of concern to forestry exist, significant progress has been made in restricting the global movement of quarantine pests moving in association with wood packaging. The adoption and implementation of a global standard for the treatment of wood packaging will significantly reduce the future global movement of pests and pathogens in association with wood packaging. While this standard will greatly reduce or eliminate new incursions of pests associated with untreated wood packaging, it is likely that multiple other exotic species have been introduced and remain undetected in our forests. Efforts need to be focused on their detection before they become problems in our forests. Additionally, other significant pathways remain to be addressed. Future efforts need to focus on reducing and / or eliminating the movement of forest pests and pathogens associated with the trade in live plants.

An Oregon case study of the agricultural risks of the intracontinental movement of raw wood products

James LaBonte - Oregon Department of Agriculture

The Oregon Department of Agriculture (ODA) has surveyed for exotic wood boring and wood associated insects since 1997. Targeted sites include raw wood importers, wood recyclers, and urban forests. Various traps and lures have been used. The primary trap used has been the 12-funnel Lindgren trap.

A railroad tie creosoting plant located at The Dalles along the northern Oregon border in the Columbia Gorge has been surveyed by ODA since 1998 because raw ties are imported from various regions of North America, mainly British Columbia and the southeastern United States. There is no other known source of significant volumes of imported raw wood products in the immediate area. The following non-indigenous beetles (with regard to Oregon) were detected from 1998-2003: *Monochamus carolinensis* (Olivier), *Tetropium castaneum* L., *Xylotrechus sagittatus sagittatus* (Germar) (Cerambycidae), *Gnathotrichus materiarius* (Fitch), *Monarthrum fasciatum* (Say), *Xyleborinus alni* (Niisima), and *Xylosandrus crassiusculus* (Motschulsky) (Curculionidae: Scolytinae). Most of these species are natives of eastern North America, while the remainders are exotics, one of which, *T. castaneum*, is not known to be established in North America. It is not surprising that most of these species are known to attack conifers since the bulk of the imported ties were from softwoods. With the exception of *X. aln*i, these are the first documented trapping records of these species for Oregon, the Pacific Northwest, and the western United States.

In 2004, new exotics were detected: *Euplatypus compositus* (Say) and *Oxoplatyupus quadridentatus* (Olivier) (this latter species was not trapped, but found in ties) (Platypodidae), *Monarthrum mali* (Fitch) (Scolytinae), and *Phileurus valgus* (Olivier) (Scarabaeidae). Furthermore, 156 *X. crassiusculus* were trapped (versus 30 from 1998-2003). Unlike prior years, these species, other than *P. valgus* (which is not wood associated) all predominantly attack broadleafed woody shrubs and trees. The change in fauna was due to a change in rail tie source material. As of late 2003, the majority of ties were from hardwoods in the Southeast, mainly oak and hickory from Arkansas, Missouri, and Texas. With the exception of *X. crassiusculus*, these species are indigenes of that region. As with the exotics trapped prior to 2004, these are the first documented trapping records of these species for Oregon, the Pacific Northwest, and the West. Unlike the conifer-attacking species, several of these "new" species are known or have the potential to be primary pests of fruit trees or ornamentals, major agricultural commodities in Oregon.

This situation is a prime example of the risks associated with the unregulated movement of raw wood products within North America. In this instance, agricultural threats are posed by both regional indigenes and an intercontinental exotic established in North America.

Defoliator Impacts, Management and Control

Moderator - Karen Ripley, Washington Department of Natural Resources, Olympia, WA

This workshop consisted of three presentations with short discussion following.

Western spruce budworm impact data

Bruce Hostetler – USDA Forest Service, Mount Hood National Forest, Sandy, OR

In 1980 defoliation was detected in the Blue Mountains of northeastern Oregon in what would turn out to be a large western spruce budworm outbreak, which would continue through 1992. This was the first outbreak in this area since the one, which started in the mid 1940s and lasted through about 1958. The initial area of defoliation mapped in 1980 was about 5,000 acres increasing to over 300,000 acres in 1981. At the peak acreage in 1986 defoliation was mapped on almost 4 million acres.

It wasn't until 1986 that a project was initiated to collect data to assess the effects of defoliation by western spruce budworm on trees and stands within the outbreak area. Data were initially collected from each of 34 stands (21 on the Malheur National Forest and 13 on the Wallowa-Whitman National Forest). "Outbreak intensity" was assigned to each stand (High [5]; moderate [23]; low [6]). Within each stand approximately 30 points were established at which both a variable radius plot (trees ≥ 3-in dbh) and a fixed radius plot (trees < 3-in dbh and at least 6 in tall) were sampled. All trees ≥ 3-in dbh were numbered and tagged. The normal tree metrics were measured (species, dbh, height, crown ratio, crown class) for all trees. In addition, for host trees (Douglas-fir, grand fir, Engelmann spruce) we measured percent dead top, percent bare top, and estimated current and total defoliation by crown third. We also recorded the incidence and severity of other insects or diseases which had an influence on the sample trees (bark beetles, dwarf mistletoes, root diseases) and estimated a Root Disease Rating for the plot using a rating system similar to that used by pathologists from Northern Region, USDA Forest Service.

Defoliation and topkill data were collected from each tagged tree annually from 1986 through 1995, and then again during the final data collection in 1997. In addition, in 1997, dbh, height to top of live crown, and crown ratio were measured for each plot tree and each ingrowth tree. Mortality data were collected every year, 1986 through 1997. In 1996 and 1997, increment core data were collected from a subsample of trees in each stand. Two cores (one each from opposite sides) were extracted from about 500 trees or about 15 trees per stand. The PNW tree ring laboratory in La Grande, Oregon, has measured tree rings from the cores, but the data have not been processed or analyzed as yet.

With the assistance of Tommy Gregg, data were reformatted and run through the Forest Vegetation Simulator (FVS) to calculate some additional variables (crown width, total basal area at point, host tree basal area at point, total basal area of larger trees at point, trees per acre at point, and stand density index). Using information from the raw data, we also calculated percent total defoliation, percent current defoliation, and length of dead top for each tree. The end result was a master data file containing 13 records per tree for each of 5,582 trees and put into a format, which would allow Mike Marsden to develop topkill and mortality equations using logistic regression procedures.

The logistic regression analysis resulted in the selection of key variables as shown in the following topkill and mortality equations:

Proportion of tree that is topkilled = 1/(1+exp(X)), where

X = B0(sp)
+ B1(sp) * elevation
+ B2(sp) * elevation^2 + B3(sp) * dwarf_mistletoe_rating
+ B4(sp) * proportion_topkilled_last_year
+ B5(sp) * missing_foliage_top
+ B6(sp) * missing_foliage_middle
+ B7(sp) * missing_foliage_top * proportion_topkilled_last_year
+ B8(sp) * missing_foliage_middle * proportion_topkilled_last_year
+ B9(sp) * missing_foliage_top * missing_foliage_middle

Probability of mortality = 1/(1+exp(X)) , where

X = B0(sp)
+ B1(sp) * elevation
+ B2(sp) * elevation^2
+ B3(sp) * basal_area_at_point
+ B4(sp) * host_basal_area_at_point
+ B5(sp) * missing_foliage_top
+ B6(sp) * topkill category
+ B7(sp) * missing_foliage_top * missing_foliage_middle

We still need to do further testing and analysis to determine if these equations with the associated coefficients will be the final ones which will be used in any defoliation simulation models.

Changes in stand tree densities and basal areas in the 33 stands (one stand was logged in 1995) from which data were collected varied considerably. Some stands showed dramatic reductions in tree densities while most showed moderate reductions with a few showing little effect. Basal areas effects varied considerably. Stands which showed the largest increases in basal area are those in which there was compensatory growth by non-host tree species. Stands with few or no non-host trees showed some of the largest decreases in basal area. The breakdown of stands by increases or decreases in density or basal area are shown below.

Table 1. Numbers of stands in tree density or basal area change categories

Change Category	Stand Tree Density	Stand Basal Area
>25≤50% increase	0	4
>10≤25% increase	1	5
0≤10% increase	1	6
>0≤10% decrease	8	7
>10≤25% decrease	13	6
>25≤50% decrease	4	3
>50≤75% decrease	2	2
>75≤100% decrease	3	1

What is next?

Topkill and mortality equations will be incorporated into the General Defoliation Model, which will link to FVS and which is being worked on by Kathy Sheehan and Ann Lynch, among others. The model will then be validated and calibrated using empirical data sets from areas throughout western North America.

There is a plan to work with Ann Lynch to analyze the increment core data.

A complete report of all aspects of the Blue Mountains Western Spruce Budworm Impact Project will be completed. This report will include charts showing pre- and post-outbreak stand characteristics for each of the 33 stands.

The Budworm Impact Project data set, along with a data dictionary, will be made accessible to everyone so that the information will be available to be used in other analyses.

A discussion with others interested in defoliator impacts is needed to see if there is any perceived need or desire to conduct a 20-year re-measurement of the Blue Mountains Budworm Impact plots in 2006.

Oviposition traps to survey for population trends and defoliation prediction of the western hemlock looper (*Lambdina fiscellaria lugubrosa*) (Lepidoptera: Geometridae) in British Columbia.

Arthur J. Stock[1] and Marnie A. Duthie-Holt[2]

[1] Art Stock Consulting Ltc., Nelson, BC

[2] Medi-For Forest Health Consulting, Cranbrook, BC

Introduction - Western hemlock looper (WHL) is a devastating defoliator causing extensive tree mortality mainly of hemlock. Egg sampling for population predictions and expected defoliation is usually conducted by collecting lichen. However, this technology is arduous, tedious, time-consuming, expensive, requires presence of lichen, old eggs need to be separated out before viable eggs are counted, and requires a specialised extraction process. An artificial substrate could be standardized, cheaper, easier, more robust, and could be used by non-specialists.

Methodology - Twenty of the 58 permanent sample sites in BC were chosen based on recent WHL populations. At each site, five treatment trees were selected in a cross formation, with a centre tree and 4 trees approx. 20 m distance in cardinal directions. 10 x 30 cm white foam strips were stapled August 2004 at dbh to the north and south sides of the bole. Foam strips and lichen samples were collected October 2004. The foam was then examined, recording presence of WHL eggs and their rate of parasitism.

Results - Egg counts on foam were very low, average 2 per site or 0.67 eggs per 3,000cm^2 and there was no significant relationship with Spearmans' Rank Correlation when compared to egg samples collected in lichen from the same sites, although there was a correlation to same-site larval counts. Over all sites, total egg parasitism was 80% and WHL population collapse is considered to be imminent when egg parasitism reaches 30%. This suggests that virtually no local populations will be evident next summer.

Current contract costs for lichen-based egg sampling *vs*. estimated operational costs of the foam strip sample; foam=$222.50/site and lichen=$358.13/site, for a 62% savings for foam sampling, even with the two entry approach.

Conclusions - First year findings show a proof of concept, however, there is still the need to calibrate through an entire outbreak cycle, with the possibility of additional sampling with a light source during low populations. This technique must also be calibrated against current standard population estimation procedures from high outbreak through to low endemic WHL populations.

Mortality of gypsy moth (*Lymantria dispar*) induced by *Bacillus thuringiensis* var. *kurstaki* is inversely related to temperature

Kees van Frankenhuyzen - Canadian Forest Service, Sault Ste. Marie, ON

Despite 3 decades of operational use of *Bacillus thuringiensis* for management of gypsy moth populations, little is known about the processes underlying its efficacy. Larval responses to sub-lethal and lethal doses of Foray 48B were investigated as a function of temperature and instar. Sub-lethally dosed larvae ceased feeding for a period that depended on dose, temperature and instar. Feeding inhibition of 10-15 h was observed at dose levels as low as one tenth of the LD_{50}. Time to recovery of third instars dosed with a LD_{50} increased from ~20 h at 25^oC to ~80 h at 13^oC. The 50% lethal dose ranged from 0.02 International Units (IU) for first instars to 2.0 IU for fourth instars. Larval mortality progressed rapidly and was complete within 3 (first instars) to 4 (fourth instar) days after dosing at 22^oC. Rearing temperature was varied from 13 to 25^oC and had a profound effect on mortality. In each larval stage, mortality progressed more rapidly at higher temperatures, but the maximum level of mortality attained was inversely related to temperature. Mortality always occurred during logarithmic growth of vegetative cells, well before onset of the stationary phase. The possible role of vegetative insecticidal proteins in causing the observed mortality patterns was discussed.

Impacts and Assessments of Management

Moderator - Art Stock, Art Stock Consulting Ltd. Nelson, BC

Unintended consequences: impacts of mountain pine beetle & *Ips pini* on thinned young lodgepole pine (Pl) stands within salvage areas of the Vanderhoof Forest District in 2004

Robert Hodgkinson - BC Ministry of Forests, Prince George, BC

The objective of the study was to assess the impact of mountain pine beetle and *Ips pini* on young lodgepole pine plantations surrounded by MPB killed mature lodgepole pine. Stands were within salvage areas of the Vanderhoof Forest District (central British Columbia). The study examined lodgepole pine stands < 41 years old. In these stands, 25.1% of trees had been attacked and killed by MPB, 1.4% had been attacked and killed by *Ips pini,* and 13.8% had been attacked and killed by both MPB and *Ips pini*. The impact in young stands could be related to thinning shock, drought in spring 2004, high densities of *Ips pini* emerging from adjacent MPB-killed Pl, and very high numbers of MPB. Recommendations made by BC Forest Service Entomologists were: postpone any thinning and/or pruning in young Pl stands in areas moderately or heavily attacked by MPB; wait until MPB and lagging *Ips pini* populations have collapsed; and, thin in newly-attacked areas at your own risk.

Jerry Carlson - Forest Health and Protection, New York State Lands and Forests, Albany, NY

Invasive species such as chestnut blight, gypsy moth, Dutch elm disease, woolly adelgid and beech bark disease and our current context of Asian longhorn borer (ALB), emerald ash borer and sudden oak death have had, or may have, substantial impacts, even though people do adapt to changes in the forest. The scenario of Federal and multiple State Agency policy, funding, management directives, monitoring and implementation of invasive or outbreak pests is certainly interesting. Integration and coordination of multiple affected and powerful stakeholder groups and government agencies is the largest hurdle.

Effective partnerships among all levels of government are important first steps to build capacity to control and eradicate invasive species across the country. The nationally legislated powers of APHIS led to instant organization at the outset, but created multiple problems for delivery of program operations through the term. Specifically, current laws do not clearly address the prevention of invasion across foreseeable pathways or provide explicit direction on management between introduction of a new non-native species and when it becomes established.

It may be that one of the big differences between New York (where ALB control has had moderate success), and Chicago (where there has been apparently good control of ALB), is that in the latter the public seemed to take the whole issue more to heart. …New Yorkers seem to have a lot of things other than beetles or trees on their minds….

Assessing management effort

Art Stock – Art Stock Consulting Ltd., Nelson, BC

This was a summary of issues and questions that arose during my experience from within and without the BC Forest service as it responded to the mountain pine outbreak currently extent in the central interior of BC, 1996-2005.

1. Assessing management intent - what are we trying to do when we apply "pest management" on the landscape? Obviously, we are trying to do "something". However, we do not usually have the resources to treat every hectare of concern. As Bruce Hostetler remarks: "Are we going to be able to maintain a reasoned approach to management when we have several million hectares of infestation on the landscape, and lots of very excited citizens.?" Within the context of increasing mountain pine beetle populations in British Columbia, provincial politicians finally (after nearly 2 decades of operations) require that proposed control measures be stated, as strategic objectives that are definable, measurable, and verifiable, and that funding will only be allocated to projects with some likelihood of "success". The obverse of this is that we also define failure as not meeting proposed objectives, and consequently may lose funding.

2. Timber supply analysis - "Oldest first" even-flow management over a rotation does not make sense if there is an abundance of mature lodgepole pine on the landscape. Can we do the same exercise for other tree / insect species defoliators?

3. The management imperative - The best available management tools are useless without the political will to use them in a uniform effort over time and space. How do we achieve that? The BC model of decentralised discretionary powers allocated to "local" statutory decision makers only works if there is accountability. Accountability may need to be constructed via legislative imperatives (acts, regulations, and policy). How good is our public profile and credibility? As Samman and Logan (2000) observe "public education opportunities abound for the (US) Forest Service and its associates." The

“management imperative” has not been fully achieved for forest pest outbreaks in BC.

4. Loss of expertise and experience - Given current demographics, institutional memory is going to fade. Most of the BCFS entomologists will be eligible for retirement about when the current central interior MPB outbreak ends. But loss of memory occurs in a much less profound ways – staff movement and attrition. The public will also lose memory, which may lead to an erosion of political will.

5. Finally, I wonder what will be the fallout from the current MPB out break in central BC. Does it represent a failure, or was it inevitable?

High Elevation Forests/Extreme Environments

Moderator - Lorraine Maclauchlan, BC Ministry of Forests, Kamloops, BC

This workshop addressed new or changing issues and research in high elevation forests and forests experiencing extreme conditions such as fire or drought.

Budworm in the great white north

Jennifer Burleigh - BioForest Technologies Inc., Prince Albert, SK

Saskatchewan has just over 15 million hectares of commercial forests and an annual allowable cut of approximately 4.8 M m^3 of softwood and 8.2 M m^3 of hardwoods. Major insects in the province include spruce budworm (*Choristoneura fumiferana*), jack pine budworm (*Choristoneura pinus*), forest tent caterpillar (*Malacosoma disstria*) and the major disease is lodgepole pine dwarf mistletoe (*Arceuthobium americanum)* on jack pine.

Spruce budworm defoliation began increasing in the early 1990’s, reaching a peak in 1999 at just over 500,000 ha of moderate and severe defoliation, peaking again in 2002 at 695,000 ha of moderate and severe defoliation. Defoliation has been decreasing since 2002 and covered an area of 292,493 ha in 2004. A Series of 97 plots were established throughout budworm’s range in Saskatchewan. Annual plot evaluations include: tree mortality, top condition, current and cumulative defoliation and L2 samples for population predictions. Intensive measurements are conducted every 3-5 years, where tree height, dbh, crown length and tree cores are collected in addition to the annual measurements. In 2004, a total of 3,787 host trees evaluated in 64 plots. As much as 80-90% of the spruce volume has been killed by budworm defoliation in the more heavily impacted stands. Information gathered from these plots provides valuable insight on stand decline/recovery, population trends and overall stand impacts. This information will be used to help calibrate the Spruce

Budworm Decision Support System which is currently being used to plan management programs in Saskatchewan.

Fire severity, salvage logging and boreal ground beetles (Carabidae)

Matti J. Koivula and John R. Spence - Department of Renewable Resources, University of Alberta, Edmonton, AB

Fire is one of the most important "natural" disturbances in boreal forests. The effects of fire are many, including both economic and ecological aspects. In addition to initiating primary succession, fire creates a pulse of food and habitat resources for various forest organisms, many of which are specialized to exploit these spatially and temporally patchy resources. However, the process of post-fire succession is often altered by salvage logging i.e. post-fire removal of merchantable timber. We studied the effects of fire severity and post-fire logging at the House River fire area, central Alberta, Canada, during 2003-2004 by examining a total of 24 landscapes (625 ha each) that varied in relation to merchantable timber (two levels), salvage-logging intensity (unlogged i.e. control, and low, moderate and high logging intensity) and fire severity. We will present two-year results on ground beetles (Carabidae) responses to these three factors.

Detecting balsam woolly adelgid infestations in subalpine fir stands using lichen cover

David L. Overhulser - Oregon Department of Forestry, Salem, OR

For almost half a century, aerial surveyors in Oregon have used fading foliage in true fir as the primary indicator for infestations by the balsam woolly adelgid (BWA). Using the fading foliage signature, very few acres of BWA damage were mapped in Oregon since the early 1970’s. In contrast, recent roadside ground surveys have indicated that BWA infestations have in fact spread into many host stands in eastern Oregon and are causing significant damage not detected by aerial surveys prior to 2000. The fading foliage signature for BWA infestations was clearly not working.

In 2000, aerial surveyors in Oregon started using the black color in subalpine fir stands as the only BWA signature. This black coloration was later found to be associated with lichen cover on dead and declining trees. Using the black coloration of trees as a BWA signature, the acres of BWA damage mapped in Oregon has increased to levels not seen in more than three decades. In 2004, ground crews sampled nine polygons drawn during the 2003 survey using the black tree signature. All of the 2003 survey polygons visited contained BWA hosts and damage. The lichen signature was more pronounced in subalpine fir than the other tree species present in these high elevation mixed conifer stands. The prominent lichens from subalpine fir in these polygons were species of *Bryoria*. It appears visible *Bryoria* cover is a living signature for dead and declining subalpine fir associated with BWA infestations. This signature can be used by both aerial observers and ground personnel to identify BWA infestations. Because lichen cover, unlike fading foliage, is always present, it provides a stable signature during the times aerial or ground surveys are normally conducted.

Causes and cumulative effects of multiple insect outbreaks in Arizonan high elevation forests

Ann Lynch - USDA Forest Service, Flagstaff, Arizona

Forest insect populations in western North America have already been influenced by recent climate trends. Outbreaks have been:

More extensive and severe -

- mountain pine beetle in British Columbia
- spruce beetle in Alaska, British Columbia, and Utah
- various bark beetles on ponderosa pine in Arizona
- piñon ips in Arizona and New Mexico
- spruce aphid in Alaska and Arizona

Further north or at higher elevations -

- mountain pine beetle in British Columbia and Idaho
- southern pine beetle in Arizona
- Mexican pine beetle (*D. mexicanus*) in Arizona

Of species that were previously unknown or innocuous (examples are from Arizona) -

- *Nepytia janetae*
- unknown Geometrids
- southern pine beetle
- *Phloeosinus* spp. on junipers

Warming climate also affects the likelihood that exotic pests will establish and become pests, with potentially serious consequences for sensitive ecosystems. A seemingly small increase in temperature (about 1°C since 1940 at 2100 m in Arizona) has dramatically altered the seasonality of temperature limits associated with insect populations. Winter is shorter and minimum temperatures are warmer. Spring is earlier, warmer and less frosty. In some areas, warmer temperatures have been accompanied by drought. Many of the contemporary insect and disease outbreaks are clearly associated with these warm temperatures, while others are associated with prolonged drought. As climate change progresses, insects and pathogens will serve as agents of change, catastrophically disrupting forest ecosystems in relatively short periods of time.

Subalpine fir, bark beetles and a changing habitat

Lorraine Maclauchlan - BC Ministry of Forests, Kamloops, BC

Subalpine fir, *Abies lasiocarpa*, is well adapted to cold, high-elevation ecosystems, typically ±1,600 m in British Columbia. Succession is a slow, gradual process in these subalpine fir ecosystems, usually consisting of single or small groups of tree dying and falling out of the stand and being replaced by understory regeneration of the same or other species (spruce). Very infrequently, ±300 years, catastrophic fires will destroy fairly large areas of subalpine fir forests, but typically in BC you will find these forests in some phase of a slow successional transition.

The western balsam bark beetle, *Dryocoetes confusus*, is the most dominant tree-killing agent in these forest ecosystems. The mortality pattern caused by *D. confusus* mirrors the size and pattern of spruce found within these ecosystems and creates small and medium size gaps where subalpine fir and other species can be found regenerating. *D. confusus* typically has a two year life cycle but in warmer years can switch to a one-year cycle, with multiple generations in one tree. *D. confusus* has periodic “outbreaks” where it can kill up to 8% of stems in a stand annually but it rarely sustains this level of attack for more than 5 years.

What happens when the delicate balance of tree mortality and regeneration changes – ever so slightly? Density of subalpine fir is dependent upon many factors, mainly climatic – temperature and moisture regime. The drier, colder sites typically have lower stem densities, whereas sites with a more moderating moist, cool climate (with high snow packs) have higher densities. Smaller, suppressed stems drop out of a stand first, lowering overall density. *Dryocoetes* is first noticed when average stand age reaches 70 years or older. The largest, often older stems in a stand are colonized first but there is a wide size variation between stands that *Dryocoetes* will attack.

Tree mortality proceeds, with some live and dead trees blowing down and creating small gaps in the forest canopy. An interesting aspect of this dynamic is the sequence and magnitude of mortality and blow down as it relates to insect colonization and stand succession. The majority of blow down in natural subalpine fir ecosystems is already dead, typically killed by *Dryocoetes confusus*. Attack dynamics, brood production and survival in downed, standing (or pheromone-baited trees) shows little difference among the host resources. Baiting in a stand did not artificially “trigger outbreaks” over subsequent years if left unaddressed. The controlling factor of *Dryocoetes confusus* populations seems to be the availability of highly susceptible hosts and climatic conditions.

Dryocoetes-killed subalpine fir is significantly more aggregated than live subalpine fir, with live trees occupying more space than dead trees. Windthrow in stands occurs in a spatially random pattern. Smaller subalpine fir stems in a stand die first, typically suppressed and colonized by: *Pityokteines minutus; Pityophthorus sp*.; *Crypturgus borealis;* and *Pissodes striatulus*. Since 2002, numerous large diameter subalpine fir have been attacked and killed by *Pissodes striatulus* in the study plots. In summary, these high elevation fir-spruce forests continually experience low level, constant mortality caused by *Dryocoetes confusus* and other associated insects, thus creating small canopy gaps for regeneration. With our changing climate, we may begin to see other insects elevated to “tree killer” status and these forests may begin to experience more catastrophic successional events more typical of lower elevation forests.

Graduate Student Presentations

Moderator: Kimberly Wallin, Oregon State University

Do plantations reduce biodiversity? Patterns in the literature

S. Sky Stephens and M. R. Wagner - Northern Arizona University, School of Forestry Flagstaff, AZ

Plantation forests are becoming an increasingly important component of the world's forested ecosystem. As plantation forests area has increased, several questions have been raised regarding plantation forests impacts on biodiversity. It is assumed that establishing plantations negatively affects biodiversity. However, the effect of forest management on biodiversity is highly variable. Biodiversity assessments in plantation forests have found plantations to have impoverished, marginally different and unexpectedly high biodiversity. This variation stems largely from whether the comparison is plantations versus natural or semi-natural stands or plantations versus alternative intensive land uses, i.e. agriculture.

We review the literature and illustrate that the impact of establishing plantations need not have negative impacts on biodiversity, particularly when comparing plantations with other intensive land use practices. Also we provide original data from Ghana, West Africa, that illustrates species selection can greatly affect the subsequent biodiversity of ground dwelling ants.

Linking natural disturbances, forest composition and structure, and insect biodiversity: example from the boreal mixedwood forest.

J. Colin A. Bergeron[1], John R. Spence[1] and W. Jan Volney[2]

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Ecosystem processes present in mixedwood boreal forest such as disturbances (i.e. wildfires, insect outbreak, floods, harvesting), soil properties, climate and physiography contribute to maintain wildlife and habitat diversity by inducing spatial and temporal variations in forest composition and structure. This always changing spatial-temporal mosaic supports a range of habitats where resources are inconstantly available for wildlife. Variability in the type of resources needed and the way by which different wildlife species obtains these resources create patterns of association between wildlife and habitat. For example, a species needing resources mostly available in old growth forest will occurs mainly in areas skipped by recent stand replacing disturbances. To investigate the role of ecosystem processes in maintaining biodiversity, this project simultaneously studies biological communities, composition and structure of habitat and the ecosystem processes that create habitat diversity. For this purpose, a systematic grid of 200 sites was established on 84 km^2 of boreal mixedwood forest at the EMEND (Ecosystem Management Emulating Natural Disturbance) research area in northwestern Alberta. In every site, natural disturbance regime, habitat composition and structure, and ground-dwelling beetle communities have been characterized. Result from 4,985 trees and 41,446 beetles show that beetle total abundance varies according to stand composition and structure. Habitats dominated by late successional tree species, occurring mainly on the north facing aspects of the landscape where historical fire events have been uncommon, support the highest abundance of beetles. Trees species occurring on lowlands where floods are frequent support the lowest abundance of ground dwelling beetles. A family of beetles that needs wood to survive, the Staphylinidae, shows higher abundances with increasing tree diameter. Conservation of biological attributes of a landscape requires the preservation of habitat diversity on this landscape. In order to conserve the full range of habitat diversity of a particular landscape it is essential to conserve the ecosystem processes shaping this forest.

Long-term impacts of thinning and prescribed burning on Ponderosa pine physiology and bark beetle abundance in northern Arizona

Gregory L. Zausen, Thomas E. Kolb, and Michael R. Wagner - Northern Arizona University, School of Forestry Flagstaff, AZ

Ponderosa pine forest conditions in northern Arizona have been degraded due to overgrazing, logging, and fire suppression that accompanied Euro-American settlement in the late 1800’s. Overstocked stands of suppressed trees with low structural and species diversity dominate the landscape. These conditions create high risk of catastrophic fires and insect outbreaks. We investigated the long-term effects (8-16 years post-treatment) of thinning and thinning + prescribed burning (3-10 years after last burn) on Ponderosa pine water stress, leaf carbon and nitrogen composition, oleoresin exudation flow, and growth, relative to unmanaged controls, and also treatment impacts on bark beetle abundance in 12 stands replicated across the landscape. Pre-dawn water potential in late June of 2003 and 2004 and basal area increment were lower in unmanaged stands relative to managed stands. Oleoresin exudation flow and percent leaf nitrogen varied between years, but not strongly among treatments. We found no strong effects of prescribed fire on any tree characteristic separate from the effects of thinning. Our results can be explained, in part, by relationships between tree competition and the measured physiological and growth parameters. Tree competition and water stress were positively correlated, and tree competition and growth were negatively correlated. Pheromone-baited trap catches of *Dendroctonus brevicomis/frontalis* were higher in unmanaged than managed stands, whereas *Ips pini* abundance did not differ among treatments. We conclude that thinning and prescribed burning can have

long-term effects on Ponderosa pine water stress, growth, phloem thickness, and bark beetle abundance.

Simulated effects on fire return rates on ease of dispersal of the mountain pine beetle

Laura Benson and Hugh Barclay - Canadian Forest Service, Pacific Forestry Centre, Victoria, BC

A Monte Carlo simulation was run to assess the forest age structure of a 1 million hectare lodgepole pine forest after 2000 years of forest fires. The resulting age structures were classified in terms of mountain pine beetle susceptibility using the Shore-Safranyik Susceptibility Rating System. We used 8 different susceptibility boundaries to classify the landscapes as either high or low susceptibility. The landscapes were assessed to see if the beetles could travel across by freely moving through highly susceptible patches, and by traveling a maximum dispersal distance between these patches. This quality was labeled traversability. Using traversability and other spatial statistics, we developed a discriminant function that allows landscapes to be classified as traversable or not. To test the accuracy of the discriminant function, we measured the traversability of BC and compared the results to the traversability classification predicted by the discriminant function. It predicted traversability with 93.3% accuracy. Other results from the simulation include (i) long fire cycles resulted in landscapes that were highly susceptible to mountain pine beetle attack; (ii) fire suppression resulted in landscapes that were highly susceptible to attack; (iii) many small fires created landscapes that were easily traversable by the beetle; and (iv) harvesting reduces the traversability of the mountain pine beetle.

Fire effects on Douglas-fir beetle reproduction in the first year after fire

Kjerstin R. Skov and Diana L. Six - University of Montana, College of Forestry and Conservation

Both fire and bark beetles are important agents of disturbance in the western United States. A major area of concern after fire is the potential for increased tree mortality due to bark beetles. In particular, Douglas-fir beetle (DFB) populations have been observed to increase after fire. DFB may kill fire-weakened trees and emerging brood may move into green trees. Little research has investigated this interaction or identified trees that contribute to this population growth. We selected 28 Douglas-fir trees located on the Cooney Ridge fire east of Missoula, MT. Trees were assigned to Low, Medium, and High fire damage categories based on combined damage to the crown and bole. Unburned control trees were outside the fire. All trees were baited in May 2004 and bark samples were removed September 2004. In each bark sample we counted new progeny and assessed factors that limited or contributed to reproductive success (crowding, resin defense, woodborer competition, and evidence of natural enemies). The lower bole of trees in the High treatment produced the most DFB for the next generation. These same trees had the highest number of DFB in egg and larval stages and subsequently the most intraspecific competition. Trees in the Medium treatment had the most woodborer activity. Trees in the Low treatment had the most resin-based defense, while trees in the High had the least. In the High treatment, low tree defense and woodborer competition may be more important to DFB reproductive success than higher intra-specific competition. Woodborer competition may limit DFB reproduction in the Medium treatment. Our future work will include monitoring DFB attack and reproduction in the second and third years after fire, measuring DFB reproduction in naturally attacked trees, and assessing Douglas-fir chemical defenses and food quality of phloem.

Woodborer abundance in fire-injured ponderosa pine of the Black Hills, South Dakota

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Wood-boring larvae in the families Cerambycidae, Buprestidae and Siricidae are often found in high densities after wildland fires. They are important in tree decomposition, as an avian food source and often reduce the value of salvageable timber. Trees in areas of low, moderate and high fire severities were examined, within three fires. One to three years old fires were surveyed during the summer of 2004. Variables measured included both tree characteristics and woodborer presence. Fire age did not affect differences in woodborer presence among fire severities, except for the one-year old fire low severity plots. In general, trees in the moderate and high severity plots had significantly more woodborers than trees in low severity plots. Classification trees were constructed to model the probability of woodborer presence. Among low severity fires tree injury variables, including crown scorch and cambial surface blackening, were important predictive variables. In high severity fires, tree size variables, including diameter at breast height and tree height, were important predictive variables.

Pioneer behaviour in the mountain pine beetle: what determines success? (*Dendroctonus ponderosae*)

Tanya Latty and Mary Reid - University of Calgary, Calgary, AB

The reproductive success of mountain pine beetles, *Dendroctonus ponderosae* Hopkins, depends on mass-attack to overcome the defences of live trees. Aggregations are initiated by individuals called pioneers, who face greater risks due to conifer defences. Successful pioneering depends on an individual's ability/propensity to enter un-colonized trees, to survive the trees defences and to recruit conspecifcs. This project aimed to identify the factors that determine whether a beetle will successfully initiate an aggregation. In 2003 and 2004 a series of implantation experiments were conducted in Banff and Kootenay National Parks. Contrary to predictions, we found that neither beetle size nor tree resin defences had an impact on pioneer success. Entrance time depended on date such that beetles were more likely to become pioneers early in the season. We also found that beetles were significantly more likely to become pioneers in 2003, a drought year. Pioneer survival depended on date, such that beetles had lower mortality if they entered trees late in the season. Beetles were also more likely to survive on large diameter trees. Recruitment was dependent on beetle energetic status, such that starved beetles were significantly less likely to recruit then un-starved beetles.

Mechanistic understanding of the impacts of thinning ponderosa pine on pine bark beetles.

Monica L. Gaylord and Michael R. Wagner - Northern Arizona University, School of Forestry, Flagstaff, AZ

Since the arrival of Europeans, the ponderosa pine (*Pinus ponderosa*) forests in northern Arizona have been altered by fire suppression, grazing and logging. Pre-settlement conditions consisted of clumpy patches of large old yellow pines with a grassy understory. In contrast, current conditions consist of dense stands of trees. There is extensive interest in using thinning and/or thinning and burning as a tool to help restore the ponderosa pine forests to pre-European condition. These treatments generate controversy and much of the debate centers on how aggressive these treatments should be. Other important issues raised include the appropriate age class distribution (should all large trees be retained), spatial distribution (clumps *vs.* evenly spaced) and the frequency that stands are re-entered in the future. We propose to investigate the response of several species of pine bark beetles (Coleoptera: Scolytidae) to ponderosa pine (*Pinus ponderosa*) thinning. Using an observational approach, we will examine how bark beetles respond to an experimental range of stand densities, tree spatial patterns within a given density, influence of time since thinning and tree age. These comparisons will be made using both natural infestation patterns and induced attacks (using pheromone baits) across a range of existing experimental treatments and a planned complete randomized block experiment. Once the observational studies provide a clear indication as to which elements of stand thinning are important to bark beetles, we will initiate a series of mechanistic studies to evaluate the relative importance of hypothesized alternative mechanisms that may explain bark beetle preference, performance and impact across these conditions. In 2004, we baited ponderosa pine trees with the lure for *D. brevicomis* across a range of thinning treatments (60, 80, 100, 120 and 150 ft^2/acre) and monitored days to attack, if the attacks were successful and density of attacks. Preliminary results indicate that trees in the 150 ft^2/acre treatments were attacked sooner and more trees were successfully attacked in this treatment than in all other treatments. We anticipate continuing this research in 2005 and 2006. These experiments will provide us with regionally appropriate experimental data that supports or refutes the conventional wisdom that stand

density regulation is the most effective strategy to prevent pine bark beetle damage to southwestern ponderosa pine forests.

Biological control of ambermarked birch leafminer in Alaska

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Ambermarked birch leafminer (*Profenusa thomsoni* Konow) a sawfly native to Europe, was introduced to Alaska sometime in the late 1990's. Since then, populations have increased to outbreak levels and now cause significant damage to birch trees in and around Anchorage, Fairbanks and Haines Alaska. This insect caused similar damage to birch in Edmonton Alberta from the 1960's to the 1990's until it was controlled by the ichneumonid parasitoid *Lathrolestes luteolator*. It is hoped introducing this parasitoid to Alaska can control the leafminer. The first shipments of *L. luteolator* parasitized *P. thomsoni* pupae to Alaska were made in May and June of 2004. Parasitoids were then reared to adult stage in Anchorage and released. Male emergence peaked around 10 July, with female emergence peaking about a week later. This emergence was earlier then expected. We attributed this to an increase in the number of degree days owing to the design of our rearing cage, which was usually warmer than the ambient conditions. In total 180 individuals were reared, 97 females and 83 males, of which 55 survived to be released. Emergence was greater for parasitoids collected in Hay River, Northwest Territories than for those collected in Ft. Smith.

Life history of *Pseudips mexicanus* and interactions with endemic mountain pine beetles: A project overview.

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The mountain pine beetle (*Dendroctonus ponderosae*) is currently the most destructive forest insect pest in British Columbia. While a great deal of research has been conducted on epidemic populations of this insect, endemic populations have been studied very little. As epidemics grow from small populations, it is important to examine and understand the population dynamics of the endemic phase. While in the endemic phase, mountain pine beetles interact with a number of other bark beetles. The secondary bark beetle, *Pseudips mexicanus* is often found co-inhabiting stressed lodgepole pine trees with endemic mountain pine beetles. The effect of this interaction on the latter's resource use and brood characteristics are currently unknown. The purpose of this study, to be carried out in 2005, is to evaluate the effect the presence of *P. mexicanus* has on the quality of resources available to endemic mountain pine beetles and the subsequent effect on brood fitness. A description of the life history of *P. mexicanus* will be undertaken, allowing for discussion of interactions between the two species. Specific measures of interaction will be determined and assessed, such as ovipositional gallery overlap, mountain pine beetle brood size and fitness and ovipositional gallery lengths. This research will also explore the effect *P. mexicanus* has on mountain pine beetle host detection, both to bolts infested with *P. mexicanus* and to the aggregation pheromone of *P. mexicanus*. The study is part of larger project examining the dynamics of population growth by mountain pine beetles from endemic to incipient.

Abstracts of Poster Presentations

Chemical treatment of spruce aphid defoliated Sitka spruce

Author: Mark Schultz, USDA Forest Service, Alaskan Region

Abstract: Spruce aphid (*Elatobium abietinum* Walker) defoliation of Sitka spruce in southeast Alaska occurs mostly in the beach fringe. Not all trees on aphid-favorable southern aspects are attacked. Most treated (acephate – acecap) trees survive and slowly re-foliate but heavily infested trees (95% defoliated) die (usually slow growing trees). The cities of Sitka and Craig are losing a number of their landmark trees to repeated defoliation (5-6 years of defoliation). Untreated trees lose foliage but are still alive. Moderately defoliated and healthy trees continue to re-foliate. 80% defoliation can cause tree mortality. As the epidemic continues, treatment will become necessary for some trees. Pacific Southwest Research Station and State and Private Forestry, Forest Health Protection, are beginning a treatment comparison to determine which method(s) best protect trees against defoliation.

Rangewide genetic structuring in *Dendroctonus ponderosae,* the mountain pine beetle

Authors: Barbara Bentz[1], Karen Mock[2], Eric O'Neill[2], Jer Pin Chong[2], and Michael Pfrender[3]

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Abstract: The mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae, Scolytinae), is considered one of the most important drivers of ecological change in western pine ecosystems. MPB was originally described as two geographically separated species (*D. monticolae* and *D. ponderosae*) (Hopkins 1909) that were later synonymized (Wood 1963). Across the range of MPB outbreak populations, univoltinism predominates, and seasonality is maintained by direct temperature control of life stage-specific developmental thresholds and rates. In a recent study, Bentz et al. (2001) observed latitudinal differences in MPB development time and size, suggesting that MPB response to climate change may vary across its broad range. Because the geographical differences in life-history strategies appear to be genetically based, we initiated a phylogeographic characterization of the species to elucidate patterns of gene flow across the species' range.

Adult beetles were collected from eight locations across the range, DNA was extracted and AFLP marker profiles generated using seven selective primer combinations. Results suggest limited gene flow among the populations sampled which may be a function of a large scale isolation-by-distance pattern, rather than the result of specific ecological barriers. We observed no genetic

differentiation between beetles from different host trees in the same locale. The relatively small genetic distance observed between the Fort St. James BC population and Bonners Ferry ID, suggests a relatively recent colonization of northern BC from more southern localities, more extensive gene flow due to greater habitat continuity, or both. The pattern of relatedness among MPB populations sampled for this analysis is similar to that of the original two species described by Hopkins (1909). The Mojave Desert appeared to present a significant barrier to gene flow, resulting in a horseshoe-shaped pattern of divergence following the distribution of host tree species. The two southernmost populations in our study were among the most proximal populations geographically, but were the most genetically divergent of all population pairs. From an evolutionary standpoint, this horseshoe-shaped gene flow and range pattern presents an interesting situation because although the southernmost populations are geographically proximal, independent evolutionary trajectories may result in differential population response to a changing climate.

Bentz, B.J., J.A. Logan, and J.C. Vandygriff. 2001. Latitudinal life history variation in *Dendroctonus ponderosae* (Coleoptera: Scolytidae) development time and size. Can. Ent. 133: 375-387.

Hopkins, A.D. 1909. Contributions toward a monograph of the Scolytid beetles. The Genus *Dendroctonus.* Washington, U. S. Government Printing Office, U.S. Bureau of Entomology Technical Series No. 17, Part 1, 169 pp.

Wood, S.L. 1963. A revision of bark beetle genus *Dendroctonus* Erichson (Coleoptera: Scolytidae). Great Basin Naturalist 23(1-2): 1-117.

Limitations of the benthic index of biotic integrity in forest management

Authors: Michelle P. Barkway and John R. Spence, Department of Renewable Resources, University of Alberta, Edmonton AB.

Abstract: The Benthic Index of Biotic Integrity is a commonly used stream health assessment method in forested watersheds. It is a multimetric index that compares the stream invertebrate community of an undisturbed reference stream to that of a potentially disturbed one, based on a series of community attributes, or metrics. Its results are quantitative, replicated and regionally specific. However, several limitations to its application in forest management are apparent: equal weighting of inclusive metrics to final index scores, resolution of selected metrics, lack of natural reference sites, loss of biological information, snapshot of community response and regional specificity. Although a useful tool, I advise caution against over-interpretation of the results of the B-IBI and suggest that it be used as an initial tool to determine whether further, more intensive investigation is merited.

Effects of prescribed fire on bark beetle colonization in the southwest

Authors: Carolyn Breece[1], Thomas Kolb[1], Karen Clancy[2], Joel McMillin[3], Brett Dickson[4]

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Abstract: Prescribed fire is increasingly used as a tool to restore SW ponderosa pine forests to pre-settlement conditions, improve forest health, and to reduce risk of large, stand-replacing wildfire. While it is important to restore forests to healthy conditions using prescribed fire, there are possible drawbacks to this method, such as increased bark beetle activity and unacceptable levels of tree mortality.

We are interested in the effects of prescribed fire on bark beetles and tree mortality: Does bark beetle activity increase in a forest treated with prescribed fire? How do bark beetle groups vary at different bole heights in burned and unburned stands? How do bark beetles affect mortality of fire-damaged trees? What extent of fire damage to a tree will predispose it to successful bark beetle attack?

We measured fire damage to trees and bark beetle presence in 4 different treatment sites in Arizona and New Mexico. Treatment sites are paired with an unburned control site of similar size and stand structure.

We found a clear increase in bark beetle activity in ponderosa pine stands treated with prescribed fire. While the numbers of bark beetle attacks were low on both the burned and unburned sites, more attacks occurred on the burned sites than the unburned sites. The amount of tree crown damage is a good indicator of probability of bark beetle attack: most bark beetles attacks occurred on trees with greater amounts of crown damage. The *D. brevicomis/ D. frontalis* group and the *Ips* group appeared to colonize at different heights of the bole, indicating possible resource partitioning. These data are from the first year of a 3-year project. We anticipate subsequent bark beetle attacks and tree mortality in the next 2 years.

Investigation of host preference by *Saperda calcarata* Say

Authors: Cynthia L. Broberg and John H. Borden, Dept. Biological Sciences, Simon Fraser University, Burnaby, BC.

Abstract: *Saperda calcarata* (Col., Cerambycidae) attack is common among trembling aspen, *Populus tremuloides* Michx., in BC, but rare among black cottonwood, *P. trichocarpa* Torr. & Gray, and willow, *Salix* spp. We tested the hypotheses that *S. calcarata* is attracted to aspen volatiles and would preferentially feed and oviposit into aspen over the other salicaceous species in the laboratory, and in the field. Both sexes of *S. calcarata* were moderately attracted to aspen leaf volatiles and preferentially fed on aspen over cottonwood

and willow when given a choice between the three types. When no choice was given, cottonwood became increasingly acceptable. Cut bolts from all three species were acceptable for oviposition. Thus, feeding preferences best explain attack patterns observed among the three hosts.

The pattern of mountain pine beetle, (*Dendroctonus ponderosae*), build up in pheromone-baited leading edge stands

Authors: Sam Coggins, Angela Gomm, and John McLean, Department of Forest Sciences, University of British Columbia, Vancouver, BC

Abstract: Ten experimental plots were set-up in lodgepole pine leading stands within the Cascades Forest District to map the 2003 and 2004 attack by the mountain pine beetle. Stand Visualization System software showed the pattern of attack by the mountain pine beetle in plots where a central tree was baited with mountain pine beetle pheromones. Attack and emergence densities were recorded for selected trees.

The effects of hazardous fuel reduction treatments in the wildland urban interface on the activity of conifer-infesting bark beetles in ponderosa pine stands

Authors: Christopher J. Fettig[1], Joel McMillin[2], John A. Anhold[2], Shakeeb Hamud[1], Steven J. Seybold[1] and Robert R. Borys[3]

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Abstract: Selective logging, fire suppression, forest succession, and climatic changes have resulted in high fire hazards over large areas of the western USA. Federal and state hazardous fuel reduction programs have increased accordingly to reduce the risk, extent and severity of these events, particularly in the wildland urban interface. In this study, we examined the effect of mechanical fuel reduction treatments on the activity of bark beetles in ponderosa pine, *Pinus ponderosa* Dougl ex. Laws., forests located in Arizona and California, USA. Treatments were applied in both late spring (April-May) and late summer (August-September) and included: (1) thinned biomass chipped and randomly dispersed within each 0.4 ha plot; (2) thinned biomass chipped, randomly dispersed within each plot, and raked 2 m from the base of residual trees; (3) thinned biomass lop-and-scattered (thinned trees cut into 1-2 m lengths) within each plot; and (4) an untreated control. The mean percentage of residual trees attacked by bark beetles ranged from 2.0% (untreated control) to 30.2% (plots thinned in spring with all biomass chipped). A three-fold increase in the percentage of trees attacked by bark beetles was observed in chipped versus lop-and-scattered plots. Higher levels of bark beetle colonization were associated with spring treatments, which corresponded with peak adult beetle flight periods as measured by funnel trap captures. Raking chips away from the

base of residual trees did not significantly affect attack rates. Several bark beetle species were present including the roundheaded pine beetle, *Dendroctonus adjunctus* Blandford (AZ), western pine beetle, *D. brevicomis* LeConte (AZ and CA), mountain pine beetle, *D. ponderosae* Hopkins (CA), red turpentine beetle, *D. valens* LeConte (AZ and CA), Arizona fivespined ips, *Ips lecontei* Swaine (AZ), California fivespined ips, *I. paraconfusus* Lanier (CA), and pine engraver, *I. pini* (Say) (AZ). *Dendroctonus valens* was the most common bark beetle infesting residual trees. A significant correlation was found between the number of trees chipped per plot and the percentage of residual trees with *D. valens* attacks. A significantly higher percentage of residual trees were attacked by *D. brevicomis* in plots that were chipped in spring. Engraver beetles produced substantial broods in logging debris, but few attacks were observed on standing trees. At present, no significant difference in tree mortality exists among treatments. A few trees appeared to have died solely from *D. valens* attacks, as no other scolytid attacks in the upper bole were observed. In a laboratory study conducted to provide an explanation for the bark beetle responses observed in this study, monoterpene elution rates from chip piles declined sharply over time, but were relatively constant in lop-and-piled treatments. The quantities of β-pinene, 3-carene, α-pinene, and myrcene eluting from chips exceeded those from lop-and-piled slash during each of 15 sample periods.

Disruption of western pine beetle, *Dendroctonus brevicomis* (Coleoptera: Scolytidae), response to baited traps with non host angiosperm volatiles and verbenone

Authors: Christopher J. Fettig[1], Stephen R. McKelvey[1] and Dezene P.W. Huber[2]

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Abstract: Non-host angiosperm volatiles and verbenone were tested for their ability to disrupt the response of western pine beetle, *Dendroctonus brevicomis* LeConte, to attractant-baited multiple funnel traps. Verbenone significantly reduced attraction, however, no difference was observed between 4 and 50 mg/24 hr release rates. Combinations of six bark volatiles (benzyl alcohol, benzaldehyde, *trans*-conophthorin, guaiacol, nonanal, salicylaldehyde), three green leaf volatiles [(*E*)-2-hexenal, (*E*)-2-hexen-1-ol, and (*Z*)-2-hexen-1-ol], and the nine compounds combined did not significantly reduce *D. brevicomis* response to attractant-baited traps. However, a significant effect was observed when the bark and green leaf volatiles were combined with verbenone. The nine nonhost angiosperm volatiles (NAV) significantly augmented the effect of both release rates of verbenone, reducing trap catches to levels significantly below that of either release rate of verbenone alone. *trans*-Conophthorin, a compound reported to have behavioral activity in a number of other scolytids, was not critical to the efficacy of our NAV blend. Our results suggest that the addition of nonhost

angiosperm volatiles to verbenone could be important for developing successful semiochemical-based management techniques for *D. brevicomis.*

Weather factors associated with spruce aphid (*Elatobium abietinum* Walker) outbreaks in southeast Alaska

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Abstract: Spruce aphid (*Elatobium abietinum* Walker (Homoptera: Aphididae)) is an exotic insect introduced to the Pacific Northwest in the early 1910s. By the late 1920s it was distributed throughout the coastal Sitka spruce (*Picea sitchensis* (Bong.) Carr.) range from northern California to Alaska. This insect feeds on needle phloem fluids of dormant spruce. Outbreak frequency in southeast Alaska has increased alarmingly in recent years, from approximately 1 in 12 years to more than 1 in 2 years since 1970, with a corresponding increase in outbreak severity. In European areas with maritime climates, spruce aphid is known to incur springtime outbreaks after mild winters, so we analyzed weather data from Sitka-Japonski for patterns associated with outbreaks in southeast Alaska. At Sitka, mean annual daily midpoint temperature has increased by 2.2°C since 1944 (3.7C°/100 yrs), and mean December and January midpoint temperatures have increased 1.9 and 2.7°C (3.2 and 4.6 and 0°C has decreased by 21 days each. Winter minimum temperatures now seldom fall below -12°C, while minimums of -16 to -18°C used to be common. The frost-free period is about 15 days longer. Years with widespread springtime spruce aphid outbreaks occurred after winters with minimum temperatures above -11°C, relatively few freezing events, few cold events below -5°C (especially years in which the few cold events were closely spaced), early timing of the last spring frost, and normalized mean DJF midpoint temperatures above zero. If contemporary weather patterns continue, spruce aphid outbreaks will continue to be frequent and severe, and Sitka spruce stands will decline. Coastal fringe and lowland stands are most at risk.

Scolytus schevyrewi Semenov, the banded elm bark beetle, an exotic pest of elms in the United States

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Abstract: *Scolytus schevyrewi* Semenov, the banded elm bark beetle, was first detected in North America in April 2003 in Colorado and Utah by the Rapid Detection and Response Pilot Project sponsored by APHIS and USDA Forest Service, Forest Health Protection. After its detection, studies were initiated in June 2003 and are continuing on its biology and chemical ecology. Since April 2003, *S. schevyrewi* has been detected in 22 states. The life cycle of *S.*

schevyrewi was completed in 30 days in an enclosed shed, but may take longer under field conditions. Studies conducted in 2003 and 2004 tested attractants for the detection and monitoring of *S. schevyrewi.* Lindgren funnel traps baited with various attractants were used with five treatments replicated eight times in 2003 and six treatments replicated seven times in 2004 and located on the Denver Federal Center in Lakewood, CO. In 2003, treatments included: Multilure^{TM}, an attractant for *Scolytus multistriatus*; Ips typographus attractant (2-methyl-3-buten-2-ol, cis-verbenol, and racemic ipsdienol) from IPM Tech; 4-methyl-3-heptanol from Phero Tech; 2-methyl-3-buten-2-ol formulations from IPM Tech; and a control. In 2004, the 4-methyl-3-heptanol and the Ips typographus attractants were dropped and 2-methyl-3-buten-2-ol formulations from Phero Tech and ChemTica and 3-methyl-3-buten-1-ol from ChemTica were added. Traps with Multilure^{TM} catch both *S. schevyrewi* and *S. multistriatus*. In 2003, traps baited with Multilure^{TM} and 2-methyl-3-buten-2-ol caught more insects than traps baited with other lures. 2-Methyl-3-buten-2-ol attracts *S. schevyrewi* almost exclusively; this may be important in the design of detection surveys. *S. multistriatus* was more selective in its response to treatments. Collections from all treatments were combined and used to examine flight patterns. Early flights of *S. schevyrewi* seem to be much more temperature dependent than flights of *S. multistriatus*. *S. schevyrewi* appears to have two flight periods, and likely two generations per year (similar to *S. multistriatus*). The second peak of *S. schevyrewi* was more predictable, occurring mid- to late July. *S. multistriatus* appears to have predictable peaks in mid- to late May and late August.

Forest entomology teaching resources at UBC Forestry

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Abstract: The web site FETCH21 (Forest Entomology Textbook CHallenge for the 21st Century) was developed to support the teaching of forest entomology to third year Forestry students at UBC. Originally designed to link to relevant forest entomology web sites around the world, the site has been expanded to include a hypertext laboratory manual, self testing items as well as course bulletins and updates. A correspondence version of the third year course was migrated to WebCT in 2005. The WebCT course draws on the information in FETCH21 which still remains available to the general public.

Western pine beetle *(Dendroctonus brevicomis)* outbreak on the Spokane Indian reservation in eastern Washington

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Abstract: The western pine beetle feeds and breeds in ponderosa pine, and is a primary tree killer. It usually attacks individual large, slow-growing, diseased or damaged trees. It is also common for these beetles to kill groups of densely-stocked young trees, particularly during times when tree vigor is low and beetle population is high.

There have been few recorded outbreaks of western pine beetle in response to storm damage. In eastern Washington, the only such outbreak on record occurred from 1931-1933. However, a population buildup of western pine beetles following winter storm damage to ponderosa pines on the Spokane Reservation has affected nearly 27,000 acres and killed over 100,000 trees. In November 2001, about 16,000 acres sustained severe winter storm damage, resulting in extensive top breakage in young (under 100 years), vigorous, well-spaced ponderosa pines. There were 15 to 25 trees per acre broken. The majority were larger than 10” dbh, and were broken below the live crown. The Tribe began salvaging these damaged stems.

Trees that have had tops sheared off are usually not attractive to bark beetles. Their roots will continue to take up water for some time, and the absence of a transpiring crown causes high oleoresin pressure, which beetles cannot overcome. But severe drought in 2001 resulted in low available soil moisture.

In June 2002 western pine beetles began to colonize standing boles & down logs. Blue stain made the wood unmarketable; salvage was suspended. In August 2002, newly emerged beetles attacked live trees in the area. Tree killing increased substantially. Group killing involved 15 to 50 trees, with 1 to 3 groups per 100 acres. According to aerial survey estimates about 26,600 acres were affected, and over 35,400 trees were killed. In 2003, another 42,000 trees were killed.

Field surveys were conducted in September 2004 to determine the extent of tree mortality for the current year. It is estimated that ponderosa pine mortality due to bark beetles will be as high in 2004 as it was in 2003. Trees attacked in 2004 will appear recently dead (red needles) in 2005, and will be recorded on the aerial survey.

Drought may have played a role in making these trees more susceptible to bark beetles. We conclude that extensive top breakage following severe drought can provide good habitat for western pine beetles, and result in an outbreak.

Effect of ***Atta texana*** (Hymenoptera: Formicidae) on soil nutrients, pH, and organic material.

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Abstract: *Atta texana* in Louisiana excavate huge nests in sandy soil and have a major impact on ecosystems through their foraging and excavation activities. We excavated nests and determined that ant's activity results in large differences in soil pH, percent organic matter, and several nutrients that may be important for plant growth.

Identification of antennally active non-host volatiles for the southern pine beetle, ***Dendroctonus frontalis***

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Abstract: In order to identify compounds that could potentially affect the behavior of southern pine beetles (SPB), *Dendroctonus frontalis* Zimm., we analyzed non-host volatiles (NHVs) commonly found in the bark and/or foliage of angiosperm trees. We hypothesized that SPB can detect some of these compounds, allowing the beetles to avoid unsuitable hosts. Using coupled gas chromatography-electroantennographic detection, we measured electrophysiological responses of SPB antennae exposed to approximately 100 ng of 11 synthetic NHVs. The largest responses were to hexanol, cis-3-hexen-1-ol, nonanal, and guaiacol. Smaller responses were recorded for benzaldehyde, methyl salicylate, and benzyl alcohol. The beetle antennae did not respond to hexanal, trans-2-hexenal, heptanal, and salicylaldehyde. None of the responses were as strong as those measured when the antennae were exposed to the inhibitory pheromone, verbenone. We also identified NHVs from six non-host hardwoods common in southern pine forests: sweetgum (*Liquidambar styraciflua* L.), blackjack oak (*Quercus marilandica* Muenchh.), black tupelo (*Nyssa sylvatica* Marsh.), southern red oak (*Quercus falcata* Michx. var. *falcata*), mockernut hickory (*Carya tomentosa* Nutt.), and black cherry (*Prunus serotina* Ehrh. var. *serotina*). These NHVs will be screened for electrophysiological activity in SPB. Compounds from both studies that elicit consistent antennal responses will be tested in behavioral bioassays.

Do bark beetle sprays prevent *Phloeosinus* species from attacking cypress and juniper?

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Abstract: *Phloeosinus*-caused mortality of Arizona cypress, *Cupressus arizonica*, one-seed juniper, *Juniperus monosperma* and alligator juniper, *J. deppeana* has been observed at high levels in Arizona during the past 3 years. Currently, there are limited preventative measures to protect high-value cypress and juniper trees against *Phloeosinus* attack. Insecticides that are being used to prevent bark beetle attack of individual high value pine trees may provide one method of protection.

This study was designed to determine the efficacy of Sevin SL (carbaryl), Permethrin Plus C (permethrin), and Biflex (bifenthrin) in protecting Arizona cypress and one-seed juniper from attack and colonization by cypress and cedar bark beetles (*Phloeosinus* spp.). Freshly cut bolts were used in the treatment as a surrogate to live trees. Treatments where 1.0% and 2.0% Sevin SL (carbaryl), 0.2% Pemethrin Plus C (permethrin), and 0.03% and 0.06% Biflex (bifenthrin).

Preliminary results using Arizona cypress indicate both the bifenthrin treatments and the permethrin treatment passed the binomial test (Null: successful defense = 90%), carbaryl did not. The bark beetle species attacking Arizona cypress was identified as *Phloeosinus cristatus*. Results from the one-seed juniper treatments were not conclusive since only 50% of the control bolts experienced beetle attacks; causing this experiment to fail to meet the criteria set for a rigorous test of the treatments. Attacking beetles were identified as *Phloeosinus scopulorum neomexicanus.*

The preliminary conclusions indicate Sevin SL (carbaryl) was not effective at a 2% formulation in preventing *Phloeosinus cristatus* attacks on Arizona cypress bolts, but was effective for protecting one-seed juniper at a 1% formulation. Both the 0.03% and 0.06% Biflex (bifenthrin) formulations and the 0.2% Permethrin Plus C (permethrin) treatment were effective at preventing successful *Phloeosinus* attacks on Arizona cypress and one-seed juniper. These single tree protection tests will be repeated in 2005 to draw more conclusive results, and will be extended to testing on alligator juniper.

Influence of elevation on bark beetle community structure in ponderosa pine stands of northern Arizona

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Abstract: Bark beetles killed more than 20 million ponderosa pine trees in Arizona during 2002 - 2004. Historically, bark beetle populations remained endemic and ponderosa pine mortality was limited to localized areas in Arizona. Consequently, there is a lack of information on bark beetle community structure in ponderosa pine stands of Arizona. Furthermore, it is unknown how elevation influences the community structure of these bark beetles. Understanding the bark beetle complex at different elevations will enable development of more effective forest management guidelines.

Ten ponderosa pine stands were selected in each of three elevational zones in north-central Arizona: 1) Low ~5500 ft, 2) Mid~7000 ft, 3) High~8500 ft. Three Lindgren funnel traps were placed at each of the 30 sites. Each trap was baited with a different combination of commercially available lures developed for *Ips pini*, *I. lecontei* and *Dendroctonus* spp. Traps catches were collected weekly (April – November) during 2004. Beetles and associated insects (predators and wood borers) were identified and tallied in the lab.

A total of 31,010 pine bark beetles belonging to 15 species were trapped and identified in 2004. More than 3,000 associated invertebrate predators and woodborers were collected. Preliminary observations indicate that *Ips* species in aggregate were most abundant at low elevation sites; however, individual species showed different distribution patterns. *Ips pini* was evenly distribution across elevations while *I. lecontei* and *I. calligraphus* numbers decreased with increasing elevation. *Dendroctonus* species in sum were most abundant at mid elevations; however, again there was considerable variation in distributions on the individual species level. *Dendroctonus frontalis* was much more abundant at low to mid elevations compared with the high elevation sites, while *D. brevicomis* was the most abundant at mid elevations. Numbers of other *Dendroctonus*, such as *D. valens*, *D. adjunctus*, and *D. approximatus*, increased with increasing elevation. The two most abundant invertebrate predators collected, *Enoclerus* spp. and *Temnochila* spp., also showed disparate distribution patterns across the elevation gradient. *Enoclerus* species increased with increasing elevation, while *Temnochila* were most abundant at low to mid elevation. The study will be repeated at the same sites in 2005, and will be used to determine seasonal flight periods for each species by elevation.

Effects of low intensity fires on resin production in lodgepole pine.

Author: Mary Reid, Dept. of Biological Sciences, University of Calgary, Calgary AB

Abstract: Low intensity fires are those that inflict some fire damage on trees, but do not immediately kill trees. Surviving trees in stands experiencing low-intensity fires may have altered tree defences as a result of two processes. First, defences may vary among trees within a stand depending on the extent of fire damage each tree experiences. Second, fire may alter the nutrient dynamics of the whole stand relative to unburned stands. I examined these processes in 4 lightly-burned stands and 5 unburned stands by measuring oleoresin production. Within burned stands, the resin response of live trees declined as burn intensity increased, but this was only significantly different for the highest intensity burn class relative to the 3 lower intensity burn classes. Overall, however, trees in the lower three burn classes had higher resin production than trees in unburned stands. Thus the effect of fire on tree defences vary with the scale at which defences are measured, such that caution should be exercised in predicting the change in vulnerability of trees to insects and pathogens as a result of low intensity fires.

Spatial movements of Douglas-fir beetle populations in Colorado and Wyoming

Authors: John R. Withrow, Jr[1] and Jose F. Negron[2], USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO

Abstract: The present study introduces a novel GIS technique that has proven useful in quantifying the spatial shifts in infestations of the Douglas-Fir beetle using aerial survey data in Colorado and Wyoming from 1994 to 2004. The results are presented for four different study areas and are displayed with corresponding graphs of total infestation area for each year. Travel distances appear in some instances to reach as high as eight to nine kilometers. Each study area appears to display beetle populations at different stages of epidemic dynamics, but for all four study areas a momentary increase in beetle movement distance appears to precede a transition to much higher beetle populations.

Group Photographs from WFIWC 2005, Victoria BC

Back: Dave MacLean, Kees van Frankenhuyzen, Richard Fleming, René Alfaro
Front: Frank Cross, Imre Otvos, Roy Shepherd, Ward Strong, Jim Vandygriff, Donovan Gross.

Back: Kangakola Omendja, John Withrow, Jr., Sally McElwey, John Popp, Cindy Broberg
Front: Stephani Sandoval, Jennifer Klutsh, Sheryl Costello, Nancy Gillette.

Back: Leo Rankin, Brian Sullivan, Nadir Erbilgin, David Wakarchuk, Tim Cudmore
Front: Ashley Lamb, Josie Hughes, Tanya Latty, Cam Oehlschlager.

Joe Cortese, Bill Schaupp, Beth Willhite, Lorraine Maclauchlan, Connie Mehmel, Kathleen Johnson.

Andrea Schiller, Angus Shand, Laura Benson, Dion Manastyrski.

Jim Heath, Nicholas Conder, Robert Hodgkinson, Lee Humble.

Back: Robb Bennett, Tim McConnell, Carlos Magallon, Robert Borys, Antonio Quiroz
Front: Bruce Thompson, Mary Ellen Dix, Zhong Chen, Carroll Williams, Robert Coulson.

Back: Eveline Stokkink, Matt Hansen, David Beckman, Doug Wulff
Front: Alan Vandry, Peter Hall, Barbara Bentz, Bob Cain.

Back: Karen Cryer, Joshua Jacobs, Michelle Barkway
Middle: Dave Langor, Matti Koivula, Jason Edwards, Chris MacQuarrie, Rick Stock
Front: Colin Bergeron.

Back: James Kruse
Middle: Danny Cluck, Jerry Carlson, Tom Eager, Erik Johnson, Lia Spiegel, David Bridgewater
Front: Richard Hofsteter, Deepa Pureswaran, Jesus Cota, Roger Burnside.

Back: William Ciesla, Bruce Hostetler, William Shepherd, Benjamin Smith, Andy Eglitis, Ken Gibson
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