Proceedings

of the

51st Annual Meeting

of the

Western Forest Insect

Work Conference

Portland, Oregon

February 7-10, 2000

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Information for Conference Members Only

Articles were reformatted for consistency, but otherwise printed as submitted. Authors are responsible for content.

Executive Committee

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Ladd Livingston, Treasurer
Mark Schultz, Secretary
Bob Hodgkinson, Counselor
Darrell Ross, Counselor
Roger Burnside, Counselor

2000 Program Committee

Darrell Ross, Chair
Bruce Hostetler, Local Arrangements
Chris Niwa
Dave Overhulser
Carol Randall

Acknowledgements

In addition to the program committee, many other people helped to make the 51st Meeting of the Western Forest Insect Work Conference a success. In particular, thanks go to all of the members who suggested session topics and/or agreed to serve as session moderators. Kevin Dodds, Maureen Duane, and Teri Lysak, graduate students at Oregon State University, helped transport supplies and equipment to the meeting site, staffed the registration desk, and helped setup and take down audiovisual equipment and poster boards. Andrew Lawson, graduate student at the University of California – Berkeley, helped to setup and take down audiovisual equipment and poster boards and assisted in taking the group photographs. A special thanks goes to Oregon Department of Agriculture personnel, Karl Puls, Alan Mudge, Kathleen Johnson, and Nancy Osterbauer, and USDA APHIS Plant Protection and Quarantine personnel, Patricia Fitterer and Gary Brown, for organizing and leading an informative "field" trip through the Portland metropolitan landscape on "Monitoring Wood Imports and High-Risk Sites for Exotic Pests".

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Final Conference Program

Final Program for the Western Forest Insect Work Conference 2000, Portland, Oregon, February 7-10, 2000

Monday, February 7 (2:00-9:00 pm)

2:00-8:00	Registration	LL1 Lobby
4:00-6:00	WFIWC Executive Committee Meeting	
6:00-9:00	Mixer	Mount Hood (R Level)

Tuesday, February 8 (8:00 am - 5:00 pm)

8:00-5:00	Registration	LL1 Lobby
8:00-9:00	WFIWC Business Meeting	Salon E
9:00-9:15	Welcome and Introductions	Salon E
9:15-10:00	Keynote Address	Salon E

The Challenges Facing Forest Ecosystem Health in the 21st Century: Disturbance, Density, Diversity, and Development, **John D. Walstad and John C. Tappeiner, Oregon State University.**

10:00-10:30	Morning break	LL1 Lobby
10:30-12:00	Concurrent Sessions	

1. Student Papers I (Darrell Ross) — Salon A

Western Forest Insect Collection: vouchers, curation and future direction, **Jason Leathers**.

Traps or trap trees: which is more effective for capturing *Dendroctonus pseudotsugae*?, **Kevin Dodds and Darrell Ross**.

Whitebark pine restoration treatments: effects on bark beetle attack rates, **Kristen Baker and Diana Six**.

Evaluation of pheromone baits for the western balsam bark beetle, *Dryocoetes confusus* Swaine (Coleoptera: Scolytidae) and partial elucidation of the pheromone for *Dryocoetes autographus* Ratzeburg, **Nicole L. Jeans-Williams and John H. Borden**.

2. Student Papers II (Mike Wagner) — Salon D

Forest vulnerability to a western spruce budworm outbreak, **Everett Isaac**.

Regional patterns in relative importance of selected mortality agents: past present, and projected, **Brytten Steed and M.R. Wagner**.

Distribution and impact of *Cryptorhynchus lapathi* L. (Coleoptera: Curculionidae) on *Salix* spp. in British Columbia, **Cindy Broberg and John H. Borden**.

Hazard rating system for spruce weevil (*Pissodes strobi*) in Sitka spruce in the northern Oregon Coast Range, **Teri Lysak, Darrell Ross, and Dave Overhulser**.

3. Interactions Among Insects, Disease, and Threatened, Endangered, and Sensitive Species (Beth Wilhite) — Salon E

Western spruce budworm, northern spotted owl, and the Mardon skipper on the Gifford Pinchot National Forest, **Beth Willhite**.

Management challenges for northern spotted owl habitat on the Deschutes National Forest, **Andris Eglitis**.

Lynx habitat/mountain pine beetle management on the Loomis State Forest in Washington, **Karen Ripley**.

Eagle nest tree and pine bark beetle management on private industrial timberlands near Klamath Lake, **Dave Overhulser**.

12:00-1:30 Lunch (on your own)
1:30-3:00 Plenary Session — Salon E

Y2K and 10K Bugs: Biodiversity Challenges in Research and Management (Andy Moldenke)

Introduction, **Andy Moldenke (OSU)**.

Management priorities and suggestions, **Judy Nelson (BLM) and Cheryl McCaffrey (BLM)**.

Academic priorities and suggestions, **Andy Moldenke (OSU) and Bruce Marcot (USFS)**.

Environmentalist priorities and suggestions, **Dominick DellaSala (WWF)**.

Example of ecosystem-level biodiversity study, **Paul Hammond (OSU) and Jeff Miller (OSU)**.

3:00-3:30	Afternoon break	LL1 Lobby
3:30-5:00	Concurrent Sessions	

1. Non-host Volatiles and Bark Beetles (John Borden) — Salon D

2. Management Implications of Arthropod Abundance and Diversity (Andy Moldenke) — Salon A

   Role of headwater streams, **Rob Progar**.

   Aspects of soil biodiversity, **Nancy Rappaport**.

   Canopy diversity alder vs. Douglas-fir, **Brett Schaerer**.

   Soil microarthropod biodiversity, **Bob Peck**.

   Forest floor biodiversity, influence of riparian buffers, **Andy Moldenke**.

   Canopy biodiversity comparisons between old-growth and mature forests, **Tim Schowalter**.

   Forest floor macroinvertebrate fauna, **Tim Work**.

   Insects as a bird food resource, **Alyssa Doolittle and Joan Hagar**.

3. Insect/Pathogen/Tree Interactions – Where Do We Go From Here? (Andrew Storer) — Eugene

4. Current Status of Insects in the West (Bill Schaupp) — Portland

Wednesday, February 9 (8:30 am – 9:30 pm)

8:30-10:00	Posters with authors present and continental breakfast	Salons B and C
10:00-12:00	Concurrent Sessions	

1. E-Bugs! Cool Internet Sites for Forest Entomology (Kathy Sheehan) — Eugene

2. Spruce Weevil: Current Research and Management (Darrell Ross and Rene Alfaro) — Portland

   Participants/presenters:
   John Borden and A. Tanaka
   Rene Alfaro
   John King
   John Manville and Tara Sahota
   Mike Hulme.

3. Monitoring Wood Imports and High-Risk Sites for Exotic Pests (Kathleen Johnson) — Salon D

4. Mountain Pine Beetle, The Next Wave: Part II (Joel McMillin) — Salon A

   The Beaver Park experience: Trials and tribulations with mountain pine beetle in the Black Hills, **Kurt Allen and Joel McMillin**.

   Manipulation of mountain pine beetle populations in a push/pull strategy for improved fuelwood harvest management, **Jim Vandygriff, Jesse Logan and Barbara Bentz**.

   Competitive interactions between MPB and secondary bark beetles**, Terry Shore and Les Safranyik**.

   The mountain pine beetle in southwestern type ponderosa pine, **Barbara Bentz**.

12:00-1:30	Lunch (on your own)	
1:30-5:00	Field Trip – Monitoring Wood Imports and High-Risk Sites for Exotic Pests (Oregon Department of Agriculture)	Lobby
6:30-9:30	Dinner	Salon E

Thursday, February 10 (8:30 am – 5:00 pm)

8:30-10:00 Concurrent Sessions

1. Douglas-fir Tussock Moth – Current Issues, Part I (John Wenz) Salon A

   Summary of 1997-99 California outbreak, **John Wenz**.

   Early warning pheromone system 1980-1999: Analysis and current status (i.e., Does it work? Are there modifications that need to be made to the system?), **Gary Daterman**.

   What follow-up actions to increased trap catches are appropriate?

   Use of artificial (cryptic) shelters to sample pupae/egg masses.

2. Insects of Whitebark Pine: Present Knowledge and Future Directions (Diana Six) Eugene

   Overview of insects utilizing whitebark pine, **Diana Six**.

   Seed and cone insects of whitebark pine, **Sandra Kegley**.

   Mountain pine beetle-caused mortality in whitebark pine stands following outbreaks in lower elevation lodgepole pine stands in western Montana, **Ken Gibson**.

   Modeling climate change induced invasion of whitebark pine by mountain pine beetle, **Jesse Logan**.

3. Biological Control Programs for Insects in the Urban Forest (Don Dahlsten) Portland

4. Arthropod Utilization of Coarse Woody Debris (Chris Niwa) Salon D

   Arthropods and coarse woody debris in southern pine forests, **James L. Hanula**.

   Wood-boring beetles and prescribed fire in southwestern Oregon: a retrospective study, **Maureen V. Duane,**

Darrell W. Ross, and Christine G. Niwa.

Sampling methodologies and parameters for characterizing log resources, **Torolf R. Torgersen and Lisa J. Bate.**

Coarse woody debris arthropod research at Blacks Mt. Experimental Forest, **Jeffrey P. Lemieux, Timothy D. Schowalter, and Nancy G. Rappaport**.

10:00-10:30	Morning break	LL1 Lobby
10:30-12:00	Final WFIWC Business Meeting	Salon A
12:00-1:30	Lunch (on your own)	
1:30-3:00	Concurrent Sessions	

1. Douglas-fir Tussock Moth – Current Issues, Part II (John Wenz) — Salon A

   Current status of DFTM in Oregon and Washington, **Iral Ragenovich**.

   - Draft Environmental Impact Statement
   - Comparisons with past outbreaks
   - Significant issues
   - Discussion of management alternatives:
     - No action
     - *Bacillus thuringiensis var. kurstaki*
     - Nuclear polyhedrosisis virus
     - Mating disruption
       - Pheromone registration- what priority?
     - Combinations of Bt.k and/or NPV with mating disruption

2. An Overview of Woodboring Insects: Current Research and Associations with Forest Disturbances (Steve Seybold) — Eugene

3. Management Challenges in High Elevation Ecosystems (Lorraine McLaughlin) — Salon D

4. Using MCH to Manage the Douglas-fir Beetle (Darrell Ross) — Portland

3:00-3:30	Afternoon break	LL1 Lobby
3:30-5:00	Concurrent Sessions	

1. Douglas-fir Tussock Moth – Current Issues, Part III

(John Wenz) Salon A

Current research on NPV

Shelf-life of TM-BioControl, **Barbara Kukan**.
TM-BioControl bioassays with natural populations, **Imre Otvos**.

Potential methods to detect NPV in DFTM populations in the field, **Imre Otvos**

Registration issues- if TM-BioControl is not able to be registered in specific states (e.g., CA), should identified "data gaps" be filled . What are the consequences of not having TM-BioControl registered in a given state(s)?

How much TM-BioControl is currently available and is there a need to produce more?

2. Sucking Insect Response to Environmental Change
(Ann Lynch) Eugene

3. Douglas-fir Beetle: Recent Research and Management
(Darrell Ross) Portland

Douglas-fir beetle response to pruning for dwarf mistletoe, **Jim Hadfield**.

Douglas-fir beetle response to thinning and residual felled trees in western Oregon, **Bruce Hostetler and Darrell Ross**.

Analysis of Douglas-fir beetle population dynamics from aerial survey data, **Carol Randall**.

Douglas-fir beetle pheromone trapping studies in northern Idaho, **Sandy Kegley**.

4. Insect Response to Fire (Ken Gibson) Salon D

Adjourn

Poster Presentations

1. Attraction of *Scolytus unispinosus* bark beetles to water stressed branches of Douglas-fir containing ethanol, **Rick G. Kelsey and Gladwin Joseph**.

2. Impacts of Douglas-fir beetle on forest overstory and understory of the Greater Yellowstone Area, **Joel D. McMillin and Kurt K. Allen**.

3. Decision support matrix for long-term development planning in the boreal forest to mitigate economic losses resulting from spruce decline syndrome, **M.A. Duthie-Holt, R.R. Setter, R. Bonny, and I. Wilson**.

4. Model Analysis of mountain pine beetle seasonality, **Jesse A. Logan and Barbara J. Bentz**.

5. The red gum lerp psyllid – a new pest of *Eucalyptus* in California, **D.L. Dahlsten, D.L. Rowney, A.B. Lawson, K.A. Davidson, W.E. Chancy, K. Robb, and J.N. Kabashima**.

6. Edge-effects on ground arthropod species composition and community structure in old-growth forests, **Timothy T.Work and Timothy D. Schowalter**.

7. Moisture and saprotroph effects on respiration from coarse woody debris, **T.D. Schowalter, R.A. Progar, C.M. Freitag, and J.J. Morrell**.

8. Canopy arthropod communities among Douglas-fir forests in the Pacific Northwest, **R.A. Progar and T.D. Schowalter**.

9. Arthropod community structure in regenerating Douglas-fir forests: influence of tree diversity, density, apparency, and quality, **Brett Schaerer**.

10. Development and implementation of IPM for the elm leaf beetle (*Xanthogallerucae luteola*) in a large urban area (Sacramento, CA), **Andrew Lawson, Donald Dahlsten, David Rowney, Martin Fitch, and Jennifer Lystrop**.

11. Resistance of elms (*Ulmus* sp.) and elm hybrids to elm leaf beetle (*Pyrrhalta luteola*) under field conditions in east central Arizona, **Paul P. Bosu, Michael R. Wagner, Frederic Miller, and Steve Campbell**.

12. Pupal diapause of *Coloradia pandora*: thermal constraints on successful pupation, **Elizabeth A. Gerson, Rick G. Kelsey, and Darrell W. Ross**.

13. North American Forest Insect Work Conference 2001, **J. Volney, J. Spence, and H. Ono**.

14. Scolytidae and associated insects in ponderosa pine stands under different structural conditions in northern Arizona, **Guillermo Sanchez-Martinez and Michael R. Wagner**.

15. Ground beetle community structure as indicator of forest health in *P. ponderosa* and *P. hartwegii* stands, **J. Villa-Castillo and M.R. Wagner**.

16. Monitoring wood imports and high-risk sites for exotic pests, **Kathleen Johnson, Nancy Osterbauer, and Alan Mudge**.

Executive Committee Meeting

Western Forest Insect Work Conference
51st Annual Meeting
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7 February, 2000

Present were: Tom Eager, Chair
Darrell Ross, Counselor and 2000 Conference
Ladd Livingston, Treasurer
Bruce Hostetler, 2000 Local Arrangements
Roger Burnside, Counselor
Boyd Wickman, Founders Award Committee
Mark Schultz, Secretary

The Chair called the meeting to order at 4:15 PM.

Ladd said that Ann Lynch reported that the proceedings for the Rapid City Meeting 1995 were complete and ready for the printer.

The **Minutes of the Executive Committee** held on 13 September, 1999 were read. Darrell moved to accept the minutes, seconded, and motion passed. It was agreed to include the 1999 minutes in the 2000 Proceedings.

Committee Reports

The **Founders Award Committee** Report was presented by Boyd Wickman.

Bill Ives was selected for this meeting but could not come because he is on crutches. A plaque will be awarded next year. Ladd would like to ask Bill if he would write something up for the proceedings. Darrell will send a letter to him to see if he wants to submit something. Les Safranyik wants to resign from the committee. We would like to find a Canadian to replace Les. John Bordon selected for the Founders award. Also, John Schmidt should be given credit for doing the plaques.

Common Names Committee:

Tom asked who was on that committee and no one present knew. Boyd said that Torgy Torgenson is one of the members. He thought that Torgy would have a report at the Initial Business Meeting (IBM).

History Committee report presented by Boyd Wickman**:**

Mal Furniss and I have written a one and one-half page report that Mal was going to send me. Ladd suggested that it could be faxed to the hotel and read at the Final Business Meeting (FBM). Also, the biography of Walter Buckhorn, submitted to the American Entomologist should come out this year. Part one of the entomology photo history that was in an issue last year. Part 2, on the PNW station entomologists will come out this year. Tom suggested that we read the notes at the FBM.

Memorial Scholarship Fundraising Committee report presented by Tom Eager**:**

Lorraine McLauchlan, Mike Wagner, and Don Dahlsten are on the committee. They are working hard to come up with a selection of awardees for this meeting.

Treasurers Report presented by Ladd Livingston:

Bill Schaupp has money in an account from the Rapid City meeting. Ann has the mailing list and the Rapid City proceedings will go to the printer shortly. No disbursement of funds will occur from the Breckenridge meeting until after the proceedings is sent out. I have not heard from pathologists yet on what the dollar amount might be. It will be split according to meeting attendence.

There $14,000 in the checking account (largely due to the registration from this meeting), $3,100 in the McGregor CD, $6,700 in the Memorial Fund CD, and $2,921.29 of CD interest and earned receipts in the savings account (copy attached). Any excess over $4,000 in the checking account gets put into the savings account.

In regards to the tax-exempt status the IRS sent me a letter that they need more information. They need the criterion about how the Memorial Scholarship Fund is awarded along with several other questions before they will grant tax-exempt status. Darrell suggested that though the list of applicants come from the whole membership the committee will make the selection. Ladd will provide a copy to the selection committee of what the IRS wants. Once we gain tax-free status we will have to do an IRS report every year. Right now there is no need for tax-exempt status because we have not paid any taxes. Karen and Steve believe that pursuing tax-exempt status is worth it because of the cooperate money that might be attracted. If filling out the paper work is too great a task Ladd will hire an accountant.

Tom asked for a volunteer to audit the books. No-one volunteers. Lorraine (past chair) and Tom will do the audit.

Ralph Their will report on the letter sent by Senator Craig in November to obtain MCH registration.

Darrell said that Jan and John have sent him a letter concerning the title of the meeting in Alberta in 2001.

New Business:

Item 1: Darrell offered to host a WFIWC permanent web site at Oregon State. Kathy Sheehan is willing to continue to work on it as she has done for this meeting. Tom will ask Ann and get the vote of the membership in the initial business meeting. Boyd would like to get the award criteria for the Founders award on the web site.

Item 2: Darrell reported on a policy for commercial exhibitors at the meeting. Dave Overhulser, Bruce Hostetler and I talked it over and decided that commercial exhibits could be a good marketing opportunity. We decided on a price would be $200 for a poster board and table. We might want to generate a list of companies and sent them a letter previous to the meeting. Pherotech, IPM technologies, and Great Lakes IPM are the companies I can think of that could receive this invitation. Ladd thought that the membership discussed this some years ago. The mixer was paid for and it bothered some people. We might want to go back and look at the business notes of previous meetings. We could also ask the provider of that the outcome of that policy. Darrell will draft a proposal for the FBM and mention it at the IBM.

Item 3: Darrell thinks that based upon the comments he heard that the membership should reassess the need for a joint meeting with the pathologists. There was no real integration in Breckenridge but the amount of work to stage the meeting was considerable. Joint sessions can be organized within each conference. Boyd stated that the Albuquerque meeting got integrative. Tom wondered if it is in our charter that we will meet jointly every five years. We can bring this up to whole body at the IBM.

Item 4: Ladd would like the information required by the IRS put in our constitution. Tom said at the IBM we will vote on it.

Item 5: Tom discussed the 2002 meeting in Mexico. There is an invitation from R1 if the Mexican government can not host it. We will ask some of the membership, Andy Eglitis for one, to help our Mexican representatives with some of the meeting organization. If there is no commitment in 6 months (by end of July) the meeting will go to R1. We will then try to get the meeting rescheduled for Mexico in 2003.

Item 6: Tom said we needed to vote for a new chair and one new councilor.

Darrell motions Bruce seconds to adjourn.

Initial Business Meeting

Western Forest Insect Work Conference
51st Annual Meeting
Portland, Oregon

8 February, 2000

Chair Tom Eager called the meeting to order at 8:00 AM.

Secretary Mark Schultz read the minutes of the 1999 Final Business Meeting. The notes were accepted as is. Darrell moved that the minutes be accepted, they were seconded by Terry, and passed.

The Secretary read the minutes of the 2000 Executive Committee meeting. Jon Volney moved that the minutes be accepted, seconded by Bill Schaupp, and passed.

Ladd Livingston presented the Treasurer's report. There was a voice vote to approve the report. Funds were set aside for the Rapid City proceedings and there should be no impact on our balance.
The IRS received our application for tax-exempt status but they sent a list of items for additional information. There was a $150.00 processing fee for applying for tax-exempt status. ***1.*** We need some criteria of how the scholarship award is made and what we would do with the money if the awardee is not able to receive it. Lorraine was given the list of questions. Ladd mentioned that we have to get through this process before we release scholarship monies. ***2.*** We have to promise not to do anything wrong with donated funds as a tax-free entity. ***3.*** The IRS wrote that our organization does not meet their organization test. Eric wondered what were the right answers to their questions. Ladd talked with an IRS representative but nothing was offered as possible answers. Ann Lynch said that she was familiar with this process for two other organizations. IRS rejected those requests for the first two applications but finally approved the request. We might have to hire a tax attorney to narrow down the list of questions. Roger Burnside suggested that we contact another organization and pattern our application after theirs. Roger thought that he could provide Ladd with that information from a similar organization. Ladd said that he tried to do this some years ago. Bruce Hostetler suggested that it might be easier in Canada. Ann offered that the majority of members were from the US. Dave Wood said that the California Forestry Pest Action Council had obtained TF status. A motion was made by Mike Wagner to include the IRS paragraph in the constitution and was this seconded by Bill (note: a two-thirds vote of the membership is needed to include this into the constitution).

Founders Award Committee report presented by Boyd Wickman:
For the 2001 meeting the Founders Award will be presented to John Bordon.

Common Names Committee report was presented by Torgy Torgensen. I have 206 names submitted for insects that are in Furniss and Carolin's Western Forest Insects. Iral Ragenovich, Larry Stipe, Lee Humble, and Torgy are on the committee.

Tom asks that committee reports be tabled until the FBM as we were getting short of time.

NEW BUSINESS

Jon gave an update on the May 14-18, 2001 meeting in Alberta. Sunil K. Ranasinghe and Hideja One from the Alberta Environmental Protection, Land and Forest Service and John Spence will help with meeting arrangements. The Canadian Forestry Minister signed off on it. The comments on a less expensive location were considered in choosing the location. We can not afford Banff so Edmonton was chosen. It will be comparable to the cost of the North American Forest Insect Work Conference meeting held in Texas in 1996. There will be a registration of $300 Canadian for members and $240 Canadian for students. There will be several technical sessions on Tuesday and Friday, two field trips and a poster session.

Tom said there were items for sale at the registration booth. The money goes into the scholarship fund.

Darrell reported that he had to make a decision about commercial exhibits for which there was no known policy. It was decided that $200 would be charged for a table and poster board and that these exhibits would be separate from the poster session but that he had had no takers yet. Please see him if you have any comments. He will develop a motion to present before the membership at the FBM .

Tom said that we have a new chair and councilor to nominate and elect. Mike Wagner is on the nomination committee.

Jon made a motion to adjourn and Bill seconded the motion.

Keynote Address

The Challenges Facing Forest Ecosystem Health in the 21st Century

John D. Walstad
Head, Forest Resources Department
College of Forestry
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and

John C. Tappeiner
Senior Research Forester
Forest and Rangeland Ecosystem Science Center
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Corvallis, Oregon

Forest ecosystem health is defined as "A condition where biotic and abiotic influences on forests do not threaten management objectives now and in the future" (Edmonds et al. 1999). Although vague in concept, healthy ecosystems do have some tangible features such as functional integrity, resiliency, sustainability, and a degree of diversity that is within the historic range of variability. Important forces affecting forest health are factors such as periodic disturbance, stand density, structural and biological diversity, and encroaching development by humans. This paper discusses the important features of each, with allusions to silviculture and the role of forest entomologists in fostering forest health.

Disturbance is the initial and necessary step in periodic forest renewal. It's triggered by both major catastrophic events like fire and wind as well as by more localized phenomena like root rot and lightning strikes. Drought, windthrow, and insect pests often play a predisposing role. Disturbance occurs at a variety of spatial and temporal scales, creating a diverse fabric of vegetation across the landscape.

The dynamic nature of disturbance makes it impossible to maintain forests in a steady state. Whether it be old-growth ecosystems or young plantations, forests undergo change. Active and adaptive management are needed to ensure that forests meet management objectives. Forest entomologists should participate in this process by understanding the role of insects, learning when to expect problems, and helping managers deal with them should they occur.

Stand density is the primary determinant of ecosystem structure, diversity, and trajectory. Consequently, it affects multiple attributes ranging from individual tree vigor to the quality of wildlife habitat. Suppression of wildfire, intensive harvesting, and aggressive reforestation have had dramatic effects on stand density throughout the Pacific Northwest. In general, stands are carrying far more growing stock than in previous centuries. This trend has important implications for both silviculturists and forest entomologists. Maintaining stand densities below certain thresholds will be crucial to avoid excessive outbreaks of bark beetles and other pests. A variety of silvicultural tools such as thinning and prescribed fire, coupled with the intelligent use of stand-density diagrams and risk-grading schemes, can be used to enhance forest health as stands develop.

Structural and biological diversity are keystones of ecological resilience and persistence. As Aldo Leopold taught us, “If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering” (Leopold 1949). So, it’s important to save all the pieces--at least somewhere. Otherwise, we risk losing some of the important species, key ecological functions, and future options contained within our current ecosystems. Providing for such diversity is not only prudent, it’s the law. Silviculturists, forest entomologists, and other disciplinary specialists will need to work together to foster this aspect of resource management. Forest entomologists are particularly needed to establish the significant linkages and interactions involving insects and other components of the ecosystem. This is an important area of basic research as well as public education.

The final factor affecting forest health is a relatively new one--encroachment by humans on our natural resources. Rapidly rising demand for both products and amenities is putting enormous pressure on wildlands, particularly forests and associated wildlife and riparian areas. Problems range from excessive extraction of raw materials to trampling of campgrounds, trails, and alpine areas. Urban and suburban expansion are carving into wildland areas at an alarming rate, and increasing global commerce threatens to introduce exotic pests. Forest entomologists--working with silviculturists, land-use planners, and other specialists--must help society anticipate and avoid devastating insect outbreaks associated with these kinds of perturbations.

Thus, there are significant challenges ahead in the 21st century. Working through them will require a combination of sound scientific knowledge, interdisciplinary teamwork, nimble management, and a measure of good luck. Forest entomologists should contribute at both the tactical and strategic levels as we address these challenges.

Literature Cited

Edmonds, R.L., J.K. Agee, and R.L. Gara. 1999. Forest Health and Protection. McGraw-Hill, New York, NY. 504 p.

Leopold, A. 1949. A Sand County Almanac. Various publishers.

Concurrent Sessions

Student Papers I

Moderator: Darrell Ross, Department of Forest Science, Oregon State University, Corvallis, OR

USDA Forest Service Western Forest Insect Collection (WFIC): Vouchers, Curation, and Future Direction

Jason Leathers, Department of Entomology, Oregon State University, Corvallis, OR

The WFIC is a voucher collection that contains most of the earliest forest insect collections made in the Northwest. In 1990 Representatives from the USDA Forest Service, the OSU Department of Forest Science, and the OSU Department of Entomology decided to consolidate the WFIC at Oregon State University with the Oregon State Arthropod Collection (OSAC). It was felt that locating the WFIC with OSAC and the H.J. Andrews Experimental Forest collection would provide a valuable resource for forest insect studies. The WFIC currently contains 88,760 specimens representing at least 3,117 species collected from 1906-1990. Such voucher specimens are valuable in identifying pests and associates, recording snapshots of biodiversity, tracking invasives, tracking species declines, tracking disease, and protecting the integrity of research. We assess priorities for curation during an annual profiling of the WFIC using the Smithsonian collection health index. Current priorities for 1999-2000 include removing all of the curation level ones from the collection. We would also like to increase use of the WFIC in the future. Microscopes, Hopkins folders, and microfiche are available to researchers working in the collection. Specimens are also available for loan and space is available for voucher material to be deposited. Information on use of the WFIC is available at http://www.ent.orst.edu/osac.

Traps or Trap Trees: Which is More Effective for Capturing *Dendroctonus pseudotsugae*?

Kevin Dodds and Darrell Ross, Department of Forest Science, Oregon State University, Corvallis, OR

Pheromone-baited traps and trap trees were compared to determine their efficacy in the management of Douglas-fir beetle (DFB) populations. Pheromone-baited traps caught significantly higher numbers of DFB than did trap trees. Significantly higher numbers of male DFB were caught in pheromone-baited traps than in trap trees, while significantly higher numbers of females were caught in trap trees. Additional benefits of pheromone-baited traps include, easy deployment, reduction of mortality to some beneficial insects, and low cost.

Whitebark Pine Restoration Treatments: Effects on Bark Beetle Attack Rates

Kristen M. Baker and Diana L. Six, School of Forestry, University of Montana, Missoula, MT

Whitebark pine is an important component of high elevation ecosystems in the western United States and Canada. Many wildlife species, such as grizzly and black bears, squirrels and birds, forage on the large, wingless seed. Whitebark pine relies heavily upon the Clark's nutcracker for seed dispersal and regeneration. Due to fire suppression, white pine blister rust, and the mountain pine beetle, whitebark pine is declining across most of its range. In western Montana, researchers are implementing restoration treatments to try to combat the decline and increase natural regeneration. Treatments include silvicultural strategies, prescribed fire, and combinations of the two; the treatment that best restores and preserves whitebark pine may be implemented at a large scale.

The study site was located on Beaver Ridge, Powell Area, Lochsa District, Clearwater National Forest. Silvicultural treatments at the study site were implemented in summer 1998. This study was to evaluate the effects of the restoration treatments on bark beetle attack rates. Tenth acre permanent plots were established throughout the treatment areas to measure tree data and complete the bark beetle surveys.

Logistic regression showed that bark beetles preferentially chose to attack trees in the nutcracker openings and slashing treatments over the control. As well, the mountain pine beetle attacked only whitebark pine at the site, which supports a mixed species forest with a significant lodgepole pine component. Whitebark pine had a smaller mean diameter and height, as well as significantly more bark beetle attacks per tree than lodgepole pine. Plots evaluated for two years, 1998 and 1999, showed no increase in bark beetle populations. These results suggest that type of restoration treatment affects the distribution of bark beetles, but may not cause an increase in beetle populations. The reasons underlying mountain pine beetle preference of whitebark pine warrants further examination. The results of this study show that managers must consider all components of the ecosystem before implementing whitebark pine restoration treatments.

Evaluation of Pheromone Baits for the Western Balsam Bark Beetle, *Dryocoetes confusus* Swaine (Coleoptera: Scolytidae) and Partial Elucidation of the Pheromone for *Dryocoetes autographus* Ratzeburg

Nicole L. Jeans-Williams, Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada

The western balsam bark beetle, *Dryocoetes confusus* Swaine (Coleoptera: Scolytidae), causes substantial mortality in subalpine fir forests in western North America. Management tools, including pheromone baits, are in demand by forest managers. A commercial (±)-*exo*-brevicomin bait is currently available. In past studies the greatest response by beetles to traps and baited trees was obtained with blends of (+)-*exo*- and (+)- or (±)-*endo*-brevicomin, which imitate the natural male-produced aggregation pheromone. I conducted trapping and tree-baiting experiments to determine whether low-release enantiospecific blends [9:1 (+)-*exo*-brevicomin: (+)-*endo*-brevicomin, or 9:2 (+)-*exo*-brevicomin: (±)-*endo*-brevicomin released at 0.3, 0.1 or 0.03 mg/day] could compete with, or improve the efficacy of the standard (±)-*exo*-brevicomin bait released at 1.2 mg/day. Multiple funnel traps baited with the experimental blends caught more beetles than the unbaited traps, but only traps baited with the 9:2 (+): (±) blend released at 0.3 and 0.03 mg/day caught significantly more male and female beetles than those baited with the standard bait. Thus trap sensitivity can be improved with the addition of (±)-*endo*-brevicomin. In this trapping experiment, the sympatric bark beetle *D. autographus* Ratzeburg was captured in significant numbers in traps baited with (±)-*exo*-brevicomin. A subsequent trapping experiment showed that *D. autographus* responded to (+)- or (±)-*exo*-brevicomin, and the antipode was benign, suggesting (+)-*exo*-brevicomin is the principal aggregation pheromone component in this species. In the tree-baiting experiment, the standard and experimental baits were no different in effectiveness at inducing attack by *D. confusus* on trees. Baited 9 ha block experiments compared the ability of the standard and 9:2 (+)-*exo*-brevicomin: (±)-*endo*-brevicomin baits to contain and concentrate infestations prior to harvesting. Again, both baits were equally effective as potential stand management tools, based on attack on baited trees, green to red ratios and attacks per ha, as well as the distribution of attack surrounding baited and red trees. I recommend that the standard bait continue to be offered commercially for treatment of stands infested by *D. confusus*.

Student Papers II

Moderator: Michael Wagner, School of Forestry, Northern Arizona University, Flagstaff, AZ

Forest Vulnerability to a Western Spruce Budworm Outbreak

Everett Isaac and Robert I. Gara, College of Forest Resources, University of Washington, Seattle, WA

The western spruce budworm (*Choristoneura occidentalis* Freeman), hereafter referred to as budworm, is a native defoliator to Eastern Washington. Historically, frequent, low-intensity fires limited budworm host species, primarily Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) on the Yakama Indian Reservation. As a result of past management practices, such as fire suppression and overstory selective removal of early successional species, much of the landscape has become favorable budworm habitat. The budworm has been at epidemic levels since 1985. In 1996, approximately 152,000 acres were being adversely affected by the budworm.

Three stand structures were examined to determine the relationship between structure, defoliation severity and tree growth. The stand structures examined were: single-storied condition that developed after a precommercial thinning, a multi-cohort condition that developed after a commercial thinning, and a multi-storied condition that developed after selective overstory removal (high-grading) and fire suppression. .

Basal area ratios were calculated using basal area growth prior to budworm defoliation divided by basal area growth post budworm defoliation. An ANOVA was conducted upon basal area ratios and significant differences in growth between the stand structures were indicated. Results of Tukey test showed no significant difference in tree growth in stands that were thinned (both precommercial and commercial). Tree growth in each of the thinning treatments was significantly different in growth compared with the high-graded stand. A paired sample t-Test indicated that there was a significant difference in growth between host and nonhost species.

Results of this study indicate that proactive silvicultural treatments, such as thinning, can be prescribed to mitigate adverse impacts of budworm defoliation.

Regional Patterns in the Relative Importance of Selected Mortality Agents: Past, Present, and Future

Brytten E. Steed and Michael R. Wagner, School of Forestry, Northern Arizona University, Flagstaff, AZ

Understanding mortality agent activity across the Western United States is important for both natural resource management and development of ecosystem dynamics theories. Ideally, the study of mortality agents would include several temporal and spatial scales (biologically defined), many measures of mortality, measures of biological impact, and various mortality agents (specific and group). It would also encompass the many interactions between agents. Our analysis of West-wide mortality, however, was limited by available data. Difficulties in analyzing available West-wide mortality information included differences in region delineations, mortality measures, mortality agent groups, as well as combinations of growth loss with mortality and use of acres-affected instead of mortality. We discuss these difficulties and present our methodologies for reconciling these information inconsistencies. Our final analysis includes average values for three time periods representing past, present, and future mortality agent activity for areas delineated by Forest Service geo-politically boundaries. Finally, we present many of the difference in mortality agent activity between regions and within regions over time.

The data indicates that bark beetles have been the most important source of mortality of the western United States, and, with the possible exception of the Northern Region, this trend is expected to continue. Defoliators, although important in growth loss, have not had a large mortality impact. Present and projected-risk data presented in this paper indicate that root disease may be an even more important factor in tree mortality than indicated in recent literature. All regions throughout the West show high impacts by dwarf mistletoe (*Arceuthobium* spp.) during the past 20 years, although regional measures of actual mortality are not available. Fire affects relatively few acres compared to insect and disease, but the biological effects are important.

The Distribution and Impact of *Cryptorhynchus lapathi* (L.) on *Salix* spp. in British Columbia

C. L. Broberg and J. H. Borden, Centre for Environmental Biology, Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada

The poplar and willow borer, *Cryptorhynchus lapathi* (L.), present in British Columbia since 1923, primarily attacks species of *Salix* and *Populus*. Larvae bore into stems, causing them to break easily. We documented the distribution and prevalence of *C. lapathi* in B.C. within different biogeoclimatic subzones and *Salix* hosts, and described the between-tree and within-tree dynamics of *C. lapathi*. Our survey spanned five biogeoclimatic zones, 15 subzones, 45 locations, 135 sites, and 3360 trees, 675 of which were measured in detail. The range of *C. lapathi* has at least doubled since 1963. The weevil was present in 38 locations and 14 subzones and has not yet fully established its potential range in BC. Weevil-attacked trees were less prevalent in cold than in warm subzones (e.g. number of months with mean a temperature >10°C, P <0.0001, r^2 = 0.808). Of 18 *Salix* spp. encountered, there were 11 new host records and no evidence of host preference. In general, attacked trees were larger, had more dead wood and stems, more adventitious branches per stem, more total breaks per stem, and more naturally-caused breaks per stem than their attack-free neighbours. Breaks caused by *C. lapathi* tended to be slightly larger in diameter and lower on the stem than naturally-caused breaks. Bases of stems were preferentially attacked, and *C. lapathi* selected larger stems in which to oviposit. As large attack-free trees become less abundant, weevils apparently start to attack small-diameter stems. Although *C. lapathi* is adversely affecting the health of willows in B.C., there is no evidence that any *Salix* species is threatened by weevil-caused extinction.

Hazard Rating System for Spruce Weevil in Sitka Spruce in the Northern Oregon Coast Range

Teri Lysak and Darrell W. Ross, Department of Forest Science, Oregon State University, Corvallis, OR

The spruce weevil (*Pissodes strobi*) is a serious pest of Sitka spruce in Oregon. Weevils kill the leader of the tree, causing deformities such as crooks and forks which can render the tree unmerchantable. This study will predict the amount of damage that a stand is likely to experience based on various stand and environmental characteristics. The information will then be used to develop planting guidelines for Sitka spruce in the northern Oregon Coast Range.

Analysis is currently in progress. So far, each potential explanatory variable has been examined independently using simple regression. Of all the variables examined, the one with the most explanatory power is radial growth, which accounts for 11% of the variation. Damage increased as radial growth increased. Distance from the ocean also showed a slight positive correlation with damage. Percent spruce and elevation showed slight negative correlations with damage, while stand density, hardwood shading, height, age, soil drainage, aspect, whether the stand faced the ocean or not, landform, and latitude showed no correlation with amount of damage. Stands that contained greater than 20% salal in the understory also had less damage.

The next step in the analysis is to examine these variables concurrently, using multiple regression. Hopefully as analysis proceeds, stronger trends will be seen.

Interactions Among Insects, Disease, and Threatened, Endangered, and Sensitive Species

Moderator: Beth Willhite, USDA Forest Service, Westside Service Center, Sandy, OR

Western Spruce Budworm, Northern Spotted Owl, and the Mardon Skipper on the Gifford Pinchot National Forest

Beth Willhite, USDA Forest Service, Westside Service Center, Sandy, OR

The Gotchen Late-Successional Reserve (LSR) is located on the east side of the Cascades on the Gifford Pinchot National Forest in south-central Washington. This area is bordered by a variety of other forested ownerships, including the Yakama Indian Reservation, private industrial timberlands, and Washington State lands. Primary management objectives for the Gotchen LSR are to protect and enhance late-successional habitat for associated species such as the northern spotted owl. A large proportion of the forest within the LSR is dominated by grand fir growing in dense, multilayered stands. Another key feature of this landscape are scattered forest openings in the form of meadows, rocky outcroppings, and old plantations, which are potential habitat for the mardon skipper, a small butterfly recently listed as “endangered” by the State of Washington.

In 1985, a western spruce budworm outbreak on non-federal lands to the east of the Gotchen LSR began. Budworm defoliation was first mapped in the LSR in 1994, and has been recorded annually in the LSR, as well as on adjacent ownerships, since that time. Concerns over the detrimental effects of budworm defoliation on critical spotted owl habitat and LSR function prompted Forest Service managers to propose highly focused B.t. treatments on four one-hundred acre owl “activity centers” to protect core nesting and roosting habitat, along with strategically-placed silvicultural treatments to reduce the likelihood of catastrauphic fire. Opposition to B.t. treatments in the LSR have risen from concerns for mardon skipper populations that might be affected by spray drift. Opposition to silvicultural treatments spring from concerns for short-term loss of late-successional habitat. The budworm outbreak has generated a great deal of concern from adjacent landowners who are pressuring the Forest Service to spray the entire budworm-affected area. Some landowners who have not yet experienced any defoliation on their land are concerned about spread from non-treated lands. Other landowners are taking aggressive measures in dealing with the budworm and are highly concerned by other owners who are not taking similar actions.

The question of long-term sustainability of LSR’s located on the east side of the Cascades Crest in Oregon and Washington is highlighted by the budworm situation in Gotchen LSR. In addition, the complexity of managing these “reserved” forest systems for a variety of “listed” species that may require divergent habitat management tactics, and in the context of multiple land ownerships, makes eastside LSR management a daunting task.

Challenges for Managing Habitat of the Northern Spotted Owl in Eastside Forests of Central Oregon

Andris Eglitis, USDA Forest Service, Deschutes National Forest, Bend, OR

A large portion of the forest on the east side of the Cascade Mountains has experienced significant changes in its vegetation in the past few decades. The most important of these changes has involved a shift in tree species from the "historic" forest. Forests once dominated by widely-spaced ponderosa pines now contain extensive amounts of white fir and other shade-tolerant species. These current forests are often multi-storied stands of highly complex structure and a level of diversity that was uncommon in the early 1900's. The complexity of these stands is such that they are currently being utilized as habitat for the northern spotted owl, *Stryx occidentalis*. Habitat for the spotted owl is more commonly associated with the forests on the west side of the Cascades where high stand densities and complex structure are more in keeping with the long-term carrying capacity of these more productive sites. However, recent habitat loss has been extensive on the west side of the Cascades, which has resulted in the listing of the northern spotted owl as "threatened" under the Endangered Species Act. As such, the spotted owl habitats on the east side of the Cascades have become even more critical until the time that the westside habitats can be recovered.

Recent events in the Metolius Watershed (Sisters RD, Deschutes NF) have shown that these eastside habitats for spotted owl are very unstable and are vulnerable to various insect and disease disturbance agents. An outbreak of the western spruce budworm, *Choristoneura occidentalis*, affected nearly 150,000 acres of white fir-Douglas-fir stands in the watershed between 1985 and 1992. In addition, these dense stands have extremely high levels of Armillaria root disease (*Armillaria ostoyae*), annosus root disease (*Heterobasiodion annosum*) and several dwarf mistletoes (*Arceuthobium* spp.) which are also contributing to the high mortality levels within these stands. Once the spruce budworm outbreak subsided, there was evidence of widespread tree mortality on more than 60,000 acres within the Metolius watershed.

Under the Northwest Forest Plan, over two-thirds of the Metolius watershed is designated as Late-Successional Reserves (LSRs). The primary focus of management activities in LSRs is to maintain or enhance the habitats of associated species. The watershed presently contains 17 spotted owl nest sites. Sixteen of these 17 sites are located in vegetation that is classified as white fir climax, or higher site productivity (one nest occurs in stands classified as "ponderosa pine"). It is important to note that 14 of these 17 nests occur in vegetation that was dominated by ponderosa pine in 1953. This means that these stands have only recently become "suitable habitat" for the northern spotted owl. (Suitability for foraging is determined by the presence of an understory of densely growing small trees, and suitable nesting habitat requires 70% overall canopy cover to provide protection from predators).

The condition of the vegetation following the spruce budworm outbreak was evaluated for the entire watershed from color infrared photograhs. The photo interpretation showed about 30,000 acres as having been "highly damaged" within the Metolius watershed. Nine of the 17 owl nest sites are located within this area of heaviest damage. Ground data from these heavily damaged areas indicates that recent tree mortality is nearly 40% of the basal area.

It is estimated that these 17 pairs of owls require 20,000 acres of suitable habitat; 37,000 acres were considered to be suitable habitat within the watershed. Many of the heavily damaged nest sites still contain high basal areas of live trees, but the condition of the trees is poor in many cases. Although these stands may presently be described as being "suitable habitat" maintaining them as such will prove to be challenging.

The challenge is one of managing a vegetative condition that is very unstable. Some work is being proposed within an LSR in the Metolius watershed that will examine the feasibility of attaining and keeping stands in a condition that is suitable for nesting and/or foraging for the spotted owl. The effects of various stand treatments are being projected through the Forest Vegetation Simulator (FVS) and the resultant stand conditions are displayed using the Stand Visualization Simulator (SVS). The root disease model extension is being linked to the FVS model in order to evaluate the effects of this pathogen on the attainment of the objectives. These growth projection tools can compare different treatments with the "no treatment" option in order to plan for habitats across the landscape over time.

In addition to the issue of stand stability, another serious challenge to the implementation of stand treatments is the economic viability of sales that involve the removal of low-value material from the woods.

Lynx and Mountain Pine Beetle in Washington

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

Lynx (*Lynx canadensis*) are currently listed as “threatened” in Washington State. Lynx occupy high elevation coniferous forests where heavy snows accumulate. The areas occupied by lynx in Washington represent one of two places were reproducing populations exist south of Canada. Much of the prime lynx habitat in Washington is dominated by continuous lodgepole pine forests in excess of 100 years old. These forests are highly susceptible to damage by the mountain pine beetle (*Dendroctonus ponderosae*). In 1993, a mountain pine beetle outbreak in the area of the Loomis State Forest, Okanogan National Forest, and Pasayten Wilderness area exceeded 48,000 acres.

The Washington Department of Natural Resources manages 5% of the primary lynx habitat in Washington and is committed to incorporating lynx habitat associations into its timber management plans. Lynx habitat management efforts include providing forested travel corridors along major ridges saddles and streams; maintaining a 70% minimum of forested habitat in lynx management units; and, within the forested habitat, maintaining 20% minimum forage habitat (young, dense lodgepole pine stands that provide winter food resources for snowshoe hare, the primary food of lynx) and 10% minimum denning habitat. Attention is also focused on the configuration of habitat components to ensure connectivity.

Timber management and wildlife specialists reached several agreements over lynx habitat management in Washington. The forests are dominated by old lodgepole, which is susceptible to beetles. The lynx currently need more hare to eat and the hare need more young stands of lodgepole to eat (“forage”). Mechanical salvage of dead and dying lodgepole is an effective way to create “forage” stands, but its immediate result is to create “non-forested habitat” for several years until the lodgepole regeneration grows to above the snow depth. Harvest planning and forest growth models were used to plan several decades of management on State Land in critical lynx areas in order to ensure the continuity of lynx habitat and timber harvest over time, resulting in a future forest mosaic which will support lynx, produce revenue, and be more resistant to mountain pine beetle.

Eagle Nest Tree and Pine Bark Beetle Management on Private Industrial Timberlands near Klamath Lake

Dave Overhulser, Oregon Department of Forestry, Salem, OR

(Abstract not available)

Plenary Session

Y2K and 10 K Bugs: Biodiversity Challenges in Research and Management

Moderator: Andy Moldenke, Department of Entomology, Oregon State University, Corvallis, OR

Management Priorities and Suggestions

Judy Nelson and Cheryl McCaffrey, US Department of the Interior, Bureau of Land Management, Portland, OR

(Abstract not available)

Academic Priorities and Suggestions

A.R. Moldenke, Department of Entomology, Oregon State University, Corvallis, OR, and
B.A. Marcot, USDA Forest Service, Pacific Northwest Research Station, Portland, OR

A number of cogent reasons for caring about arthropod diversity were presented during the FEMAT scientific consultation process. Current information on arthropods in the PNW is, at one and the same time, both limiting (most data have not been collected directly to answer the specific concerns of management agencies) and too vast to deal with (too many species). Since arthropods not only respond to changes in forest management, but control ecosystem processes (i.e., nutrient cycling, pollination, herbivory) that must within healthy constraints, it is perhaps even more critical to monitor their diversity and populations than any other taxa. Research needs to proceed on two fronts simultaneously as established by the original FEMAT consultants. First, the published literature and scientific specialists need to be consulted to establish the known pattern of biodiversity across the landscape; this is especially critical in the southern region of the range of the NSO as pointed out in the ROD. Since different groups of arthropods are differentially important and differentially distributed, it must be established that the pattern of reserves already in place is adequate. Since it is known that a large percentage of the most sensitive species are not associated with sites under a forest canopy, it is likely that additional protections are required. This consultation process is long-term. Secondly, curent studies by Niwa and Rappaport (response of ground-dwelling arthropods to controlled burning) are excellent examples of the interrelation of biodiversity to ecosystem processes directly related to management protocols. An equally important set of unanswered question is: “What arthropods are associated with old-growth? Which of these species are found only in old-growth and not in commercially mature forests? How large a stand of old-growth is necessary to maintain these interior forest taxa?”

This last set of questions is being addressed by our current studies in the Cispus AMA, WA. This design examines the arthropod fauna at the center of mature forest islands, the center of adjacent clear-cuts, and along a transect line across the habitat interface. A broad spectrum of arthropods are collected by pitfall trapping, beating and sweeping and Berlese sampling. Statistical design allows the differentiation of species which require forest interiors, open

canopy, forest edges, etc. Most of this is information new to science. Applying this methodology to a series of dozens of stands of varying dimensions allows precise examination of the relationship between forest-interior species diversity and patch size. Collaboration with bryologists, mycologists and botanists places the data in an overall pattern of ecosystem processes. This research, employing largely non-professional volunteer field and laboratory hands demonstrates that complex questions can be addressed when professional input is brought to bear on research design, site selection, identification and analysis.

Biodiversity of Lepidoptera in Ecosystem Foodwebs

Paul Hammond and Jeff Miller, Department of Entomology, Oregon State University, Corvallis, OR

The caterpillars of Lepidoptera (butterflies and moths) are the primary defoliating herbivores in forest ecosystems, and are often highly specialized to feed upon specific groups of plants. Each plant group supports a guild of 20-30 species, and a typical forest ecosystem in North America will support 400-500 species of macromoths and butterflies. Thus, taxonomic diversity of plants supports taxonomic diversity of herbivores, which in turn supports diversity in predators which feed upon caterpillars. These predators include arthropods such as ants, spiders, wasps and vertebrates such as small mammals and passerine birds. Migratory passerines travel from Central and South America each spring to feast on caterpillars in North American woodlands. Studies in eastern hardwood forests have shown that 75-98% of herbivoreses on leaves during the spring are caterpillars and that birds consume 18-63% of these insects. In western coniferous forests, our studies have shown that only 10% of caterpillar species actually feed on conifers and that 90% feed upon flowering plants. Moreover only 10-20% of lepidopteran biomass as measured by moth abundance comes from conifer herbivory (except for epidemic outbreaks). In moist forests west of the Cascade crest about 70% of moth biomass comes from hardwood trees and shrubs, with 10% from herbs and grasses. Drier forests east of the Cascades produce about 55% of the biomass from species feeding on the herbs and grasses of the forest floor, while 40% comes from hardwoods. Therefore, diversity in herbivores and the predators they support higher in the foodweb is largely dependent upon the flowering plant component of the forest ecosystem, not the conifers. Forests with a dense monoculture of a single conifer species have a greatly reduced diversity. Increased diversity is achieved when the balance of flowering plants increases. Natural processes of wildfire and epidemic outbreaks of conifer-feeding herbivores can increase diversity in this way, as can management practices of prescribed fire treatments and selective thinning of dense conifer stands.

Concurrent Sessions

Non-host Volatiles and Bark Beetles

Moderator: John H. Borden, Centre for Environmental Biology, Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada

Participants: C. Randall, B. Steed, G. Sanchez-Martinez, D. Wakarchuk, K. Deglow, T. Shore, K. Puls, B. Thompson, D. Scott, L. Maclauchlan, J. Wenz, D. Schultz, T. Eager, H. Ono, J. Stein, J. Allison, L. Livingston, D. Overhulser, M. Johnson, K. Allen, H. Burkwhat, M. Wagner, S. Werner, G. Daterman, D. Czokilo, D. Morewood

There were no invitational presenters at this workshop. The Chair opened the proceedings by presenting a scenario wherein a host seeking coniferophagous bark beetle must detect and avoid any non-host angiosperm tree, but with a finer level of discrimination, must also be able to detect and avoid non-host conifers. The reverse would occur for angiosperm-infesting species. On questioning from the Chair, only three of the 26 participants professed to have any knowledge or experience in this subject. The Chair then directed a wide-ranging discussion that focussed on five general areas.

Identification. Considering the range of potential interactions with non-hosts, it was readily apparent that most bio-active non-host volatiles were not yet identified. The Chair explained how coupled gas chromatographic-electroantennographic detection analysis (GC-EAD) and GC-mass spectrometry are used to identify only those compounds that may potentially show behavioural activity, and to discard all the rest. A discussion ensued on the diversity of these compounds, including the occurrence of two bark beetle pheromones in angiosperm tree bark: frontalin in *Alnus* spp. and conophthorin in *Acer*, *Populus*, *Salix* and *Betula* spp.

Explanation. The methodology for investigating the role of non-host volatiles in nature was explored, particularly the use of attractant-baited traps. When candidate non-host volatiles are added to the attractive baits, most prove to be repellent, but the Chair cited one instance in which a repellent blend for the mountain pine beetle proved to be attractive to the spruce beetle, possibly because the riparian habitat of spruce beetles contains many non-host angiosperm species.

Exploitation. The workshop explored the potential uses of repellent non-host volatiles with interest. It was generally agreed that because of the complexity, expense and release-rate engineering involved, the use of non-host volatiles would be largely restricted to the protection of high value individual trees or small group of trees. Wrap-around devices were described that with convection currents flowing up a tree would provide protection around the entire bole circumference. The Chair also described a hollow PVC tube device that is being used experimentally to protect logs from attack by ambrosia beetles, and a discussion ensued on other potential devices to use to protect stored timber.

Integration. The use of non-host volatiles as supplements to antiaggregation pheromones was stressed as a means to obtain consistently reliable treatments. The attendees agreed that it made little sense to attempt to protect trees or logs from attack if this tactic is not part of an overall IPM program that will reduce the challenge to protective treatments. Silvicultural methods that remove beetles from a site were mentioned, as was the use of attractant-baited trees or traps in a push-pull tactic.

Registration. Some concern was expressed at the need to register non-host volatiles as pesticides. There was apparent agreement that registration should be sought for blends rather than for individual components of bio-active blends. For each target species the blends might differ in one or two components, but the commonality of most components argues for the initial registration of a generic multicomponent blend.

Management Implications of Arthropod Abundance and Diversity

Moderator: Andy Moldenke, Department of Entomology, Oregon State University, Corvallis, OR

Are Headwater Streams Important to Forest Ecosystems?: Adult Aquatic Insect Communities in Temporary and Perennial Headwater Streams in Western Oregon

R.A. Progar and A.R. Moldenke, Department of Entomology, Oregon State University, Corvallis, OR

The riparian areas encompassing headwater streams comprise over fifty percent of federally managed land in the Pacific Northwest. Forest management practices and their consequences are likely to have direct effects on the abundance and diversity of arthropods in these sensitive habitats, and indirect effects through the foodweb on vertebrates of concern. We examined the effect of stream flow (perennial vs. dry-season temporary), and canopy presence on adult insect fauna collected from emergence traps in headwater streams at three sites in the conifer forests of western Oregon. In comparing temporary and perennial streams, Trichoptera and Ephemeroptera emerged in greater numbers in perennial streams, taxon richness was higher overall, and density and biomass of aquatic insects were higher during the summer in perennial streams than in temporary streams, which by then were either dry or drying up. In contrast, Diptera and Plecoptera emerged in greater numbers from temporary streams, and density and and biomass of all aquatic insects were higher in these streams during the spring. These results are consistent with our hypothesis that the absence of vertebrate predators (fish and giant salamanders) allows insects in temporary streams to flourish, and supports our conclusion that temporary streams are as important as perennial streams in serving as: (1) a potential source of colonization for perennial streams and (2) an important factor in the terrestrial food web as an abundant food source for insectivorous vertebrates. Both temporary and perennial headwater streams flowing through clearcut uplands support higher densities, biomass and richness than forested streams. The proliferation of insects in headwater streams flowing through clearcuts may be attributed to higher insolation which increases primary production.

Soil and Litter Arthropod Studies at Blacks Mountain Ecosystem Research Project

Nancy Rappaport, USDA Forest Service, Pacific Southwest Research Station, Berkeley CA

Soil and litter arthropods conduct essential ecosystem processes, including nutrient cycling, organic matter decomposition, and soil bioturbation. In addition, soil arthropods are phenomenally diverse, with estimates of species richness ranging an order of magnitude greater than the above-ground fauna. Because soil is an opaque and difficult medium to sample, however, extremely little is known about the effect of disturbances such as timber harvest and fire on soil fauna. The effect of biodiversity losses on essential soil processes is not well understood. Although there is expected to be some redundancy of function, a loss of species richness and/or diversity might be expected to degrade soil health.

Optimum sampling protocols for soil and litter arthropods in forest ecosystems were developed at Blacks Mt. Two sampling protocols were tested in 1997 to determine whether tree-centered transects, by accommodating heterogeneity induced in the below-ground habitat by the presence of trees, provide a more sensitive test of effects of tree harvest on soil and litter-dwelling Coleoptera than do spatially random transects. Samples were taken in September 1997 soon after harvest operations were completed. The two sampling protocols consisted of (1) six-meter long east-west transects centered on randomly selected 35-cm d.b.h. ponderosa pines, and (2) identical transects centered on spatially random stakes (fig. 22). Tree-centered transects, by most measures, captured more of the beetle richness, diversity, and abundance than spatially random transects.

Preliminary results from oribatid mite sampling using tree-centered transects in the fire/no fire splits plots (spring 1998) suggest that low intensity prescribed fires have little effect on species richness, diversity and evenness, but moderate intensity prescribed fires have a more profound effect on both mite abundance and the measures of mite community structure. These preliminary conclusions are based on a single replicate, however, so it is too soon to draw firm conclusions.

Canopy Diversity Alder vs. Douglas-fir

Brett Schaerer, Department of Entomology, Oregon State University, Corvallis, OR

(Abstract not available)

Short- and Long-Term Effects of Prescribed Fire on Litter and Soil Microarthropod Communities in SW Oregon

Robert W. Peck and Christine G. Niwa, USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR

Within the Northwest Forest Plan, arthropod biodiversity was managed by classifying each species into one of 15 functional groups. Under current forestry practices, four of these groups were identified to be at risk within the southern range of the Northern Spotted Owl. They are: arthropods that live within litter and soil; those in coarse wood debris; gap herbivores, and;

canopy herbivores. This talk will discuss results of a study investigating the effects of prescribed fire on arthropods within the litter and soil.

In SW Oregon, prescribed fire has become an important tool for reducing the risk of high-intensity wildfire. However, it is unclear how these relatively low-intensity prescribed fires influence the abundance, diversity and function of litter and soil organisms, and ultimately their effect on forest health and productivity. This retrospective study investigated the short- and long-term effects of prescribed fire on litter and soil microarthropod communities (Acarina and Collembola). Within a Douglas-fir dominated forest, 9 burned sites differing in the number of years since burning (ranging from <1 month to 15 years) were chosen for comparison. Adjacent unburned sites were paired with each burn to act as a control. Microarthropods were extracted from litter and soil cores using Berlese-type funnels, identified to species, family or suborder level and counted. For analyses, microarthropods were placed into the following groups: oribatid mites (fungivores and bacteriovores); predatory mites (predators of mites and Collembola); and Collembola (fungivores).

On average, over 23,000 microarthropods/m^2 were collected from burned and unburned sites. In the litter, oribatid mites and Collembola were similar in abundance (approximately 48 and 44%, respectively), while predatory mites comprised approximately 8% of the samples. With increasing depth, Collembola increased in dominance (70-85% of total) as both oribatid and predatory mites decreased in abundance. Within the litter layer, significantly more individuals of all three groups were found in unburned sites than in burned sites. No differences were found for the two soil depths. The relationship between abundance and time since fire was statistically significant for oribatid mites but not for predatory mites or Collembola. That is, for oribatid mites, the probability of an individual being collected in a burned site compared to an unburned site increased 3.7% for each additional year after fire. The variability in numbers of microarthropods collected among burns of differing ages was high, possibly making stronger patterns difficult to detect. Large differences in the intensities of fires performed on different years likely contributed to this variation.

Forest Floor Biodiversity, Influence of Riparian Buffers

Andy Moldenke, Department of Entomology, Oregon State University, Corvallis, OR

(Abstract not available)

Canopy Arthropod Communities in Douglas-fir

T.D. Schowalter and R. A. Progar, Department of Entomology, Oregon State University, Corvallis, OR

Insects are particularly sensitive to environmental conditions and can serve as responsive indicators of changing climatic patterns and habitat conditions. However, changes in abundance patterns over environmental gradients in forest ecosystems are poorly known. To examine landscape patterns of invertebrate assemblages, arboreal arthropods were collected during two seasons (spring and summer) by bagging branches from the lower, middle and upper canopy levels from six stands in nine second-growth (100-150 years old) forests and old-growth (500 years old) forests in Washington and Oregon. Detrended correspondence analysis was used to

assess partitioning of the arthropod community by geographical location, rainfall and tree age. Multi-response permutation procedure showed significant differences in the composition of the canopy assemblages conforming to latitude, precipitation and tree age. Indicator analysis was used to assess each taxon's importance in relation to the environmental variables. Individual taxa showed associations with latitudinal and precipitation gradients, and between old-growth and mature Douglas-fir. These changes in the spatial patterns of invertebrate assemblages may be used to predict effects of climate change or land use scenarios.

Forest Floor Macroinvertebrate Fauna

Tim Work, Department of Entomology, Oregon State University, Corvallis, OR 97331

Edge effects resulting from forest fragmentation are likely to alter the distributions and interactions of resident species. We evaluated changes in species composition, species turnover, and relative abundance of ground arthropods across replicated transects extending from regenerating clearcuts into Old-growth Douglas-fir forests. Arthropods were collected from 23-May 1998 to 31-July 1998 using sets of five pitfall traps placed at -25 m (in the clearcut), 0 (forest edge), 25, 50,100, and 200 m into the forest. Changes in species composition and relative abundance were compared using non-metric scaling ordination. One hundred eighty-eight species representing 18850 individuals were collected. Edge effects on species composition and relative abundance were apparent up to 50 m into Old-growth forests. To further address the impacts of edges on community structure, changes in species abundance of predator taxa across the edge-forest gradient were compared to four models of resource partitioning. Observed patterns of species abundance did not differ across the edge-forest gradient and were consistent with a model where an individual predator species utilizes resources independently of other predators. This pattern was consistent whether species abundance was expressed as numerical abundance or biomass. Our study suggests that edge effects resulting from forest fragmentation alter species composition and may negatively affect interior forest species. Furthermore, although species composition changes across forest edges, our study suggests that resource partitioning by a trophic group such as predators remains unaffected by forest edges.

Arthropod Communities on Understory Shrubs in Thinned and Unthinned Douglas-fir Stands in the Central Oregon Coast Range

A.G. Doolittle and J. Hagar, Department of Forest Science, Oregon State University, Corvallis, OR

I sampled arthropods on salal, vine maple, understory hemlock, sword fern and bracken fern. I compared arthropod communities on these shrubs and found host plant species to be the greatest determinant of arthropod community. I discussed differences in arthropod communities due to silviculturally influenced stand conditions by shrub species. The points I discussed help to illustrate the complexity of arthropod communities by showing that drivers of the arthropod communities are far more complex than stand structure alone. Plant differences and structural differences all affect arthropod community composition. To illustrate the link between neo-tropical migrant birds in these stands and the arthropod community, I showed results of my indicator species analysis with results from Joan Hagar's fecal sample analysis. There are some overlaps, which provides evidence to determine the shrub species that are important food sources

for birds. We can tell that Wilson's warblers and Swainson's thrushes are feeding on the arthropods from the shrubs I've sampled. The results so far from these two studies suggest that when trying to assess the arthropod community present, shrub species are the best indicators of the arthropods.

Insect/Pathogen/Tree Interactions - Where Do We Go From Here?

Moderator**:** Andrew J., Storer, Division of Insect Biology, University of California, Berkeley, CA

Participants: René Alfaro, Kristen Baker, H. Barclay, Jon Bell, Barbara Bentz, Kathy Bleiker, Paul Bosu, Cindy Broberg, Dave Bridgwater, Beverly Bulaon, Jennifer Burleigh, Steve Cook, Jim Hadfield, Chrispoher Hanlon, Liz Herbertson, Everett Isaac, Nicole Jeans-Williams, B. Kuken, Andrew Lawson, Jesse Logan, John Manville, Chris Niwa, Bernie Ryan, Les Safranyik, Tara Sahota, Safiya Samman, Bob Setter, Diana Six, Eric Smith, Doug Wulff.

The starting point for this workshop on insect/pathogen/tree interactions was a consideration of questions such as:

1) What should be the research goals in the next 10 years with respect to:
    a) Systems that are studied?
    b) Research topics that are studied?
2) How can we translate the available information into management recommendations?
3) Are there novel approaches to studying interspecific interactions that may be useful in the future?

The following are summaries of the presentations given at the workshop.

An Overview of Western Regional Research Projects W-110 and W-187

David L. Wood, Division of Insect Biology, University of California, Berkeley, CA

Research during the 1970s and early 1980’s was focused on a “systems” approach to the study of bark beetles, pathogens and tree mortality. An integrated pest management program for the western pine beetle was developed where stand dynamics, pest population dynamics, treatments and cost/benefit analyses were studied. Research was focused on: 1) interactions among tree killing bark beetles, blackstain root disease in ponderosa pine and Douglas-fir in California and Oregon, 2) annosus root disease in white fir, ponderosa pine and incense cedar in California, 3) interactions among bark beetles, root diseases and tree mortality in lodgepole and western-white pine, Douglas-fir, and grand fir in Idaho, and 4) interactions among tree-killing bark beetles, their symbiotic fungi and lodgepole pine and grand fir mortality in Washington. A considerable effort was also made to determine the behavioral mechanisms that explain host colonization behavior of tree-killing bark beetles in ponderosa pine in California.

The 1987-92 project was expanded to include projects from Louisiana, Utah and Virginia. Studies now included bark beetle and weevil interactions with root pathogens and red pine in Wisconsin; bark beetles, symbiotic fungi and tree interactions in ponderosa, loblolly, and lodgepole pine and grand fir in California, Louisiana and Washington, and beetle interactions with loblolly pine under varying physiological conditions in Louisiana.

In the 1993-1998 proposal, investigators proposed numerous studies that were identified on explicit interaction diagrams. The key components are bark beetles, host trees, pathogens, natural enemies and fungal associates all interacting among each other and with the biotic and abiotic environment. The 1999-2004 proposal follows the same goals described explicitly on the same interaction diagrams.

Research Questions Relating to Fungi that are Associated with Bark Beetles

Timothy D. Paine, Department of Entomology, University of California, Riverside, CA

1. What are the benefits to beetles of carrying fungi? What are the possible roles of fungi in the nutritional ecology of the beetles, and what other post-colonization benefits do they provide?

2. How is specificity in these associations maintained despite the wide range of fungi that are found under the bark?

3. How do the fungi under the bark interact with one another?

4. What are the mechanisms surrounding tree death? What are the roles of phenolics and other chemicals in determining which of the tree and the bark beetles will be the winner and which will be the loser?

Unexplained Mortality of Tanoaks and Coast Live Oaks in California

Brice McPherson, Richard Standiford, Peng Gong, Maggi Kelley, David Wood, and Andrew Storer, University of California, Berkeley; **Thomas Gordon**, University of California, Davis; **Pavel Svihra and Steve Tjosvold**, UC Cooperative Extension

Widespread and unprecedented mortality of tanoak (*Lithocarpus densiflorus*) and coast live oak (*Quercus agrifolia*) has been increasing in coastal California, particularly in the Coast Range, since it was first reported in 1995. The syndrome was first reported from tanoak in Marin County, and has since led to the death of large numbers of tanaoks and coast live oaks. Tree mortality is associated with an unusual seeping of dark reddish/brown sap from the lower trunk, the appearance of *Hypoxylon* sp. (*Xylariaceae*) fruiting bodies on the lower trunk, and colonization of this region by bark and ambrosia beetles. Affected trees typically decline rapidly from an apparently healthy state to death in remarkably short order. The insects found colonizing these trees are the bark beetle *Pseudopityophthorus pubipennis*, and the ambrosia beetles *Monarthrum scutellare* and *M. dentiger* (Scolytidae). *Hypoxylon* is commonly encountered on dead and dying hardwoods, but has not been known to be pathogenic in these forests.

Efforts to isolate pathogens from tree tissues have not yet identified a plausible candidate to explain the mortality syndrome. The significance of the presence of these beetles on dying trees is presently unknown, since these species are characteristically associated with trees that are already weakened or dead. In the absence of any identified causal agent, this mortality has been attributed to climatic extremes (prolonged drought followed by unusually heavy precipitation), resulting in weakened trees more susceptible to fungal attack. It is also possible that this condition represents the effects of an introduced pathogen. The role of beetles in tree death may be secondary. We are establishing a series of field study sites to monitor the spread of mortality and to seek its cause(s). Fungal cultures will be prepared from affected trees and from beetles arriving on and emerging from trees and cut logs.

Additional goals of this research are to survey forests to establish the extent of the developing syndrome. This will involve aerial monitoring of trees by acquiring digital spectral signatures, then correlating this information with ground-based symptoms. We hope to develop the ability to detect affected trees before the foliage exhibits symptoms in the visible spectrum.

Note: Since the WFIWC meeting, a new *Phytophthora* species has been implicated as a significant causal agent of the mortality discussed here.

Forest Structure & Health

Carroll B. Williams, Division of Forest Science, University of California, Berkeley, CA

The present-day structure and species composition of American forests is very different from those existing prior to European settlement. These changes are apparent in every region of the country and they have serious forest health consequences by increasing the incidence of outbreaks by insects, pathogens, and the severity of wildfires, particularly in the dry inland forests of Washington, Oregon, Idaho, western Montana, and California.

Pre-settlement forest stands at the low to mid-elevation levels of the inland west tended to be open and park-like in structure, and dominated by large trees, primarily ponderosa pines, in the overstory, and grasses and wildflowers in the understory. These forest stands were created by frequent low-intensity fires set by Native Americans and caused by lightning strikes. Frequent low-intensity fires consumed much of the grassy and woody fuels on the forest floor, and in the process killed a high proportion of the small tree reproduction. These fires kept fuel levels low and favored the survival of fast-growing tree species that rapidly developed thick bark, generally western larch and ponderosa pine; and selected against slower-growing species that were among the last to develop thick bark--the true firs. Frequent burning from below by these low-intensity fires created the open park-like forest stands of large pine trees encountered by the first European settlers to the inland west.

The extinction of Native American fires and the suppression of lightning-caused and all other fires, coupled with the selective logging of the large pines resulted in a forest of high stem densities of true firs and Douglas-fir with large accumulations of fallen branches and stems on the forest floor. Under these high fuel conditions wildfires that infrequently did escape fire suppression efforts quickly became intense fires with high flame lengths destroying large areas of forests. This change in fire regimes is probably the number one health problem in these inland western forests.

Trees growing in high stem densities experience chronic moisture stress much of the growing season. These trees are more vulnerable to insects and pathogens. The fir engraver beetle, *Scolytus ventralis*, is a major problem in the dense, chronically-stressed, present-day forests of true firs as compared to the more open pre-settlement forest of pines. The fir engraver attacks and kills true firs weakened by stress from pole size to full maturity. Overall the residual trees, relieved from the competition stress, are more healthy with enhanced ability to repel future attacks. The mountain pine beetle, *Dendroctonus ponderosae*, plays a major role in the regeneration of lodgepole pine forests in both present-day and pre-settlement times. Given the relative open structure of pre-settlement forests the mountain pine beetle outbreaks on pines other than lodgepole pine were likely infrequent, and beetle activity was limited to low vigor trees in pre-settlement forests.

The western budworm has become the most destructive forest defoliating insect in the inland forests of the west. It's main hosts include all the true firs, Douglas-fir, western larch, and Engelmann spruce. Budworm damage was light in stands dominated by pines. Whereas, present-day forests consisting of dense multi-storied stands of the shade tolerant true firs and Douglas-fir are very susceptible to severe damage by budworms; a condition resulting from 80-100 years of wildfire suppression, selective logging of pines and retention of the firs. Outbreaks of the budworm are large and last many years. Trees growing under stress due to competition and/or defoliation are highly vulnerable to the disease-causing pathogens.

Armillaria spp. is omnipresent in forest soils and attacks both hardwoods and conifers. Armillaria behaves as saprophyte and becomes a virulent pathogen in stressed ecosystems. Armillaria was widely distributed in pre-settlement forests where in the relative absence of stress, minor infections had little effect on tree and forest health. Whereas, in the dense chronically stressed present-day forests Armillaria has become an aggressive pathogen on Douglas-fir, true firs, and pines. Fire suppression has also increased infections by dwarf mistletoe and the incidence of infection is now much higher than natural levels. The low-intensity, high frequency fires killed small infested trees and reduced the rate of spread. Moderately sized trees with witches broom clusters near the ground, which created fuel ladders to the crown, were particularly vulnerable to these fires.

Current Status of Insects in the West

Moderator: Bill Schaupp, USDA Forest Service, Lakewood Service Center, Lakewood, CO

(Abstract not available)

E-Bugs! Cool Internet Websites for Forest Entomology

Moderator: Kathy Sheehan, USDA Forest Service, Pacific Northwest Region, Portland, OR

Forest Entomology Sites

Western Forest Insect Work Conference
http://www.fsl.orst.edu/wfiwc/

North American Forest Insect Work Conference
http://nofc.cfs.nrcan.gc.ca/nafiwc

FETCH21: Forest Entomology Textbook Challenge for the 21st Century
http://www.forestry.ubc.ca/fetch21/fetch21/FETCH21.html
developed and presented by Dr. John A. McLean (email: mclean@interchange.ubc.ca)

Pacific Forestry Research Center

Developed by Alan Thomson (email: athomson@PFC.Foresty.CA) and others

Tree Diseases of British Columbia

http://www.pfc.cfs.nrcan.gc.ca/health/td_web/

Healthy Forests

http://www.pfc.cfs.nrcan.gc.ca/hforest/

Insects and Diseases in Nurseries

http://www.pfc.cfs.nrcan.gc.ca/nursery/

On-line Herbarium

http://www.pfc.cfs.nrcan.gc.ca/biodiversity/herbarium/

B.C. Ministry of Forests

http://www.for.gov.bc.ca/hfp/hfp.htm

suggested by Peter M. Hall (email: peter.hall@gems6.gov.bc.ca)

Forest Health Protection (USDA-FS Washington Office)

http://www.fs.fed.us/foresthealth/

Forest Health Techn. Enterprise Team (USDA-FS, Ft Collins, CO & Morgantown, WV)

http://www.fs.fed.us/foresthealth/

USDA-FS Southern Research Station

http://www.srs.fs.fed.us/

USDA-FS St. Paul Field Office

http:/willow.ncfes.umn.edu/

Forest Insects and Diseases (USDA-FS, Pacific Northwest Region)

http://www.fs.fed.us/r6/nr/fid/

General Forestry Sites

(these next 3 sections were provided by Eric Smith, USDA-FS; email: elsmith@fs.fed.us)

METLA's (Finland) WWW Virtual Library: Forestry

http://www.metla.fi/info/vlib/Forestry/

BC Forest Service Links to other sites

http://www.for.gov.bc.ca/hfp/other.htm

Canada's Forest Network

http://www.forest.ca/

VA Tech's Natural Resources Research Information Pages

http://www4.ncsu.edu/~leung/nrrips.html

Bugs and Cruds

Entomology on World-Wide Web (WWW) (Colo State)

http://www.colostate.edu/Depts/Entomology/www_sites.html

Entomology Index of Internet Resources (Iowa State)
http://www.ent.iastate.edu/List/

Alexei Sharov's Population Ecology Site
http://www.ento.vt.edu/~sharov/popechome/

Plant Pathology Internet Guide Book, Inst. for Plant Diseases, University of Bonn
http://www.ifgb.uni-hannover.de/extern/ppigb/ppigb.htm

Eric's Favorite Web Tools

The ultimate reference hypersite:
MARTINDALE'S * THE REFERENCE DESK (Guide to Everything)
http://www-sci.lib.uci.edu/HSG/Ref.html

Search Spaniel (search several search sites at once)
http://www.searchspaniel.com/cgi-bin/spaniel.pl

WebFerret (cool desktop search tools)
http://www.ferretsoft.com/netferret/download.htm

Northernlight search engine (biggest and maybe the best)
http://www.northernlight.com/

Spruce Weevil: Current Research and Management

Moderator: Darrell Ross, Department of Forest Science, Oregon State University, Corvallis, OR

Participants: About 25-30 people attended this session including – Peter DeGroot, Jerry Beatty, Bruce Hostetler, Karen Ripley, Dave Overhulser, John Borden, René Alfaro, Sunil Ranasinghe, Carrol Williams, Mike Johnson, Beth Willhite, Mike Hulme, Jan Volney, Hugh Barclay, Liz Gerson, Don Scott, Tara Sahota, John Manville, Jeremy Allison, Teri Lysak, Jim Hanula, Lorraine MacLaughlan, and Cindy Broberg.

Four speakers presented research results during this session. The presentations illustrated several different research approaches and conclusions. Throughout the session there was considerable lively discussion among the speakers and audience.

Screening for Resistance to the White Pine Weevil

René I Alfaro[1] , John King[2], John Borden[3], and George Brown[1]
[1] Canadian Forest Service, Victoria, BC, Canada
[2] BC Ministry of Forests, Victoria, BC, Canada
[3] Simon Fraser University, Burnaby, BC, Canada

Sitka spruce (*Picea sitchensis* (Bong.) Carr) in Coastal British Columbia (B.C.) and spruce plantations of interior B.C. (white spruce (*P. glauca* (Moench) Voss) and Engelmann spruce (*P.engelmanni* Parry)) have come under serious attack from the white pine weevil, *Pissodes strobi* Peck (Coleoptera: Curculionidae). This pest which attacks the current terminal leader causes serious growth loss and deformities. Genetic resistance to successful weevil attack was found in earlier Sitka provenance trials and interior spruce genetic trials. Since 1993 we have initiated a series of screening trials to confirm this resistance and to broaden the base of selections especially in the Sitka spruce breeding program. To accelerate the screening process, and create a uniform weevil pressure, insect populations have been augmented at many of these trial sites. This artificial infestation has allowed quick and effective screening and has allowed us to now proceed with the construction of an F-1 population to more fully understand the mechanisms behind this resistance. We hope that these selections will form the basis for successful establishment of Sitka spruce plantations in B.C.

The mechanisms of resistance are currently being studied by various research teams. After examining over 29,000 trees, we concluded that resistance in spruce to the white pine weevil is likely to follow the model developed by Panda and Kush ("Host plant resistance to insects". CAB international,1995). In this model resistance is viewed as a multi-layered defense system involving nutritional, constitutive, inducible and guild (or population) defenses. Some of these defenses may act through physiological effects on the insect. These defenses are countered by weevil adaptations to avoid, suppress or detoxify these defenses.

Spruce/weevil Relationships

Plant Defenses		Effect on Insect		Insect Offenses
Nutritional	↔	Poor nutrition	↔	Avoid Compensate
Constitutive	↔	Repellent Physical Toxic	↔	Avoid Detoxify
Inducible	↔	Repellent Toxic	↔	Avoid Suppress Detoxify
Guild	↔	Confusion	↔	Suppress

Adaptation

Adapted from Panda and Kush, 1995

J.H. Borden, Division of Biological Sciences, Centre for Pest Management, Simon Fraser University, Burnaby, BC, Canada

Resin Chemistry. One result stemming from a study in press by Dr. Elizabeth Tomlin was presented. In "interior" spruce in B.C. resin in the leaders was sampled in September from trees that had been wounded artificially to simulate weevil feeding prior to bud flush. In both the upper xylem (in the area of wounding on the leader), and the lower xylem, the resin content increased in both resistant and susceptible trees. However in both the upper and lower xylem of resistant trees, the percent of monoterpenes in the resin was more than double that in unwounded control trees. Because monoterpenes make the resin more fluid and inhibit crystalization, the xylem resin induced by wounding would be more likely than in susceptible trees to flood out weevil punctures and mines and thus to kill the eggs and young larvae.

Induction of Terpene Synthase Gene. A progress report of work being done by Dr. Aine Plant at Simon Fraser University documented the induction of terpene synthase gene expression by both artificial wounding and by weevil feeding. Two spruce terpene synthase gene-specific probes isolated by PT-PCR were used. One-year-old lateral branches of Sitka spruce (Family 898, Western Forest Products) and interior spruce (Families 1709 and 1856, B.C. Forest Service, Clearwater) were wounded with a 0.95 mm diam. drill, and harvested 1, 2, 4 and 7 days later. Similarly weevils were caged on lateral branches which were harvested 1, 2, 4 and 7 days later. RNA was isolated from the harvested tissue, which was also examined histologically to correlate the occurrence of physical symptoms of induced resinosis with the onset of genetic events. Terpene synthase gene expression was clearly induced in both Sitka and interior spruce within 1 day of wounding and in interior spruce within 2 days of the onset of weevil feeding. Physical evidence of induced resinosis did not occur until the 7^{th} day. This study provides the basis for comparing the rapidity of induced resinosis in resistant and susceptible trees and for using a molecular assay to screen parent trees and their progeny in resistance breeding programs.

John Manville and Tara Sahota, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada

Weevils (*Pissodes strobi* (Peck)) engaged in ovarian development and oviposition (Reproductively active female weevils (RAFW)) preferentially feed on and oviposit in sterigmata ridges on spruce leaders. Here the thickest primary cortex occurs. Weevils appear to utilize their snout's length to guide them towards the thickest primary cortex and thus locate suitable oviposition sites; these are most often found at the top of the main-stem leader. Laterals of open grown trees have insufficient primary-cortex thickness except at their tips and are not normally utilized for oviposition. They are utilized poorly by caged RAFW. In addition, RAFW do not normally oviposit on the main stem below the leader, but do so when they do not have access to the leader and when they are caged on lower inter-nodes. In the spring, weevils migrate from the lower stem and branches of Sitka and interior spruces, where the primary cortex is thinnest, to the top of the leader where the thickest primary cortex is found. *Picea chihuaiana* (Martinez) and *P. mexicana* (= *P. engelmannii* Parry var. *mexicana* (Martinez)) are examples of trees where this weevil will also attack laterals and the main stem below the leader. At these locations on these Mexican trees, the primary-cortex is of sufficient thickness. RAFW oviposit in a similar pattern on potted spruce trees, regardless of the tree's orientation. This finding relegates negative geotaxis and positive phototaxis to, at most, a minor, secondary role in a RAFW's

selection of suitable oviposition sites. On very small diameter trees, oviposition sites are not confined to the previous year's growth, oviposition occurs on one, two, and three years old growth. These findings illustrate the danger in extrapolating inappropriate experimental findings, reported in many papers,
to nature.

Investigations into the Biological Control of *Pissodes strobi* with *Eubazus semirogosus* Isolated from *Pissodes pini* in the European Alps

Mike Hulme, Canadian Forest Service, Victoria, BC, Canada

Many native parasitoids attack *Pissodes strobi* broods, mostly the late larval instars of the weevil. However, all these ectoparasitoids appear to be polyphagous and thus unsuitable for manipulation in applied biological control. One other parasitoid appears to be a much better candidate. It is a native egg-larval parasitoid *Eubazus strigitergum* (= *Allodorus crassigaster*), that attacks only *Pissodes* species, all of which are considered pests. It is probable that different ecotypes of the parasitoid exist because *Pissodes* species are found in a variety of habitats ranging from vigorous leaders to moribund mature boles. Clearly the parasitoid has good searching ability. It also has high fecundity. The egg laid in the host egg, hatches at the same time as that of its host but further parasitoid development is delayed until the host larva reaches maturity. The parasitoid larva then completes its development, and pupation and adult eclosion follow directly.

Parasitism by *E. strigitergum* on *P. strobi* is generally low, probably because its life cycle is poorly synchronized to that of its host. However, parasitoid species in Europe, closely related to *E. strigitergum* show much higher parasitism of *Pissodes* broods. While no *Pissodes* species in Europe occupies the same ecological niche as *P. strobi* , one species, *P. validirostris* has the same phenology and was chosen first for further testing. The isolated braconid *E. robustus*, however, proved similar to *E. strigitergum* when reared on *P. strobi*, and improved parasitism seemed unlikely. A second palearctic parasitoid we investigated, E. semirugosus isolated from high altitude biotypes of P. pini, showed improved synchronisation with the life cycle of *P. strobi* compared with *E. strigitergum* and would thus be expected to be better adapted to its host. So far we have confined our testing to cages. Cut leaders have been used in laboratory and field cages. Sleeve cages have been used on plantation trees. In all cases results are similar: the palearctic parasitoids readily accept their new nearctic host, and can readily produce a new generation.

Monitoring Wood Imports and High-Risk Sites for Exotic Pests

Moderator: Kathleen J. R. Johnson, Oregon Department of Agriculture, Salem, OR

Introduction

Kathleen J. R. Johnson, Oregon Department of Agriculture, Salem, OR

Historically, increased interest in importing wood into western North America began about 1990. Log imports from old-growth Russian Far East (RFE) forests were initially seen by some as a solution to reduced timber harvests in western U.S. forests. Importing RFE logs was blocked by the USDA, APHIS, PPQ in December 1990, followed soon by a USDA Forest Service (FS) pest risk assessment on larch from that area. Most wood imported into Oregon (excluding Canada and adjacent states of Mexico) between 1991 through 1998 has come from radiata pine plantations in New Zealand. Significant amounts have also come from native pine forests in Mexico and radiata pine plantations in Chile. Pest Risk Assessments (PRAs) led by the USDA FS have included pests and pathogens from host trees in the RFE, New Zealand, Chile and Mexico. PRAs for eucalyptus from South America and solid wood packing material (SWPM) worldwide are in draft form. PPQ has moved from regulating imported wood as miscellaneous cargo requiring only inspection to development of a comprehensive set of regulations in 1995. These rules have been somewhat controversial and have been challenged in court. For some, the controversy stems from raw wood being imported without being fully treated to eliminate plant pests and pathogens. Others would like to minimize treatments, apparently due to added costs.

Evaluating pests and pathogens according to their location on the host (on the bark, in or under the bark, or in the wood) has been particularly useful in several PRAs. Of the wood imports into Oregon from 1991-1998 that we have monitored, most have been logs (73%), followed by green lumber (22%) and some railroad ties (4.7%). However, imported kiln-dried lumber, SWPM, crafts and manufactured wood are not included in these figures. PRAs typically have focussed on logs, lumber or chips. Establishment and spread of pine shoot beetle and Asian longhorned beetle in North America and interceptions of a diversity of other species (*including Callidiellum rufipenne* and *C. villosum*) in imported wood have caused SWPM and crafts to receive increasing interest.

Some questions to ask in light of the importance of controlling or mitigating pests based on their location in or on the host tree at origin are: What part of the host tree is being imported? What part of the host tree at origin are pests associated with? Have the pests from each location been eliminated on the type of wood being imported? The following concepts are useful, I believe, in effectively mitigating the risks of importing wood. Mitigate for potential pests in each location. Mitigate at origin preferably. Use mitigation methods demonstrated to be effective. Use inspection primarily to monitor mitigation methods. Evaluate windows of opportunity or pathways for pest escape. During this workshop, I encourage you to ask how well do our current rules apply these concepts?

Russian Forest Insects: Potential for Introduction on Raw Wood and Cones/Seeds into North America.

Yuri N. Baranchikov, Sukachev Institute of Forestry, Siberian Branch, Russian Academy of Sciences, Krasnoyarsk, Russia

The Asian part of the Russian Federation, known as Siberia, has an area of 1.3 million hectares and constitutes about 20 percent of the total world forested area and nearly 50 percent of the total world coniferous forested area. Nearly all of the Siberian conifer forest is composed of a few tree species: *Larix sibirica, Larix dahurica, Larix cajandery, Pinus sylvestris, P. sibirica, Avies sibirica and Picea obovata*.

Only 90 species of insects are of real economic importance in Siberian forests. On larch the main folivores are*: Dendrolimus superans*, *Lymantria dispar* and *Zeiraphera grizeana*; the major wood borers are: *Ips cembrae* and *Xylotrechus altaicus*. The larch bud gall *midge (Dasineura rozkovi* Mam.et Nick.) is the major pest of larch seed orchards. In *Pinus sylvestris* forests the main folivores are: *Dendrolimus pini*, *Lymantria monacha* and *Bupalis piniarius*; among wood borers *Ips sexdentatus, Tomicus piniperda* should be mentioned. In the forests of Siberian fir (*Abies sibirica*), *D. superans* is the main needle-eating pest and *Monochamus urussovi* is the main wood borer. At last, in the forests with *Picea obovata* – the Siberian spruce – *Selephera lunigera* is the main folivore and *Ips typographus* and *Tetropium castanea* are the main borers.

Siberian Russia is the source of wood materials for many countries, Japan and Korea among them. There is no export of Siberian wood to the North America because of the quarantine restrictions. If the wood trade between the countries will take place, the ways of possible introduction of Siberian forest insects will be through the sea ports of Asian Russia. It may be Far Eastern ports, which represent 31% of the total Russian cargo capacity.

During last 10 years Russia and the USA have cooperated on technology and information transfer regarding pest risk assessment and control of potential pests. The Russian Far East Lymantriid monitoring system was set in the port areas of the Russian Far East. It was agreed that insect outbreaks in the nearby forests should trigger mitigation measures. The project on Siberian moth pheromone monitoring system ended this year. The sex attractant of this main pest of coniferous forests was identified and proved to be very effective. An annotated bibliography of Russian and Ukrainian literature on the gypsy moth was published at 1998. Two manuals: on the Diseases of Russian forest trees and on Major insect forest pests of Northern Asia are close to accomplishment. A dozen research projects mainly on the biology and control of the Asian race of the gypsy moth were done and published results will help in estimating of the risk of pest arrival and establishment.

USDA Inspections of Import Cargo

Patricia Fitterer, USDA, APHIS, PPQ, Portland, OR

USDA, APHIS, Plant Protection and Quarantine officers work at international points of entry, airports, land borders with Canada and Mexico and maritime ports. We inspect cargo at each port of entry and passenger baggage at airports and cruise ship terminals. Cargo is endlessly varied: fresh flowers, toys, dump trucks, and fresh produce. Solid wood packing material from all countries has become a high inspection priority, especially from China, in light of recent Asian Longhorned Beetle infestations in Chicago and New York. We look for insects, snails, weed seeds, plant and animal diseases. Exotic pests may arrive as hitchhikers or associated with imported host material. For example, mealy bugs may be found on wooden crating around machinery or on a piece of fruit. Our basic procedure for clearing cargo in Portland, OR and Long Beach, CA is:

1) Hold cargo entering the country by air or seas based on regulations, port policy and personal experience.
2) Inspect all or part of the cargo by full devan or tailgate inspection at the shipping terminal or nearby warehouse.
3) Results: Cargo is inspected and released if no pest is found. If a pest is found, it is identified and determined and either no action or action is taken, depending on the organism. For actionable pests, options for action vary: sort or grind for seed contaminants in seed; fumigate for insects or snails, except for snails on produce.

The USDA cooperates with state and county agriculture officials as much as possible. Referrals are made of state quarantine pests and staff may assist on inspections.

Oregon's Imported Wood Inspection Program – Insects and Plant Pathogens

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Since 1991, Oregon Department of Agriculture inspectors have examined over 50 million board feet of imported, untreated timber products for exotic pests (insects and plant pathogens). Products that have not been heat treated (71.1°C for 75 minutes measured at the core) are considered untreated. All products are visually inspected for signs or symptoms of pest damage. Samples are collected from damaged products and from healthy-appearing products chosen at random. All samples are brought to the laboratory for further analyses. Products inspected from 1997-1999 included logs and green lumber from New Zealand, cross ties from Russia, crafts from China, and solid wood packing material (SWPM) from Asia. Nearly every inspection conducted during that time period revealed the presence of an exotic pest. Exotic insects were intercepted on logs, crafts, and cross ties. Exotic plant pathogens were intercepted in logs, cross ties, green lumber, and SWPM. For example, during one log inspection, a fungal pathogen (*Graphium* sp.) was found with its dead bark beetle vector (*Hylurgus ligniperda*) under a piece of bark. During the inspection of a suspect shipment of artificial Christmas trees, live exotic longhorned beetles (*Callidiellum villosulum*) were found on one "tree". The "tree" was confiscated and destroyed. On both occasions, the products were accompanied by fumigation certificates. Native insects were found infesting imported wood products that were stored outside for ≥ 2 wk. Fortunately, these insects were not found on products that were already infected with an exotic pathogen(s). Our inspections show that: 1) Exotic pests are intercepted regularly on imported, untreated timber products; 2) Some pests can survive fumigation; 3) Native insects could potentially become vectors for exotic plant pathogens.

Monitoring High-risk Sites for Exotic Wood-boring Beetles and Wood Wasps in Oregon

Alan D. Mudge, James R. LaBonte and Kathleen J. R. Johnson, Oregon Department of Agriculture, Plant Division, Salem OR

Due to increasing volumes of imported timber, wood products, and solid wood packing materials arriving in the Pacific Northwest, surveys for exotic wood-boring beetles and wood wasps were initiated in Oregon in 1997. Exotic wood-borers intercepted at Oregon ports, warehouses and retail centers on imported timber, solid wood packing material (SWPM), and artificial Christmas trees include live adult *Monochamus alternatus* Hope and *Callidiellum villosulum* (Fairrnaire) (Coleoptera: Cerambycidae), and dead *Hylurgus ligniperda* (F.), and *Phloeosinus* sp. (Coleoptera: Scolytidae).

Approximately 23 high-risk sites including ports, mills, warehouses, wood recyclers, and dunnage sites have been surveyed. Survey sites are scattered throughout western Oregon with a concentration in the Portland metropolitan area. Three Lindgren funnel traps were placed at each site, one baited with a 3-component exotic Ips lure, a second with alpha-pinene and ethanol, and a third with ethanol only. Bait logs of Scots Pine (*Pinus sylvestris* L.), a preferred host for Pine Shoot Beetle, were also placed at all trap sites. Traps and bait logs were placed in the field beginning in late-January. Funnel traps were sampled biweekly until they were removed in mid-October. Bait logs were removed from the field in early May, transferred to emergence tubes, and monitored for insect emergence until mid-October.

36,981 individuals and 300 species of wood boring or wood-associated beetles and wood wasps have been identified to date and include: Scolytidae - 74 species (25%), Cerambycidae - 72 species (24%), Buprestidae - 18 species (6%) and Anobiidae - 14 species (5%). 122 other species of wood-boring or wood-associated Coleoptera (114 sp., 22 families), Hymenoptera (Siricidae - 7 sp., Xiphydriidae - 1 sp.) and Lepidoptera (Sesiidae - 1sp.) were also identified. Fourteen species of scolytids (19%) are exotic species including six exotic species previously recorded from Oregon, and 8 exotic species (11%) recorded from Oregon, the Pacific Northwest, the western U.S., or North America for the first time (Table 1.).

Other significant new records include:

Coleoptera: Micromalthidae - *Micromalthis debilis* LeConte, telephone-pole beetle.
New state record. Primitive beetle family represented by this single species. An eastern U.S. species distributed worldwide through commerce.

Coleoptera: Cerambycidae - *Phymatodes testaceous* (Linneaus), tanbark borer.
New state and western U.S record. A European species known to be established in the eastern U.S.

Hymenoptera: Xiphydriidae - *Xiphydria prolongata* (Geoffroy), willow wood wasp.
New state and western North American record. A European species formerly recorded from Michigan and New Jersey. Associated with watermark disease of willows.

All the new exotic species with the exception of *Micromalthus debilis* and *Monarthrum fasciatum*, have been trapped multiple times, most over at least two years, and probably represent established populations. While most of these exotic species primarily attack raw lumber or stressed, dying, or dead trees (both soft- and hardwoods), several are known to readily attack healthy trees, including *Hylastes opacus*, *Xylosandrus crassiusculus*, and *X. germanus*. Most of the species listed above have hardwood hosts, implicating dunnage and SWPM as probable sources. Five of these species are either native to the eastern U.S. or are European or Asian species known to be established there. At least some of these species were likely introduced to Oregon from the eastern U.S. via SWPM or raw lumber. Others originate from the American tropics and sub-tropics, Europe, and Siberia east to Asia.

Almost sixty percent of the sites surveyed yielded new state, regional, western U.S., or North American records. All the sites surveyed had a high introduction potential, but these probably represent only a modest fraction of such sites. While most of these exotics are not expected to have significant economic or ecological consequences, we cannot afford to be complacent. These detections underscore the need for effective regulations and continued monitoring of imported wood products and solid wood packing materials to prevent the introduction of exotic wood-boring insects from foreign as well as domestic sources. Systematic surveys of high-risk sites are essential to assess the efficacy of port inspection, certification, and quarantine programs, and to determine which introduced organisms may already be established. Clearly, there is much left to learn about the impacts and prevalence of introduced species in our forests and urban and rural environments.

Table 1. Historical vs. new exotic Scolytidae in Oregon

Historical Exotic Species	New Exotic Species
Hylastinus obscurus (Marsham)	[1]*Gnathotrichus materiarius* (Fitch)
Scolytus multistriatus (Marsham)	[2]*Hylastes opacus* Erichson
Scolytus rugulosus (Muller)	[1]*Monarthrum fasciatum* (Say)
Xyleborinus saxeseni (Ratzeburg)	[3] *Xyleborinus alni* (Niisima)
Xyleborus californicus Wood	[2]*Xyleborus pfeili* (Ratzeburg)
Xyleborus dispar (Fabricius)	[1]*Xyleborus xylographus* (Say)
	[2]*Xylosandrus crassiusculus* (Motschulsky)
	[2]*Xylosandrus germanus* (Blandford)

[1] Species native to other parts of the U.S.
[2] Exotic species established in eastern U.S.
[3] Exotic species established in Washington and British Columbia

Current Trends in Wood Import Issues at Plant Protection and Quarantine

Jane Levy, Plant Protection and Quarantine, United States Department of Agriculture, Riverdale, MD.

Plant Protection and Quarantine (PPQ) is responsible for keeping exotic pests out of the United States while facilitating trade. PPQ accomplishes this mission by regulating the movement of agricultural products moving into and within the United States, and by ensuring exported commodities will meet the entry requirements of the foreign country.

PPQ is the agency within the United States Department of Agriculture that regulates the importation of wood and wood products into the United States. In 1995, APHIS published comprehensive wood import regulations to prevent the introduction of quarantine pests into the United States. The import regulations are broken down into categories such as tropical/temperate, softwood/hardwood, universal options and packing material. Pest risk assessments are conducted for specific genus and origin commodities to provide better quarantine security for high volume or possibly high risk commodities. Most wood and wood products are debarked and /or fumigated prior to arrival in the United States. Wood and wood products are inspected at the port of entry for live pests and to verify entry requirements have been met.

Pest risk assessments are continually being done to evaluate the risk of importing various genus and origin combinations. The U.S. Forest Service conducts the risk assessments for PPQ. The risk assessments target high volume commodities and sections of the regulation that need clarification. Some examples are radiata pine from Chile and New Zealand, both high volume commodities, and pine and fir from Mexico, a part of the regulation that needed to be researched. The Forest Service is currently working on a risk assessment for eucalyptus from South America. Eucalyptus does not fit well into the tropical/temperate categories of the wood import regulations since most species will grow in both areas. There is also a big demand for importing eucalyptus since many plantations in South America are ready for harvest. Results from the risk assessments are used to determine which mitigation measures are needed to safely import the commodity. Quarantine pests identified by the assessment are grouped by their location on a tree; twigs/leaves, on/in the bark, under bark, sapwood and heartwood. Next, mitigation measures are prescribed for the pests, such as heat treatment for heartwood pests, or debarking and fumigation for pests found in or on the bark. Mitigation measures are developed for logs, lumber, and chips. The final step is to revise the regulation.

The wood import regulations do not address the risk associated with processed wood products. Traditionally, PPQ didn't consider decorative articles for indoor use as high risk. These items were outside of the scope of the regulation. Changes in the types of products being imported has changed that philosophy. Wood articles are being imported with little to no processing, such as artificial Christmas trees with real wood trucks. A new group has been formed in PPQ called the Processed Products Advisory Group (PPAG). This group is looking at the risk associated with processed wood articles to determine if they fall into the current wood import regulations, or whether the regulations need to be revised. The group will also identify which companies are importing these articles to provide information on new import requirements and improve awareness of current requirements. Finally, PPQ is identifying new products being imported that could pose a risk of importing quarantine pests by keeping close contact with current importing trends.

Exotic Forest Insect Issues for Canada

Jon Bell, CFIA, Westminster, BC, Canada.

The new global economy is raising concerns worldwide, not for the manufactured products that are being moved, but for the hitchhiking pests that are moving in ever greater numbers. Wood products have been responsible for moving some very high profile insects into North America over the last few years. Phytosanitary agencies are attempting to stem the flow of pests with actions such as the new legislation to restrict the entry of untreated wood from China, but what lies in the future? As markets keep expanding and the international flow of trade goods continues to rise unabated, what new pests will be found at ports of entry or worse yet, in the natural and urban forests of Canada and U.S.?

Mountain Pine Beetle – The Next Wave? Part 2

Moderator: Joel D. McMillin, USDA Forest Service, Rapid City, SD

Presenters: Kurt Allen (USDA Forest Service, Rapid City, SD), Jim Vandygriff (USDA Forest Service, Logan, UT), Les Safranyik & Terry Shore (Canadian Forest Service, Victoria, BC), and Barbara Bentz (USDA Forest Service, Logan, UT)

Participants: Approximately 35

McMillin introduced the session:

Mountain pine beetle populations are on the rise again throughout many forests of the western United States and Canada. In particular, areas of Colorado, South Dakota, Wyoming, Montana, Idaho, and British Columbia have seen large increases of lodgepole and ponderosa pine mortality beginning in the late-1990's. For example, there has been a doubling of mountain pine beetle-caused mortality to ponderosa pine in each of the last four years in the Black Hills of South Dakota.

This session was organized as a follow up session to the meeting in Breckenridge, Colorado that discussed current management tools and strategies being implemented to combat this destructive beetle. Kurt Allen began by providing an overview of mountain pine beetle and management actions in the Black Hills. Jim Vandygriff next discussed his research that examined manipulating MPB populations in a push/pull strategy for improved fuelwood harvest management. Les Safranyik presented results from studies investigating the interactions between secondary bark beetles and mountain pine beetle in British Columbia. Barbara Bentz concluded the session by sharing research focused on mountain pine beetle in the southwestern ponderosa pine type. A lively and fruitful discussion followed each presentation.

The Beaver Park Experience: Trials and Tribulations with the Mountain Pine Beetle in the Black Hills

Kurt Allen and Joel McMillin, USDA Forest Service, FHM, Rapid City, SD

There have been many recent policy decisions that have played a part in what can or cannot be achieved to manage mountain pine beetle on the Black Hills National Forest. Populations in the Black Hills have rebounded from a historic low in the mid-nineties and have increased 5 fold over the last 3 years. The area that has seen the most beetle activity is in Beaver Park, just west of Sturgis, SD. This increase has brought with it a great deal of social and political debate.

Recent management and policy decisions that are influencing management options include the Revised Land Management Plan for the Black Hills that was signed in 1997 and included Beaver Park as a RARE II roadless area. The revised plan was appealed. Since then there have been a number of landscape size projects that have been implemented or proposed for areas surrounding Beaver Park. All projects that included treatments for managing mountain pine beetle in Beaver Park was stopped until the forest plan appeal was decided. In October of 1999, a nationwide injunction against timber sale categorical exclusions was put in place. Categorical exclusions previously were used to remove small amounts of timber without going through the entire NEPA process. A common use of the categorical exclusions was for removal of beetle-infested material. Also in October of 1999, the review of the Black Hills forest plan appeal was decided. The review sided with appellants on 2 counts. Since that time, most projects on the forest that were not already actively being implemented on the ground have been pulled back. It is projected that the appeal points will be cleared up in 2 years; however, within that time frame, projects managing for mountain pine beetle probably will not proceed. Finally, the president's roadless initiative was released in November of 1999. This initiative would include the Beaver Park area as one of the places that is set aside and may preclude any management projects from being implemented.

Thus, similar to other national forests in the West, there are more questions than answers on how the Black Hills National Forest should proceed to manage for mountain pine beetle. Silvicultural tools for managing mountain pine beetle in the long term are being used less. Direct beetle control is also being prevented in several cases throughout the western United States. If these preventative thinning and sanitation harvest strategies are not used in the future, we are going to have to find other methods for managing this beetle. In conclusion, it seems that we will have to be very innovative in finding new ways for managing mountain pine beetle in the future.

A Novel Approach to Managing Fuelwood Harvest Using Bark Beetle Pheromones

Jim Vandygriff, USDA Forest Service, Rocky Mountain Research Station, Logan, UT

A three-year study within the Sawtooth National Recreation Area (SNRA) was completed in which mountain pine beetle populations were successfully manipulated with the use of synthetic pheromones in order to group tree mortality within selected fuelwood harvest areas. Because beetle induced mortality occurs randomly throughout the forest, and because current programs allow fuelwood gathering in designated "hunt and peck" areas, fuelwood harvesters often venture off designated roads to access dead trees. By grouping mortality within designated stands of lodgepole pine, close to existing roads, and away from visually or environmentally sensitive areas, we effectively demonstrated a tool whereby managers can more effectively administer the collection of fuelwood, and subsequently reduce resource damage.

Our primary objective was to determine if synthetically produced pheromones could be used in a "push/pull" strategy to push mountain pine beetle from one area and congregate (pull) them into another area where the infested trees could be readily harvested. During the first two years of our study, multiple replicates were surveyed, each consisting of three 1-acre blocks located a minimum of two chains apart. To push the beetles out of an area, one block received 40 antiaggregative verbenone bubble-caps evenly spaced throughout the block. To pull the beetles into an adjacent area, a second block was treated with 5 attractant pheromone baits. The third block was designated as a control plot, receiving no treatment. During the final year of our study, we modified our design to include a new objective of mistletoe control. Replicate sites were located in stands of lodgepole pine whose overstory was heavily to moderately infected with dwarf mistletoe.

Each year of our study, we demonstrated the highly effective use of attractant baits in moving mountain pine beetle into selected harvest areas. In every replicate, beetle attacks increased dramatically within the baited blocks, while simultaneously decreasing to near zero in associated control and verbenone treated blocks. This suggests that we were successful in moving beetles into baited fuelwood harvest plots. Utilizing these established techniques, the final year of our study we were hoping to remove a significant proportion of the dwarf mistletoe infected overstory, thereby reducing inoculum, and initiating sanitation of infected stands of lodgepole pine. While we successfully moved beetles into these baited plots, not enough overstory trees were attacked to significantly change the stand structure; hence sanitation of these stands was not accomplished. Less than satisfactory results from this year may have coincided with a dramatic collapse within local endemic populations of the mountain pine beetle (probably due to record breaking low annual mean temperatures during the beetle flight month of July).

Research has repeatedly demonstrated the effective use of pheromone baits in localizing and concentrating mountain pine beetle attacks. The challenge remains to find better ways to use this tool effectively in conjunction with local management objectives. Given the right conditions, including road access, current endemic levels of mountain pine beetle, and defined silvicultural objectives, we successfully demonstrated a strategy where local managers were able to use the mountain pine beetle to improve management of fuelwood resources as well as potentially improve stand health.

Effects of Induced Competitive Interactions with Secondary Bark Beetle Species on Establishment and Survival of Mountain Pine Beetle Broods in Lodgepole Pine

Les Safranyik and Terry Shore, Canadian Forest Service, Victoria, BC, Canada

The effects of pheromone-induced competition from secondary bark beetle species on mountain pine beetle attack and brood production in mature lodgepole pine were investigated in south central British Columbia. The effects of delaying baiting for secondary species and of felling host trees (following mountain pine beetle attack) were also examined. The pine engraver (Ips pini (Say)) was the principal competitor in all experiments and three additional secondary species, *I. latidens* (LeConte), *Pityogenes plagiatus knechteli* Swain, and *Dryocoetes confusus* Swain were included one experiment. Baiting simultaneously for mountain pine beetles and pine engravers significantly reduced mountain pine beetle attack density and brood production in one of two trials, due mainly to the repellent effects of the pine engraver bait. Use of pine engraver bait resulted in greater numbers of attacks and increased densities of that species hibernating in duff. Delaying baiting for pine engraver significantly increased their brood production, but usually not that of mountain pine beetle. Felling trees had no significant effect on attack or brood production. Baiting trees for *I. latidens*, *D. confusus*, or *P. p. knechteli* ca. one week after peak attack by mountain pine beetle caused marginal reductions in mountain pine beetle brood density and suggested that a strategy of simultaneous baiting should be explored. The complex interactions of the pine engraver and the mountain pine beetle in response to induced attacks by both species are illustrated using a hypothetical model.

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Mountain Pine Beetle in Southwestern-Type Ponderosa Pine

Barbara J. Bentz, USDA Forest Service, Rocky Mountain Research Station, Logan, UT

Periodic outbreaks of the mountain pine beetle (*Dendroctonus ponderosae* Hopkins), in combination with the roundheaded pine beetle (*D. adjunctus*), western pine beetle (*D. brevicomis*), and larger Mexican pine beetle (*D. approximatus*) have affected thousands of acres of ponderosa pine (*Pinus ponderosa*) forests on the Colorado Plateau. The Colorado Plateau encompasses southern Utah, southwestern Colorado, northern New Mexico, and northern Arizona. These insects, along with fire, are among the major disturbance agents affecting southwestern ponderosa pine forests. Since the turn of the century, however, humans have entered as an additional player, placing added demands on the ecosystem that are often disrupted by both fire and bark beetle outbreaks. Consequently, we seek ways to mitigate impacts due to these disturbance agents in particular areas where products may be harvested for human use. Specific to bark beetles, the first step in this mitigation process is to identify those areas which may be more susceptible to the initiation and growth of a population. This includes identifying forest stand and site conditions that are most conducive to a bark beetle population outbreak. Conditions favorable to an endemic or low level of beetles, however, may be very different from stand conditions which allow a beetle population to remain in the stand and infest a large proportion of the trees over several years. Additional factors include whether or not an existing beetle population is in the surrounding area, and if weather conditions are appropriate for population expansion. When these types of factors are added to the stand and site information, referred to as susceptibility, a risk rating system evolves (Bentz et al.1993, Shore and Safranyik 1992).

Susceptibility rating methods exist for ponderosa pine in the Black Hills of South Dakota (Stevens et al. 1980, Olsen et al. 1996), but stand conditions differ between the Black Hills and the Colorado Plateau. Ponderosa pine stands in the Black Hills tend to be homogeneous, even aged, and uniformly distributed, as contrasted to typical Colorado Plateau stands which are more heterogeneous with respect to age class and spatial distribution of stems. The objective of this research was to collect stand/plot-level data to develop a susceptibility rating system for the southwest ponderosa pine type. Associated projects are analyzing the role of weather and surrounding beetle population pressure in the outbreak process for development of a risk rating system.

Sites were selected where endemic, building, and epidemic populations of bark beetles were present. Ten sites were identified in northern Arizona, 27 sites in central and southern Utah and 8 sites in southwestern Colorado. Following site selection, 2 transects were randomly placed within the stand. Each transect consisted of 10 linearly contiguous 1/10 acre fixed radius plots. This design allowed for analysis of spatial patterns in beetle attacks. A plethora of stand and site measurements were recorded at each plot. Included were tree species, diameter at breast height, and status which indicated whether a tree was live or dead, and if dead, the agent of mortality. The status also included the type of bark beetle attack as either full, strip, or pitch out, the bark beetle species(s) responsible for death of the tree, and year of attack. Using visual signs of the tree, crews could reliably back-date 3 years of bark beetle attacks. The first surveys were done in 1995-96 and the second surveys were completed in 1999. Because tree mortality can be back-dated 3 years, the record of beetle activity at each site is continuous from 1992 - 1999. All plots at all sites have been established permanently and will be revisited every 2-3 years to monitor beetle activity.

A total of approximately 21,000 trees on 900 plots at 45 sites were measured. 18% of the plots had beetle-attacked trees. The 9-10 inch diameter class contained the largest frequency of attacked trees. The average ponderosa pine age was 90 years and average age of beetle-killed trees was 103 years. There was no apparent trend between Periodic Growth Ratio and percent basal area (BA) killed on a plot. As expected, there was a large amount of plot to plot variation in ponderosa pine quadratic mean diameter, BA and stand density, indicating patchy or clumped arrangement of both ponderosa pine and other tree species in the plots. An index of dispersion was calculated to describe this spatial pattern. At times, although not always, beetles were first active in plots with the largest diameter trees and highest BA. A distinct spatial pattern in the temporal pattern of attacks was observed. Attacks were initiated in one or two plots with subsequent attacks in the following years most often in plots adjacent to the initially attacked plots. At some sites, all the ponderosa pine BA was removed from a single plot before attacks in nearby plots occurred.

Classification and regression tree analysis is being used to develop a model for predicting susceptibility to a beetle outbreak. Additionally, the plots will be monitored through time, providing more accurate data on those factors most important in the development and evolution of a beetle population in a particular stand. This information will also alleviate the nagging response variable question of whether or not a stand has been challenged by a beetle population, greatly improving our ability to develop a more accurate susceptibility and risk rating system for bark beetles associated with southwestern-type ponderosa pine.

Preliminary data analysis indicates that stand conditions in the southwestern-type ponderosa pine are different from those conditions that exist in many lodgepole pine stands in the northern part of the mountain pine beetles' range. Additional studies have shown that beetle populations from central Idaho (in lodgepole pine) and southern Utah (in ponderosa pine) are also different in terms of cold-hardening and several fitness parameters including development time and adult size. Beetles from central Idaho are more cold hardy, develop faster and are smaller compared to beetles from southern Utah which have higher supercooling points, develop slower and are larger. In conjunction with observed differences in host stand conditions, these results suggest that it will be necessary to develop individual management strategies and population prediction and risk models for each region and/or host type.

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Field Trip

Monitoring Wood Imports and High-Risk Sites for Exotic Pests

Tour Leaders:
Oregon Dept. of Agriculture - Karl Puls, Alan Mudge, Kathleen Johnson, Nancy Osterbauer
USDA APHIS Plant Protection and Quarantine - Patricia Fitterer, Gary Brown

En-route to Terminal 2

Chinese Garden: The largest urban classical Chinese garden outside of China is scheduled for completion in the summer of 2000. Raw materials including stone, masonry, wooden columns etc. were imported directly from China. Some of the raw building materials can be seen stored in wooden crates under the Steel Bridge. All solid wood packing material (SWPM) was imported under the recent interim rule effective Dec. 1998, governing SWPM from China and Hong Kong. Due to the risk of Asian longhorned beetle, the interim rule requires certification that all SWPM from China or Hong Kong be heat-treated, fumigated or treated with a preservative. USDA APHIS PPQ indicates that compliance with the interim rule has so far been very good.

1) Port of Portland - Terminal 2 (hard hats and safety vests required)

Terminal 2 (T2) receives frequent international shipping traffic and is inspected as needed by the USDA APHIS PPQ. Working closely with the southern Washington and Portland import terminal stevedores, SWPM and dunnage at the point of entry is closely monitored. PPQ is notified when ships are due in port and if dunnage is to be discharged, it is inspected as soon as possible after discharge. Container shipments from China or Hong Kong certified to be either free of SWPM or to have been fumigated are randomly inspected. Shipments from other countries do not require such certification and are also randomly inspected. Those containing SWPM, (e.g. heavy equipment) are more closely inspected for presence of bark and signs of woodboring and wood-associated pests. Plant pathogens are not inspected or tested for during normal PPQ procedures. "Tailgate" inspections require containers to be opened and examined, if necessary.

Problems have occurred in the past with longshore staff taking uncleared or quarantined dunnage for personal use, resulting in disciplinary actions. Staff now understand the importance of not removing dunnage before it has been cleared or fumigated. PPQ devised a system to indicate when dunnage can be removed and when it should be left alone. Drop boxes with no tape (uninspected) or yellow tape (to be fumigated) must be left alone. Following inspection or fumigation, drop boxes are white-taped and may be removed or emptied.

Other imported wood articles inspected at T2 include green lumber and fumigated raw logs and green lumber. These materials are routinely inspected by PPQ for external evidence of insect damage and any adhering bark is removed and inspected. ODA in cooperation with PPQ also inspects for insects and surface fungi and takes core and chip samples for plant pathogens. Dead *Hylurgus ligniperda*, a European bark beetle established in New Zealand, are routinely found under the bark of fumigated *Pinus radiata* logs from New Zealand. Live pathogenic fungi have also been isolated from these logs after fumigation. Colonization of such logs by native insects has generated considerable concern. The ODA trapped T2 in 1998 and 1999 and found no target wood pests. Trapping of the Vancouver, WA, terminal yielded an exotic ambrosia beetle (*Xyleborinus alni*) only recently known from the region and a long-horned beetle tentatively identified as an exotic species, *Phymatodes testaceus*, new to western North America.

En-route to Romar:

West Coast Wire Rope and Rigging, Inc.: A good example of imported wooden spools can be seen at this sight. Most are from China, Korea, and Malaysia. Some spools are forwarded to end users and empty spools stored indefinitely outside or sent to a recycler.

Harvest Homes *Hylastes opacus* site: One of three sites in Oregon where *Hylastes opacus*, an European bark beetle, was found in Scot's Pine bait logs, representing a new state and western North American record. *H. opacus* has recently been recorded from several northeastern states and West Virginia. *H. opacus* is a noxious pest of nurseries and pine plantations in Europe. Other sites in Oregon include Sweet Home, Linn Co. and The Dalles, Wasco County.

2) Romar Trans. Systems, Inc. - Presentation by Peter Manson, Regional V.P.

Romar is a Customs Freight Service warehouse. Many unusual items move through here, including ceramic pots from Vietnam, coconut shell mulch from the Philippines, and recently a Russian MiG Fighter. Some shipments not inspected at the shipping terminals are inspected here or at similar facilities, at the request of APHIS PPQ or Customs. Inspections are often more intensive than can be performed at the terminals, and are done as soon as possible after devanning to prevent pest escape. Cargoes with pest interceptions are reloaded for safeguarding inside the container. Periodic "walk-throughs" of these warehouses are also performed by PPQ inspectors.

ODA placed Lindgren traps both inside and outside the warehouse in 1998 and 1999. Traps placed outside yielded two exotic ambrosia beetles, *Xyleborinus alni* (a new Oregon record) and *Xyleborus californicus* (although previously known from Oregon, this is a new county record). No significant detections were made in traps placed inside.

En-route to Waste Management

Asian Gypsy Moth: In 1991, a single Asian gypsy moth (AGM) was detected in this part of north Portland. Cargo ships from the Russian Far-East were found to be carrying AGM egg masses to ports in the Pacific Northwest and elsewhere. In 1992, eradication programs using *Bacillus thuringiensis* var. *kurstaki* (B.t.k.) were conducted in Oregon, Washington, and British Columbia. Approximately 8,400 acres were treated in north Portland including most of the area we've been driving through this afternoon. Approximately 18,000 gypsy moths traps are placed in Oregon each year. All gypsy moths trapped are genetically tested to determine if they are North American or Asian by the OTIS Methods Development Laboratory in Massachusetts. Thirteen gypsy moths were detected in Oregon in 1999 - the fewest since 1989! A small eradication program by ground on 10 acres is being proposed in Ashland in southern Oregon in 2000. No AGMs have been found in Oregon since 1991.

3) Waste Management, Inc. - Presentation by Richard Ritz, Manager

SWPM is received from different waste haulers and stored on site. Dunnage cleared by PPQ at T2 is also received here. This material is then sent to NW Wood & Fibre where it is ground-up for use as "hog fuel" or recycled building materials e.g. press board. ODA trapped this site in 1998 and 1999, yielding the "willow wood wasp" (Xiphydriidae: *Xiphydria prolongata)*, an exotic European species new to the western U.S. ODA has found not only the willow wood wasp at a similar wood recycling site in east Portland, but two additional exotic species new to the western U.S., *Phymatodes testaceus* (Coleoptera: Cerambycidae) and an ambrosia beetle, the "black stem borer", *Xylosandrus germanus*. The latter species is a pest attacking a wide variety of trees in the eastern United States. Movement of "exotic" pests (e.g. Pine Shoot Beetle) from eastern North America to the west is becoming an increasing concern. ODA plans to trap both Waste Management and NW Wood and Fibre in 2000.

4) Cascade Rigging, Inc. - Presentation by Scott White, Warehouse Manager

An importer of wire rope and rigging from China and Korea, this business receives four containers per year, each containing 5-30 wooden spools. Wooden crates from another business that imports directly from China are also purchased. The spools are stored outside indefinitely and are not sent to a recycler. They are occasionally reused and sent to other businesses. SWPM is more commonly removed and recycled by a waste hauler. Employees infrequently remove the wood for personal use.

In a survey done by the Canadian Forest Service in British Columbia, 92 spools from China, Korea, and Malaysia were examined for bark and insect activity. The results are tabulated below:

Spools with insect galleries	82%
Spools with live or dead insects	20%
Spools with live insects	14%
Spools using wood with bark present	90%
Chinese spools with insects	41%

Source: Exotic insect interceptions from wooden dunnage and packing material. Canadian Forest Service. www.pfc.cfs.nrcan.gc.ca/health/exotics.htm.

Wood with bark present was usually hidden in the inner layers of the spool. Because these spools are often used and left in remote forested areas, they may serve as a direct pathway for exotic insects and pathogens.

The ODA has not trapped this site, but will do so in 2000. Visual examination of the SWPM from another importer revealed many insect galleries and much evidence of fungal infestation, including live mushrooms on pallets. Seventeen species of fungi, including several potential tree pathogens, were isolated from a single pallet.

ODA Survey for Exotic Woodborers

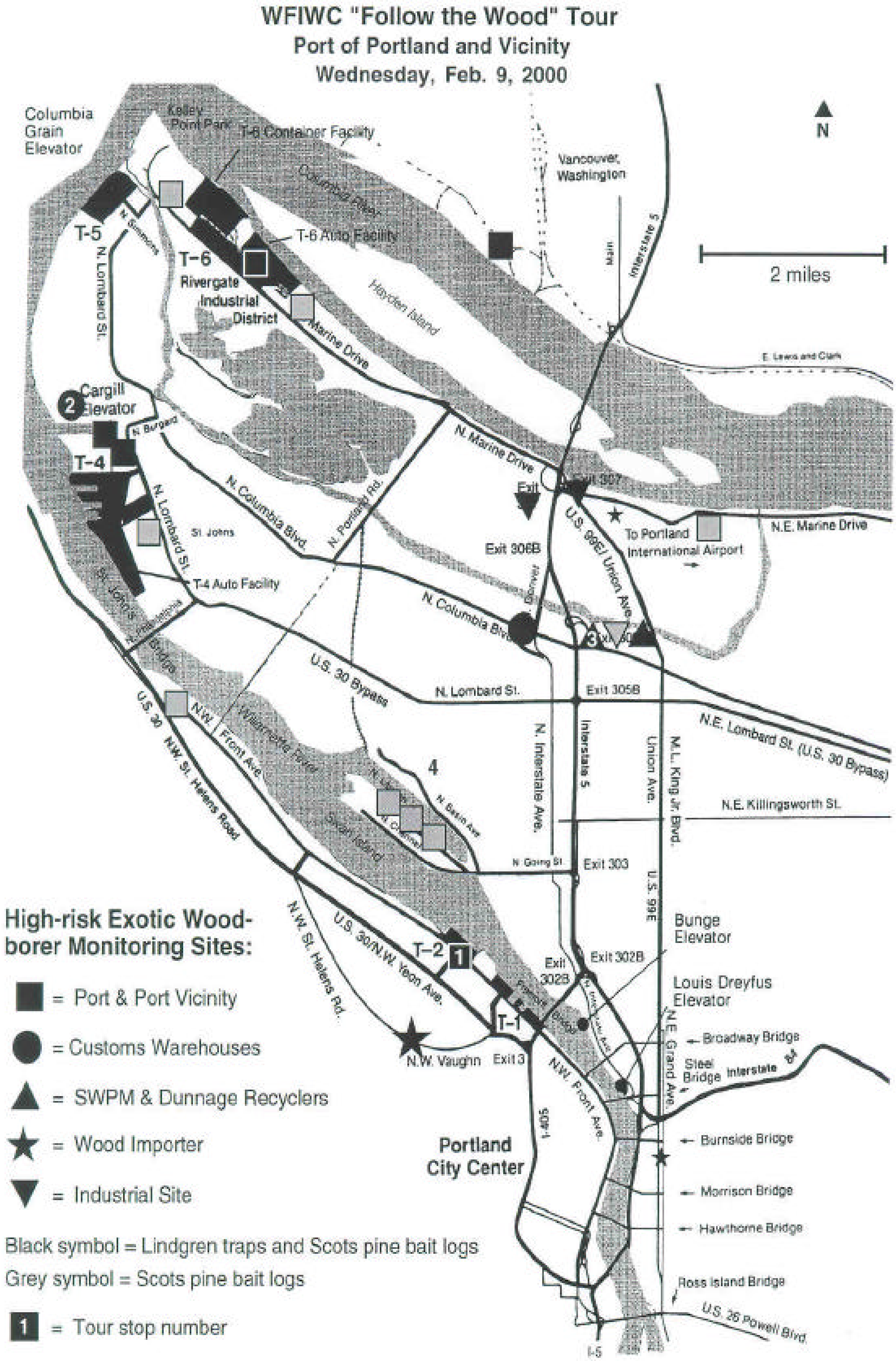
Since 1997, the Oregon Dept. of Agriculture (ODA) has surveyed for exotic wood-boring insects at ports, mills, recyclers, and other businesses which import or receive foreign wood products and packing materials. These surveys are conducted using Lindgren funnel traps and Scots pine bait logs. Since 1997, 36,981 individuals and 300 species of wood-associated and wood-boring beetles and wood wasps have been identified to date. These include fourteen new state, regional, western North American, or North American records, as well as new locality records for a previously established exotic ambrosia beetle formerly known from only two sites. Significant detections were made at 13 out of 23 sites monitored (57%).

Lindgren Funnel Traps

Lindgren funnel traps consist of a series of large, black, partially nested plastic funnels suspended from a six-foot metal rod. Lindgren traps act as flight intercept traps. Insects attracted to the trap fly to it, hitting one of the funnels and fall through the funnels into a cup of preservative below. These traps have both visual and olfactory components; the dark column formed by the funnels simulates a tree trunk while various volatile compounds in lures attract olfactorily orienting insects. Lures have varying degrees of specificity depending upon the compounds used. Since no single lure effectively attracts all target species, ODA uses three traps at each site, each with a different lure: ethanol, alpha-pinene & ethanol, and exotic *Ips* pheromones. Ethanol lures tend to target woodborers with deciduous hosts. Combined with ethanol, alpha-pinene targets conifer-feeders. Exotic species of engraver beetles (Scolytidae: *Ips* species) are lured with artificial engraver beetle aggregation pheromones. Collected insects are retrieved every two weeks.

Scot's Pine Bait Logs

Detection of Pine Shoot Beetle (PSB) (Scolytidae: *Tomicus piniperda*) is the reason for using Scot's pine bait logs. Scot's pine is the preferred host of this important nursery, plantation, and forest pest. No artificial lure is known which is more attractive than freshly cut Scot's pine. PSB overwinters under bark at the base of pine trees and leaves these sites to oviposit in recently cut or dying pine trees, stumps, or logs when temperatures reach 50ºF. Two-foot lengths of 4-8" diameter Scot's pine are cut from live trees each winter and used as bait logs. A "teepee" of three logs is lashed together and placed on the ground at each high-risk site in late January or early February. Beetles leaving overwintering sites in the vicinity will presumably be attracted to these breeding sites to oviposit. The logs are retrieved in April or early May, before any new generation PSBs emerge, and are placed in emergence tubes. Insect emergence is monitored bi-weekly until July. While no PSBs have been found by ODA, an unexpected result was the first western U.S. detection of an exotic nursery and plantation pest, *Hylastes opacus*, a European bark beetle recently recorded from the eastern United States.


WFIWC "Follow the Wood" Tour
Port of Portland and Vicinity
Wednesday, Feb. 9, 2000
Columbia Grain Elevator
Kelley Point Park
T-6 Container Facility
Columbia River
Vancouver, Washington
N
T-5
T-6
T-6 Auto Facility
Rivergate Industrial District
Hayden Island
Marine Drive
2 miles
Interstate 5
Main
E. Lewis and Clark
N. Lombard St.
Cargill Elevator
T-4
N. Burgard
N. Marine Drive
N. Columbia Blvd
N. Portland Rd.
Exit 307
Exit 306B
U.S. 99E/ Union Ave.
To Portland International Airport
N.E. Marine Drive
St. Johns
T-4 Auto Facility
St. Johns Bridge
N. Columbia Blvd
U.S. 30 Bypass
N. Lombard St.
Exit 305B
N.E. Lombard St. (U.S. 30 Bypass)
U.S. 30
N.W. St. Helens Road
N.W. Front Ave
Willamette River
4
N. Interstate Ave.
Interstate 5
Union Ave.
M.L. King Jr. Blvd.
N.E. Killingsworth St.
Swan Island
N. Basin Ave
N. Going St.
Exit 303
U.S. 99E
N.W. St. Helens Rd.
U.S. 30/N.W. Yeon Ave.
T-2
Bunge Elevator
Exit 302B
Exit 302B
Louis Dreyfus Elevator
T-1
N.W. Vaughn
N.W. Front Ave.
Broadway Bridge
Steel Bridge
Interstate 84
N.E. Grand Ave.
I-405
Portland City Center
Burnside Bridge
Morrison Bridge
Hawthorne Bridge
Ross Island Bridge
U.S. 26 Powell Blvd.
I-5
High-risk Exotic Wood-borer Monitoring Sites:
= Port & Port Vicinity
= Customs Warehouses
= SWPM & Dunnage Recyclers
= Wood Importer
= Industrial Site
Black symbol = Lindgren traps and Scots pine bait logs
Grey symbol = Scots pine bait logs
1 = Tour stop number

Concurrent Sessions

Douglas-fir Tussock Moth – Current Issues, Part I

John Wenz, USDA Forest Service, Pacific Southwest Region, Forest Health Protection, Stanislaus National Forest, Sonora, CA

Background: The Douglas-fir tussock moth (DFTM) has recently (1997-99) gone through an outbreak cycle in the southern Sierra Nevada (CA) and caused light to moderate defoliation over about 2000 acres in northeastern California in 1999. Currently, there is the potential for several hundred thousand acres to be impacted in Oregon and Washington in 2000-01. Three workshop sessions were devoted to DFTM. Each session involved 30 to 40 participants.

Summary of 1997-99 Douglas-fir Tussock Moth Outbreak in California

John Wenz, USDA Forest Service, Pacific Southwest Region, Forest Health Protection, Stanislaus National Forest, Sonora, CA

California recently experienced it's sixth DFTM outbreak since the first documented outbreak in the state between 1935-37 in Mono County on the east side of the Sierra Nevada. The 1997-99 outbreak occurred on the westside of the southern Sierra Nevada in the Sequoia-Kings Canyon National Parks and in various locations on the Hume Lake, Tule River and Hot Springs Districts of the Sequoia National Forest. The outbreak followed the historical 3 to 4 year outbreak pattern characteristic of many DFTM outbreaks, with the majority of the damage to white fir occurring in the second year (1998). Populations increased over about 44,000 acres but moderate to heavy defoliation was found over only about 6,000 acres (13.6% of the overall infested area). Much of the heavy defoliation occurred in high-use recreation and administrative areas, along heavily used transportation corridors and in sensitive visual landscapes. Larval feeding resulted in localized tree mortality and top-kill creating hazard trees and relatively small, unplanned openings in and around the developed sites. Visitors and National Park and Forest Service employees, concessionaires and other forest workers, reported numerous incidences of mild to severe tussockosis, an allergic reaction to DFTM hairs, in the summer of 1998.

Feeding injury to white fir was first detected in August, 1997 and was preceded by 2 to 3 years of increasing pheromone trap catches in the central and southern Sierra Nevada. Although no pheromone plots were located near the outbreak area, the increased awareness due to the high trap catches in other areas helped facilitate detection of the outbreak in the summer of 1997. Subsequent pupal/ egg mass sampling in the fall-winter of 1997-98 identified general areas that would likely have moderate to heavy defoliation in the summer of 1998. Short timeframes and some uncertainty about predicting site-specific negative impacts in high-value areas precluded direct management action in 1998. The Sequoia-Kings Canyon National Parks considered implementing direct control in 1999 with Btk in specific high-use, high-value developed sites but, as predicted, based on the proportion of egg masses infected by the virus, populations declined in 1999 due to natural factors. This outbreak reinforced the need to utilize the early warning pheromone system and follow-up population sampling focused in areas of high resource value such that any direct control action can be implemented in time to prevent larval feeding damage from occurring in the second (peak) year of the outbreak.

Discussion:

It was pointed out that outbreaks in California sometimes precede outbreaks in the Pacific Northwest by a year or two.

In NEPA-related discussion in the fall/ winter of 1997-98 with resource managers concerning the potential effects of DFTM-related damage to white fir stands, it surfaced that most of the concern was associated with high-use recreation areas and developed sites, sensitive riparian areas and specific wildlife habitat areas. It was generally felt that DFTM effects in the general forest, with the possible exception of fuels build-up, could be tolerated, particularly given the increased levels of true fir biomass due in part to effective wildfire prevention/suppression.

If direct control were necessary, TM-Biocontrol (NPV), would have been the most generally accepted choice in California; registering TM-Biocontrol in California would be very beneficial.

Application of the Early-Warning Pheromone System 1980-1999: Analysis and Current Status

Gary Daterman[1] , John Wenz[2], and Katharine Sheehan[3]
[1] USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR
[2]USDA Forest Service, Pacific Southwest Region, Forest Health Protection, Sonora, CA
[3]USDA Forest Service, Pacific Northwest Region, Natural Resources, Forest Insects and Diseases, Portland, OR

Populations of the Douglas-fir tussock moth (DFTM) are cyclic, ranging from extremely low densities to outbreak populations capable of causing tree mortality and growth loss over extensive areas. Because DFTM populations are capable of transitioning very quickly into the outbreak phase, an early-warning system based on the capture of male moths in traps baited with sex pheromone was developed and implemented in 1980. The lure formulations for these monitoring traps are calibrated to release very low rates of pheromone so that moth attraction is very low. Thus, even though the monitoring system is designed with the traps remaining in place throughout the flight season, relatively few moths are generally captured in areas of low DFTM populations. Increasing numbers of trapped moths are therefore expected to correlate with increasing populations, and average trap captures above 25-40 moths calls for ground sampling for larvae, cocoons, or egg-masses in the general area (1 or more miles periphery around the trapping location). This system enables land managers and pest management specialists to focus their attention on the relatively few areas of high trap captures for DFTM outbreak concerns in any particular year.

Beginning in 1980, at least 750 permanent early-warning plots have been in place annually in Oregon, Washington, California, and Idaho. During that period of time 11 DFTM outbreaks of varying size and intensities have taken place. Seven of those outbreaks were detected from one to two years in advance of evident defoliation on the outbreak sites. Of the remaining four outbreaks, either no trapping sites were within reasonable distance of where the outbreaks occurred, or trapping data was misinterpreted and ground sampling was not implemented. The most reliable and helpful early-warning data came from areas where a substantial number (one per 5-10 square miles) of trapping plots were scattered within or very near the boundaries of the areas that were eventually defoliated. Where trapping plots were so located they yielded an early-warning of an impending outbreak two-years prior to the occurrence of defoliation. Trapping plots further distant (5, 10, or more miles from the area of outbreak) yielded high trap counts as well, but average trap catches generally did not exceed the threshold numbers of 25 or 40 moths per trap until one year prior to defoliation; and, on the average the numbers caught were lower. Some managers chose to increase numbers and distribution of trapping plots the year after permanent trapping sites registered above-threshold catches. This approach is not recommended, as invariably the increased trapping plots provided data that was late and of marginal benefit.

Discussion:

Workshop discussions about trapping results provided some constructive exchanges. The Region 6 EIS evaluation of the current Oregon and Washington DFTM outbreak, and options for treatment, illustrates the benefits of proper use of the trapping system. The trapping system provided the two-year outbreak prediction that resulted in appointment of the EIS team in time to appropriately develop and evaluate the pending outbreak and its treatment options. Without the trapping system, the outbreak would not have been detected until 1999 when the first defoliation became evident. Workshop discussion also brought to light the fact that ground sampling methods for larvae and cocoons or egg-masses were developed for branch, tree, or stand assessments of populations. Trapping plots, however, are sampling a more mobile life stage, and moths originating from a high-density population site could readily disperse a distance of miles during their life span of a week or more. Consequently, it is evident that development of better ground sampling methods is needed to characterize populations across broader scales (see discussion of artificial shelter technique, below) . A related problem is the occurrence of high trap counts with no corresponding populations evident in ground sampling in the general area around the trapping plot. Data from the outbreaks over the last 20-years indicate that trap counts will go up across a sub-region (eastern Oregon, for example), but actual defoliation may be limited to a much smaller area within that sub-region. These high counts may result from immigrant moths flying passively or actively into the trapping site from miles away; or, they may result from a more local population whose numbers subside prior to reaching outbreak levels.

Generally, these results and observations call for (1- continuation of the annual trapping system with a permanent set of early-warning plots; 2)- a re-distribution of permanent trapping plots to achieve more uniform coverage (some areas currently have too few and some too many plots); 3)-an improved follow-up system for ground sampling larvae and egg-masses is needed; and, 4)-avoiding the use of additional trapping plots to supplement permanent trapping plots that have already indicated a population increase.

The use of artificial (cryptic) shelters to sample pupae/egg masses was discussed. This technique involves the use of wooden blocks attached to the bole of DFTM host trees. Holes are drilled in the blocks that are utilized by larvae for pupation sites. Through time, data from the shelters can provide pupal/egg mass population trend information as well as sex ratios, egg viability and natural enemy data. The technique is in use in California and it would be beneficial to evaluate the technique in other geographic areas; protocols are available from John Wenz.

Workshop participants also raised the issue of the use of the pheromone for mating disruption. It was suggested that it would be worthwhile to look into utilizing the current outbreak in R6 for further development of this application of the pheromone.

Insects Of Whitebark Pine: Present Knowledge and Future Directions

Moderator: Diana L. Six, School of Forestry, University of Montana, Missoula, MT

Introduction: Overview of Insects Utilizing Whitebark Pine

Diana L. Six, School of Forestry, University of Montana, Missoula, MT

At present, whitebark pine (*Pinus albicaulis*) is in serious decline because of three major factors: white pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), and fire suppression. Fire suppression has allowed shade tolerant sub-alpine fir to invade whitebark pine stands and effectively reduce whitebark pine regeneration. White pine blister rust is an introduced disease that is devastating whitebark pine across its range. With reduced regeneration due to fire suppression, little natural selection can occur among new seedlings to allow for an increase in resistance to this disease in these stands. The mountain pine beetle further damages whitebark pine stands by killing healthy trees, trees already weakened by blister rust, or spreading into whitebark pine stands from outbreaks that develop in adjacent and lower elevation stands of lodgepole pine.

Whitebark pine is an important component in high elevation ecosystems. It stabilizes soil, rocks, and snow on steep slope landscapes and modifies the environment allowing other vegetation to establish. Just as significantly, whitebark pine produces large seeds that provide an important food source for many species of birds and mammals, but particularly Clark's nutcrackers, bears and red squirrels.

Due to the non-economic status of whitebark pine, very little information exists on insects associated with whitebark pine. Epidemics of mountain pine beetle in lower elevation stands of lodgepole pine have been documented to move into whitebark pine and cause extensive mortality. Recent observations indicate that endemic populations of mountain pine beetle can also be maintained in whitebark pine while surrounding lodgepole pine remains uninfested (Baker and Six, unpublished data; Austin and Six, unpublished data). Information on other bark beetles colonizing whitebark pine is sparse. Several secondary beetles have been found to attack the boles of whitebark pine including *Ips mexicanus*, two *Pityogenes* spp. (*P. carinulatus* and *P. fossifrons*) and two species of *Pityophthorus* (*P. aquilonius* and *P. collinus*). *Pityogenes fossifrons*, has been observed commonly attacking blister rust cankers and causing mortality in both blister rust symptomatic and asymptomatic smaller diameter whitebark pines (Baker and Six, unpublished data). Whitebark pines have also recently been observed with successful attacks of the red turpentine beetle, *D. valens,* and the pine engraver, *Ips pini*, with the latter causing mortality in some trees (Baker and Six, unpublished data). These observations consituted the first records of these two bark beetle species in whitebark pine.

Cone and seed insects, as well as some sap-sucking insects, have also been recorded from whitebark pine but little is known regarding their impacts on the tree nor their biologies in these high elevation sites. Further study of insects in whitebark pine is warranted given the threatened nature and importance of this species.

Mountain Pine Beetle-Caused Mortality in Whitebark Pine Stands Following Outbreaks on Lower-Elevation Lodgepole Pine Stands in Western Montana

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

One of the most serious threats to the survivability of whitebark pine stands in the West, is the mountain pine beetle (*Dendroctonus ponderosae* Hopkins). A particular threat to mature trees, beetles have killed thousands of larger-diameter, cone-bearing, trees during beetle outbreaks in the twentieth century. These periodic outbreaks have resulted in a decline in the number of whitebark pines being regenerated, and have decreased an important food source for some animals. Widespread mortality in whitebark pine stands often leads to increases in other tree species, such as subalpine fir, or in some cases, no trees at all on those high-elevation sites. Either has the potential of seriously eroding site quality.

A survey of mountain pine beetle-caused mortality in whitebark pine was conducted in the Gallatin National Forest in 1983 and the Flathead National Forest in 1988. Both areas had experienced serious mountain pine beetle outbreaks in whitebark pine stands, which had followed earlier epidemics in lower-elevation lodgepole pine stands. Survey results showed mountain pine beetle-related mortality ranged from 22 to 44 percent of whitebark pine over 5 inches d.b.h. Beetle-caused losses were negatively correlated with elevation — mortality decreased as elevation increased. Mortality was heaviest in the lodgepole pine/whitebark pine ecotone.

Modeling Climate Change Induced Bark Beetle Invasions

Jesse A. Logan, USDA Forest Service, Logan Forestry Sciences Laboratory, Logan UT

Some western US pine forests have evolved with bark beetle disturbance as an integral part of an adapted system. Lodgepole pine, for example, has co-evolved a relationship with fire and mountain pine beetle (*Dendroctonus ponderosae* Hopkins) disturbances that serve to maintain it as a seral component of spruce/fir climax forests. Without the interaction of these two disturbance agents, lodgepole pine would be lost from much of its distribution. In contrast, other pine ecosystems have not evolved in consort with bark beetle disturbance. The high-elevation, 5-needle pines, e.g. whitebark pine, are typically found in environments lacking sufficient thermal input for maintaining synchronized, adaptive voltinism for mountain pine beetle populations. Global warming of the magnitude projected by current global circulation models has the potential to significantly impact the geographic distribution of many species. In this talk, I explore the potential consequence of global warming on the distribution and outbreak status of mountain pine beetle with respect to high-elevation habitats. I begin this investigation by exploring the dynamical properties of an existing model of mountain pine beetle seasonality (see Logan and Bentz, poster in these Proceedings). The dynamical properties of the thermal habitat are characterized by regions of adaptive, synchronous seasonality separated by regions of maladaptive, asynchronous seasonality. Global warming, by even conservative estimates of a CO_2 doubling scenario, is great enough to move high elevation habitats from a maladaptive thermal regime to an adaptive regime, with potentially deviating consequences for whitebark pine. Finally, the implications of this analysis are discussed for exotic as well as for native invasive species. In particular, the modeling approaches I discuss can be applied for assessing the potential distribution of an exotic introduction. Additionally, theoretical analysis of the model has provided insights into experimental protocols for characterizing the potential geographical limits and seasonality of a new or hypothetical introduction.

Biological Control Programs for Insects in the Urban Forest

Moderator: Don Dahlsten, University of California, Berkeley
Recorder: Andrew Lawson, University of California, Berkeley

Participants: Don Dahlsten, Andrew Lawson, Eric Smith, Paul Basu, Tim Paine, Hugh Barclay, Chris Hanlon, Bob Celaya, Mike Wagner, Bob Setter, Jeremy Allison, John Manville, Sunil Kamasinghe, Tara Sahota, Darrell Ross.

Don Dahlsten began the session by raising several current issues for biological control. He stressed concern over the movement of plant material, particularly in the horticultural industry, and the associated risks of new pest introductions. There is a growing concern in the "biodiversity camp" of the scientific community over parasitoid introductions, however, the threat of introductions from the movement of plant material seems much greater. Dahlsten is currently performing host specificity testing with a parasitoid to be released for the red gum lerp psyllid to insure it does not interfere with *Boreioglycaspis melaleucae*, a psyllid to be released for control of Australian paper bark tree, *Melaleuca quinquenervia*, in the Florida everglades. Host testing and concern over non-target impacts are increasingly prevalent in modern biological control programs. The need for economic analysis to be a part of all our studies was stressed.

Each person attending then stated where they were from and what their interest is in the urban forest and /or biological control.

Andrew Lawson reviewed work completed in Sacramento where an integrated pest management program has been implemented for the elm leaf beetle. The University of California, Berkeley cooperated with the Sacramento Tree Foundation and the City of Sacramento Department of Neighborhood services in an effort to educate the public, monitor for ELB activity, and explore alternative control options. The program began as a biological control program with an effort to establish the egg parasitoid *Oomyzus gallerucae*, however the parasitoid does not overwinter well in California and has had no impact on the beetle populations. The previous management strategy used by the city was to inject all susceptible elms on a calendar basis. Between 1995 and 1999 the city gradually adopted a simple presence absence sampling method to monitor for ELB. By sampling at egg peak, damage can be predicted and control efforts can be directed to those areas with beetle populations above the treatment threshold. This monitoring has reduced the number of elms treated from 100% to only 10% of susceptible trees. The program is now managed entirely by the Department of Neighborhood Services.

Tim Paine of U.C Riverside reviewed the introduced pests on eucalyptus in California. The eucalyptus long horned borer (*Phoracantha semipunctata)* was under relatively good biological control until a new species (*Phoracantha recurva*) was introduced. The parasitoid is not as effective on the new borer and a species replacement seems to be occurring with *P. recurva* becoming the dominant species. The long horned borer problem has recently been exacerbated by the introduction of the red gum lerp psyllid, a serious defoliator of several species of eucalyptus. A new pest is introduced in California every 60 days, so it appears that there will be more new pests on eucalyptus in the future. Paine stressed the need to focus on the entire pest complex when designing a pest management program. Efforts to document the economic benefits of such programs should also be made.

Eric Smith, from the USDA Forest Service's Forest Health Technology Enterprise Team, presented an overview of a current project involving the economics of urban forest protection. He and Todd LaBandt have reviewed published studies involving techniques for valuing urban trees and the individual benefits they provide. This information will be summarized and published later this year.

The evaluation of urban forest protection projects needs to consider the costs and benefits of the alternatives, who pays the costs and who receives the benefits, and the uncertainties of the outcomes of the various alternatives. Different valuation procedures will result in different value estimates, and not all important factors identified can be adequately quantified. Although many studies have focused on tree benefits, urban forests have significant management costs, and these costs are often increased by pest damage.

Urban forests have both onsite and off-site benefits; different valuation techniques capture different portions of these benefits. Onsite or ownership based techniques include adjusted replacement costs, addition to appraised property value, and "revealed preference" through consumer behavior. The aggregate effect approach determines the net value of tree services, including moderation of micro-climates, reduced air pollution, reduced run-off, and scenic beauty.

Arthropod Utilization of Coarse Woody Debris

Moderator: Christine G. Niwa, USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR

Arthropods and Coarse Woody Debris in Southern Pine Forests

James L. Hanula, USDA Forest Service, Southern Research Station, Athens, GA

Coarse woody debris in southern pine forests decomposes quickly making it a more ephemeral resource compared to other regions of North America. Despite its demonstrated importance in other areas, relatively little attention has been given to the role of woody debris in southern forests or to the arthropods associated with it. Recently, several studies on the interrelationship of CWD and arthropods have been initiated. These include studies examining the role of woody debris as a refuge and habitat in longleaf pine stands receiving frequent (annual or biannual) prescribed burns; studies of the rate of decomposition of longleaf pine; and a large scale manipulation study in which CWD is removed annually from 9 ha plots of mature loblolly pine. The later was initiated in 1997 on the Savannah River Site. Studies are examining the effects of CWD removal on arthropod prey of red-cockaded woodpeckers, a species that forages on the bark of live trees, and on ground-dwelling macroarthropods. Preliminary results show that removal reduced numbers of ants (Hymenoptera: Formicidae), Largidae (Hemiptera), and Clubionidae (Araneae) captured crawling up trees. Burlap bands wrapped around tree boles to monitor specific prey of red-cockaded woodpeckers showed that the first two years of woody debris removal had no effect on the abundance of cockroaches (Blattaria: Blattellidae, *Parcoblatta* spp.) or centipedes (Scolopendromorpha). Preliminary results from the first year show that removal of CWD did not affect species richness, the numbers of rare species captured or the overall abundance of arthropods in pitfall traps. Removal of woody debris did reduce the numbers of Carabidae (Coleoptera), Clubionidae, and Cryptophagidae (Coleoptera) captured crawling on the ground. Although no conclusions can be drawn from these early results, the studies should provide answers to questions about the importance of CWD as a habitat for arthropods not directly dependent on it for food.

Wood-Boring Beetles and Prescribed Burning: A Retrospective Study in Southwestern Oregon

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The Northwest Forest Plan identified coarse woody debris (CWD) chewing arthropods as an important functional group within the range of the northern spotted owl for further study and analysis. The general objective of this study was to determine if the Northwest Forest Plan land allocations and suggested management practices allow for the continued existence and function of CWD chewing arthropods. Within this large functional group, this study focuses on two families of wood boring beetles (Coleoptera: Buprestidae, Cerambycidae). Wood borers are important to nutrient cycling and decomposition and serve as an important food source for wildlife. Most species of buprestids and cerambycids do not attack live, healthy trees, but are usually associated with stressed, fire-killed or recently downed trees.

Prescribed burning is increasingly being use as a management tool to remove potential fuels, thereby reducing the risk of severe wildfires. Because burning of any kind affects both the standing vegetation and the amount of coarse woody debris in the ecosystem, it is imperative to determine how wood boring beetles are responding to this alteration of habitat. We conducted a retrospective study to determine the effect prescribed burning had on wood boring beetles over time. Buprestid and cerambycid abundance (both at family and individual species level) was compared from eight previously burned sites, representing 1 – 15 years since burn, and eight unburned, adjacent check plots in a paired plot design. All sites were located in the Ashland watershed of the Rogue River National Forest in southwestern Oregon.

Although we found no significant correlation between family or species abundance and time since burn, it was apparent that both families were more abundant in the first year following prescribed burning. Higher abundance of adults collected most likely reflected emerging individuals attracted to the site the year before, as well as those attracted the following year by readily available food resources, such as trees damaged by fire or bark beetle attack. Abundance for both families and most individual species was much higher in prescribed burn sites than in check plots. Volume of coarse woody debris was not significantly different between burned and unburned sites, indicating differences in abundance were most likely not related to food resources.

While no causal inferences can be drawn, it appears as though buprestids and cerambycids are responding positively to prescribed burning in the Ashland watershed. A valuable tool for vegetation management and hazard reduction, prescribed burning could potentially be used to stimulate and maintain viable populations of wood boring beetles. However, more information is needed regarding the response of wood borers to various scales, sizes, and seasons of prescribed burning.

Sampling Methods and Parameters for Characterizing Log Resources

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To characterize a complex stratum like log resources one must deal with a broad array of variables. These range from descriptors of spatial distribution, to features of individual logs, and of populations of logs. Appropriate sampling techniques must be able to cope with more than simply volume or numbers of logs per unit area. Sampling must also supply information on other collective variables that will describe log resources in ways that have relevance to managers with a broad spectrum of biological and bureaucratic views of what a forest ecosystem should be or do. A considerable amount of energy has been devoted to portraying down wood, including logs and finer materials, as fire fuels (Brown 1974; Fischer 1981; Koski and Fischer 1979; Maxwell and Ward 1976, 1980; and others). Fire ecologists have typically described logs in terms of tonnages or volumes. While these units of measure are descriptive for the fire ecologist, they are not sufficiently descriptive for the wildlife biologist who might want to assess log resources in ways that are relevant to use by selected wildlife species. Different forest professionals--mycologists, silviculturists, soils scientists, plant ecologists, fire ecologists, economists, logging engineers--will have different views of logs as resource or risk, and have different demands for how logs are portrayed.

Management agencies need estimates of log resources to assure compliance with management goals in planning documents. In the Pacific Northwest Region (R-6), one such planning document is the Regional Forester's Forest Plan Amendment #2, Alternative 2. This was published as a Decision Notice dated 5 June 1995. The document was issued under the title of "Decision Notice for the Revised Continuation of Interim Management Direction Establishing Riparian, Ecosystem, and Wildlife Standards for Timber Sales." This decision notice identified revised vegetative structural stages of the interim ecosystem standard, and clarified an interim wildlife standard for nine National Forests on the east side of the Cascade Mountains in the Pacific Northwest. The standards were to be applied pending completion of an East-Side Ecosystem Management Strategy for the Pacific Northwest Region. A portion of the notice identifies the need for snags and down logs for wildlife nesting, roosting, denning, and feeding. A set of guidelines stipulating appropriate amounts of down logs in specified stand types were given. Forest professionals commonly refer to the notice, and the guidelines as the "East-Side screens," or simply the "screens." The guidelines stipulate appropriate numbers of logs $\geq$6 feet long per acre, with minimum large-end diameters (depending upon stand type), and total linear feet of qualifying logs per acre.

The problem encountered by forest managers is how to assess whether they are meeting the standards set forth in the "screens." In particular, the most commonly used scheme for assessing amounts of logs, the line-intercept method (LIM) of Brown (1974) does not yield estimates of log resources in any of the parameters stipulated in the "screens," i.e. logs per acre, or linear length of logs of qualifying small-end diameters. Because of this shortcoming in using the LIM, we sought to investigate sampling methods that would give estimates of the parameters stipulated in the "screens." To these desired parameters of logs and linear length of logs per unit area, we added percentage ground cover of logs. We chose percentage cover of logs because this parameter often emerges as a significant one for wildlife use of forested habitats (Tallmon and Mills, 1994, Carey and Johnson, 1995, and others).

We chose to compare estimates of log density, percent cover, length of logs, volume, and weight of logs per unit area, as determined by the LIM, and by a strip-plot method (SPM). The latter method compared the use of strip-plots 100 m long, and 4 m wide, to the LIM with 100-m-long transects. For most of the selected parameters we found the SPM to be more efficient in terms of cost (time) and more precise in its ability to estimate the parameters. Two manuscripts are in preparation that describe the study dealing with the comparative precisions and efficiencies of the LIM and SPM. One manuscript is intended for a forestry journal, and the other will be a PNW General Technical Report in a "how to" format. The latter will describe how to design a SPM to assess log resources in different types of stands, and specially tailored to yield desired parameters most cost-effectively and with greatest precision. The GTR will also contain field data forms that can be used in electronic field data recorders, and provide macros for calculating any of the selected parameters of log density, percentage cover, length of logs, volume, and weight per unit area.

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Coarse Woody Debris Arthropod Studies at Blacks Mountain Ecosystem Research Project

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Blacks Mountain Ecological Research Project (BMERP) is a long term, large-scale interdisciplinary study site in eastside pine type, with grazing, prescribed fire, and stand structural diversity as treatments. There are two levels of grazing (with and without) and prescribed fire (with and without) and two levels of stand structural diversity (high diversity plots, characterized by multiple canopy layers, the presence of many large, old-growth trees, dense clumps of small trees, many small canopy gaps and forest floor openings, and abundant snags; and low diversity stands, characterized by a single canopy layer with well spaced trees, few large canopy gaps and forest floor openings, few snags per acre and a minimum of large old growth trees). Four Research Natural Areas serve as references for late-successional conditions. Our goal in this study is to link coarse woody debris (CWD) arthropod biodiversity with their functional role in forest ecosystems.

We are using several approaches to characterize the role of arthropods in coarse woody debris (CWD) decomposition at BMERP. The first approach is to place standardized CWD substrate (ponderosa pine logs) onto the treated units, leave them exposed for one and two years, then remove them and quantify the effects of treatments on colonization by arthropods and fungi. Changes in physical characteristics of the wood are also being measured. Bolts were placed on the plots in 1998 and the first sample was removed in 1999. They are currently being held in emergence traps for collection of emerging arthropods and culturing of fungi.

The second approach is to manipulate the access of CWD arthropod species to standard pine bolts in order to compare effects of longitudinal borers (small scolytids, principally genera in the tribes Ipini and Corthylini) vs. transverse borers (Cerambycidae and Buprestidae). Transverse borers may be essential in vectoring decomposing fungi into the heartwood, while longitudinal borers initiate decomposition of cambium and sapwood. We excluded species from pine bolts using aluminum mesh screen of variable mesh size. Treatments were (1) all beetle species excluded (using fine mesh); (2) only transverse borers excluded (medium mesh) and (3) no beetle species excluded.

We are also characterizing the CWD arthropods entering into and exiting from existing CWD. To estimate populations of CWD arthropods capable of attacking down woody debris, we established pitfall traps at varying distances from existing CWD and have monitored them over two seasons. Finally, we have constructed emergence traps to monitor populations of exiting CWD arthropods.

Final Business Meeting

Western Forest Insect Work Conference
51st Annual Meeting
Portland, Oregon

10 February, 2000

***** UNAPPROVED MINUTES *****

Chair Tom Eager called the meeting to order at 8:00 AM.

Secretary Mark Schultz read the minutes of the 2000 Initial Business Meeting. Terry Rogers moved that the minutes be accepted, they were seconded by Don Dahlsten, and passed.

Committee reports:

Founders Award Committee: Chair Boyd Wickman reported that John Bordon will receive the 2001 award in Canada. Bill Ives could not be here to receive the award this year. Les Safranik has resigned from the committee. Terry Shore has agreed to replace him. We need nominations for more members. Ken Gibson, Staffen Lindgren, and Boyd are currently on the committee.

History Committee: Chair Boyd Wickman report that Don, Carol Williams, and he are on this committee. Bill Schaupp has agree to be on it. Mel Furniss' report will be mailed to Boyd for inclusion in the 2000 proceedings.

Common Names Committee: Chair Torgy Torgensen reported that Iral Ragenovich and Larry Stipe, submitted names. Ann Lynch will also be working with Boyd on an approved name for Spruce Needle Aphid. There are 206 insects in the "Western Forest Insects" book that do not have approved common names. There is not much work to be on this committee. Ann asked to include Bobby Fitzgibben to the committee.

Scholarship Committee: Chair Lorrain Maclauchlan and Don met and determined the criteria that could be used to award the scholarship monies. Their conditions were that applicants had: 1. to be in a graduate program, 2. to have a research topic in forest entomology, 3. to be members of the work conference for at least one meeting, 4. to submit a one-page description of their research topic with the application, 5. to have two letters of recommendation plus transcripts, and 6. to have send their application to the committee by December 15. The application should be on the WFIWC web site. Because of the size of the fund we suggest $500 for the first award. We would like the award to increase to $1000. The awarded would be presented at the Work Conference. Each awardee would be encouraged to make a presentation. A plaque would be presented to them similar to the McGregor award plaque.
Discussion: It took a long time to accumulate the $2,900 in the fund (Ladd). There still needed to be some criteria placed on the award. The money would be hard to track so no stipulations should be placed on its use (Lorraine). We could say that the money was awarded to further their academic study. The first award should be noteworthy (Boyd). Make the first award

$1000. If we had $25,000 in the fund the scholarship would be reasonable and the principle would not shrink (Karen). Members are not donating much money to the fund passed the hat for contributions (Ladd). Put a donation slot on the next registration form (Terry Rogers). The recognition is more important than the amount (Darrell). It could only be awarded once per applicant (Peter Hall). It would be good if the applicant's college should match the award (Barb Bentz) but it might be difficult for some forestry entomology programs (Don). We should aim high and ask for matching monies (Bill Schaupp). Undergrads that make a significant step beyond undergraduate work should be eligible to win the award (Darrell). Should there be any geographic limitations (Jon Volney)? Could a New Hampshire student qualify? Committee members should not vote for their own students (Darrell). Also, a small plaque could be made for the awardees that they could keep. Darrell moved to put a ballot on the web site and Jon seconded it. Two weeks from now Ladd will tally the vote. Vote from the 18 until the 25th of February, 2000.

Scholarship Fund Raising Committee: Chair Karen Ripley said that the McGregor fund had to grow to $7000 before any awards could be made. These funds could be used to memorialize past members when presented to students. $50 is donated for each award. Jon asked if the committee could you come up with some tasteful process for raising funds. Karen has a big notebook on philanthropic organizations. And we pursue funding there one we get our tax free status. $236 was raised this meeting (Ladd).

Proceedings and Conference Guidelines Committee: Chair Ann Lynch said that we need a list of libraries to mail the conference proceedings. The guidelines would include for instance: 1.what timelines should be used to finalize hotel arrangements? 2. how far you had to pay the hotel in advance. 3. the different ways used to set up the meeting. Terry Shore, Bill and Ann are on this committee. These guidelines should be written by the Edmonton meeting.

New Business:

Item 1. Introduction: Bruce Hostetler introduced Ken Wright as the only member at this conference that attended the very first conference.

Item 2. Web Site: The web site will be located OSU. Kathy made the offer to maintain it. It will cost the membership nothing. Darrell made the motion it was seconded by Bruce and accepted unanimously.

Item 3. Commercial Exhibits: Darrell drafted the motion. Discussion – Bill said that at the Breckenridge meeting he called exhibitors but only one chose to bring an exhibit. Another business argued that it was not fair to have the exhibit in the poster room. Dave Wood thought that WFIWC had already voted on this and that we will have to search the minutes of past meetings. Ann said that she went through the minutes and thought that at Park City a motion was passed. Ann has accumulated things that have been voted on and that never made it into the constitution. Also there are constitutional items that we do not follow anymore. Ladd thought that it was not about exhibits but about the mixer. Peter Hall thought that the decision should be up to the local arrangements on whether to have exhibits. A motion was made to accept Darrell's amendment and seconded by Boyd. Motion was carried and it will be inserted into the charter.

Item 4. Meeting with Forest Pathologists: Darrell made a motion that the entomologists should not meet with the forest pathologists every five years but only periodically or as the need arose. *Discussion:* There was an objection to that motion (Bill). The joint meeting in Albuquerque went well. It is necessary to meet with the pathologists (Gary Daterman). Maybe we should also meet more with other professionals such as plant ecologists. The costs outweigh benefits and I saw little interaction between the two groups at the meeting (Darrell). If we do not get together with them we will not be prepared for joint positions (Carrol). The program is bad not the integration (Steve). – It is a logical construct to meet together (Dave). Integrative program management dictates that we meet (Gary). We should be one organization (Dave). I do not think we should be on organization but I support a close association (Carrol). University of California is in process of looking for a forest health specialist. At the recruiting level we recognize both groups. Motion made by Darrell to stop regular 5-year meetings with the pathologists and Dave Schultz seconded the motion. A yes vote will mean that we will not meet on an every 5-year schedule. Yes – 17. No - 48. The motion failed. Jerry Beatty will take this to the pathologists. The pathologists have not made a decision on this yet. A motion was made by Bill that the chair elect will go to the WIFDWC meeting in Hawaii in 2000 to discuss this with the pathologists. The motion carried.

Item 5. New Chair and Councilor: Barb Bentz agreed to be chair. No one opposed her appointment. Jaime Villa agreed to be the councilor. No one opposed his appointment.

Item 6. Location for 2003 meeting: The Mexican entomologists meet in odd years so this would be a good year for a WFIWC meeting in Mexico (Jaime). The final decision will be made within the next couple of months. It will probably be held Guadalajara, Mexico. Mike Wagner has agreed to help with this process. Bill made the motion to have the conference in R1 in 2002 and 2003 in Mexico. It was seconded by Mike. The motion carried.

Thank You: Boyd made a motion to thank Dave Overhulser, Chris Niwa, Bruce Hostetler, and Darrell Ross for hosting and organizing this meeting. Ann seconded the motion. Also the Marriot Hotel did a good job.

Terry Roger moved to adjourn the Final Business Meeting and Karen s move and second to adjourn the meeting.

Web Site Update

Proposed Memorial Scholarship Criteria & Information

Background: *At the Final Business Meeting on February 10, 2000 in Portland, Oregon, the work conference members considered the proposed application criteria and related information presented by the Scholarship Committee. After some discussion, a decision was made to have the proposed criteria, as modified based on discussion during the Business Meeting, posted on the WFIWC website. Work Conference members are invited to review the proposed criteria (below) and then vote by* ***February 18, 2000****, on whether to accept these criteria. The following information was prepared by Dr. Lorraine Maclauchlan on behalf of the Scholarship Committee.*

Western Forest Insect Work Conference Memorial Scholarship

The intention of the Western Forest Insect Work Conference (WFIWC) Scholarship Committee is to award the first WFIWC Memorial Scholarship to a graduate student in 2001 at the Work Conference Meeting to be held in Edmonton, Alberta. The criteria and information necessary for students interested in applying for this scholarship is outlined below. The application form attached to this website should be filled out when applying for the scholarship along with all other required information.

Scholarship Application Criteria

1. Deadline for submission of applications to the WFIWC Scholarship Committee December 15th of each year.
2. To be eligible for consideration, students must be enrolled in a graduate program at an accredited University in the United States, Canada or Mexico at the Masters or Ph.D. level.
3. Students must have a thesis/dissertation topic in the field of forest entomology.
4. Students must be members (new members are acceptable) of the WFIWC.
5. With application, students must submit a one page outline or summary of their area of research (thesis/dissertation).
6. A copy of all academic transcripts must be included with the application.
7. Students must submit two letters of recommendation with their application.
8. Any given student will only be awarded this scholarship once.
9. Applicants should be attending a university within the geographic coverage of the WFIWC.

Other information relating to the awarding of the WFIWC Memorial Scholarship

1. All applications will be evaluated on the quality and significance of their research; academic record; and, referees.
2. The Scholarship Committee will decide on recipients of the scholarship.

3. Members of the Scholarship Committee will not vote on applications from their own students or students from their institution.

4. There will be no stipulations put on how a student uses the scholarship.

5. Applicants and/or recipients of the scholarship are encouraged to make presentations (talk or poster presentation) of their research at the WFIWC.

6. The amount of the award may vary from year to year, but is estimated at between $500 to $1,000 US funds.

Members of the Scholarship Committee

- Lorraine Maclauchlan
- Don Dahlsten
- Mike Wagner
- Boyd Wickman

Western Forest Insect Work Conference
Memorial Scholarship Application Form

Applicants Name: ____

University and academic supervisor:

____

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Address: ____

____

____

Telephone: __________________________________

Fax: __________________________________

Email: ____

Biographical Information (short summary of interests, work experience etc.):

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Names of referees (2)(with letters enclosed):

1. ____

2. ____

Concurrent Sessions

Douglas-fir Tussock Moth – Current Issues, Part II

John Wenz, USDA Forest Service, Pacific Southwest Region, Forest Health Protection, Stanislaus National Forest, Sonora, CA

Current Status of DFTM in Oregon and Washington

Iral Ragenovich[1] and Bill Funk[2]
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The Pacific Northwest Region has participated in the DFTM Early Warning Trapping System for over 20 years. Previous trapping results indicated outbreaks which occurred in more localized areas in the early 1980's, and again in the early 1990's. In 1991, 116,000 acres were treated for DFTM on the Pine RD of the Wallowa-Whitman NF. In 1996 and 1997, increases in trap catches were again indicated. By 1998, the trap catches had increased significantly and, although there were localized areas with high trap counts, such as on the Pine Ranger District of the Wallowa-Whitman NF, the overall trend showed an increase in trap catches throughout the trapping area. These results indicated that a more general regionwide population build-up was occurring. There is potential that a DFTM outbreak, similar to the 1972-74, outbreak could occur. The trapping results suggested that some defoliation would be apparent in 1999 with the primary outbreak occurring in 2000 and 2001.

Based on this information, R6 Forest Service land managers determined that an Environmental Impact Statement should be completed and in place, prior to significant defoliation from the outbreak to document action or no action decisions. The intent was to have an EIS done in time for treatment actions in the spring of 2000, if determined necessary. The EIS is unique in that it would be a site-specific EIS, it would cover multiple years, and that it must be written before DFTM populations exhibited themselves and before actual locations of the outbreak were known. Also, it was not necessarily desirable to control the entire outbreak; in many cases, allowing DFTM to occur naturally would help achieve Forest Plan objectives. As a result, specific areas where defoliation and tree mortality would impact current and future management objectives were identified. These included such areas as: isolated spawning and rearing sites for T&E fish, such as bull trout and anadromous fish; nesting sites for T&E birds, such as spotted owls; designated old growth areas; high-use recreation areas, and residential and administrative sites.

The timeline for the EIS was determined by the need to do treatment in the spring of 2000, if an action alternative were selected. This put the EIS on a very tight timeline. In order to meet deadlines, the Draft EIS would need to be issued immediately after the beginning of the new year, and the final EIS will need to be issued by the middle of April.

Portions of nine National Forests are included in the analysis. The proposed alternative was to treat these areas of concern with either B.t.k. or TM-Biocontrol, should an infestation occur. If insect populations did not increase, the area would not be treated. In the Draft EIS, approximately 560,000 acres were included in the analysis of the proposed alternative. Comments received during the public scoping ranged from not treating anything, to treat everything. As a result of the public scoping process, a second alternative was developed. This was called the "expanded protection alternative", and included all of the areas in the proposed alternative, plus all areas of 60-100% host type. This alternative included 2.3 million acres in the analysis. The "No Action" alternative included all areas with susceptible host type 20-60% and 60-100%, and included approximately 4.2 million acres. The Draft EIS was issued early in January.

Both early larval spring sampling and cocoon/egg mass sampling were done in the specific areas of concern, during the spring and last fall.

In this example, the DFTM Early Warning System was used as intended. Information was used to initiate needed management actions (i.e., the NEPA process) in advance, so action, if selected, could be implemented in a timely manner. There were some difficulties associated with this process, however. In these times, when managers are constantly confronted with current issues, it is difficult to get them to respond or commit resources to an outbreak or situation that is not yet apparent (and therefore, not yet a concern). There was a fair amount of reliance on folks with a previous history and memory of the 1972-74 outbreak. Selecting the areas for protection ahead of time allows entomologists to focus on specific areas for population monitoring and sampling, and thus reduce the number of acres to be sampled more intensively. However, this approach also creates numerous smaller areas that must be visited individually and be more intensively sampled.

Discussion:

There was considerable discussion on the need for, and difficulties associated with, pupal and egg mass sampling conducted as a follow-up to increased pheromone catches and the need to spatially delineate areas for potential direct suppression. Such efforts can be time consuming and labor intensive; focusing ground sampling in specific areas identified by resource managers to be at risk to unacceptable DFTM effects can help make the process more efficient.

It was noted that there is relatively little information available on the operational efficacy of either B.t.k. or TM-Biocontrol on DFTM. Some believe that B.t.k. would cause larval feeding to stop more quickly than TM-Biocontrol, but that the additional defoliation that might occur before the virus caused cessation of feeding would not likely result in significant mortality.

Efforts are currently underway to get TM-Biocontrol registered in certain states (i.e., Washington and California). Depending on the success of this effort, it may be necessary to evaluate any identified data gaps and explore ways to obtain the needed data.

The issue of how to ensure that an adequate supply of TM-Biocontrol will be available for use when needed in the future arose. Depending on how much TM-Biocontrol (if any) is used in 2000 and/or 2001, the issue may need to be addressed in the immediate future.

An Overview of Woodboring Insects: Current Research and Associations with Forest Disturbances

Moderator: Steve Seybold, Departments of Entomology and Forest Resources, University of Minnesota, St. Paul, MN

Participants: Approximately 40, including Jeremy Allison, Barbara Bentz, Paul Bosu, Cindy Broberg, Henry Burkwhat, Bob Celaya, Darek Czokojlo, Don Dahlsten, Keith Deglow, Peter DeGroot, Kevin Dodds, Maureen Duane, Andy Eglitis, Liz Gerson, Chris Hanlon, Jim Hanula, Peter Katinic, Les Koch, Andrew Lawson, Dean Morewood, Chris Niwa, Hideji Ono, Sunil Ranasinghe, Nancy Rappaport, Terry Rogers, Les Safranyik, Guillermo Sanchez-Martinez, Dave Schultz, Mark Schultz, Bob Setter, Diana Six, Sherri Smith, Andrew Storer, Skeeter Werner, Boyd Wickman, and Dave Wood.

Introduction

The moderator began with an introduction about woodboring insects with a focus on the Cerambycidae (longhorned beetles, roundheaded borers), the Buprestidae (metallic woodborers, flatheaded borers), and the Siricidae (horntails, woodwasps) as traditional wood-boring forest insects. There are many other less studied families of insects (*e.g.* Cossidae, Sessiidae, Lymexilidae, Oedemeridae, etc.) and some Gastropoda that also bore into wood. A survey of two USDA Forest Service publications [Western Forest Insects (WFI) and Insects of Eastern Forests (IEF)] revealed some interesting facts about the diversity and life habits of North American woodboring forest insects.

Species Diversity of North American Woodboring Forest Insects

	No. Species Highlighted in WFI		No. Species Highlighted in IEF		
Family	Feeds on Conifers	Feeds on Hardwoods	Feeds on Conifers	Feeds on Hardwoods	No. Species Overall, Misc.
Cerambycidae	76	37	37	71	1400 spp. in the US; 450 spp. east of the Mississippi (IEF)
Buprestidae	36	21	28	36	700 spp. in North America (WFI)
Siricidae	11	1	9	2	Also, 1 spp. of Syntexidae on Conifers and 6 spp.of Xiphydriidae on Hardwoods(WFI) and 5 spp. of Xiphydriidae on Hardwoods (IEF)

For the purposes of this survey, species that fed on both conifers and hardwoods, were treated as conifer-infesting species. Some trends from this survey are that species of western cerambycids and buprestids tend to feed more on conifers; species of eastern cerambycids and buprestids tend to feed more on hardwoods. Siricids (whether eastern or western) tend to feed on conifers. The related xiphydriids are exclusively hardwood-infesting. In terms of life habits, cerambycids and buprestids generally begin their larval life by feeding in the phloem (eggs are laid through the bark or in cracks in the surface of the bark) and then moving into the xylem (sometimes into the heartwood) during later larval instars. In contrast, siricids begin their larval life in the xylem (eggs are laid by the female directly into the xylem) and the entire larval period takes place in the xylem. Most woodborers feed in stems, and larger roots and branches, but some cerambycids feed in cones, twigs, or even *Opuntia* cacti, while some larval buprestids feed in twigs and some are leaf miners. Adults of both families may feed on foliage or pollen.

Other items covered in this introduction included the ecological roles of woodborers including agents of woody biodeterioration, as natural enemies of bark beetles, and as primary agents of tree mortality (*e.g.* certain species of *Monochamus*, *Melanophila*, *Agrilus*, and *Sirex noctilio*). Furthermore, interactions were noted between native species and forest disturbances such as fires, windstorms, volcanic eruptions, logging activities, construction activities, drought, and smog. One question that was discussed was whether or not increased usage of prescribed burning will significantly reduce woodborer populations by burning up larvae and pupae in woody debris on the ground. Particularly if the prescribed burns exceeded historical burning patterns. Participants considered that the intensity of the fires, the phenology of the woodborers relative to the timing of the fires, and the attraction of newly dispersing adults to the fires may all impact the answer to this question.

The relative paucity of exotic woodborers in the historic literature has been replaced by an alarming recent trend of introductions (*e.g. Phoracantha semipuncta* and *recurva* on *Eucalyptus* in California, *Anoplophora glabripennis* on hardwoods in New York and Chicago, and *Callidiellum rufipenne* on *Thuja* and *Juniperus* along the Eastern Seaboard; all Cerambycidae). The relationship of woodborers with diseases of trees was briefly noted (*e.g. Monochamus* spp. and pine wood nematode, *Sirex* spp. and *Amylostereum* fungi). Finally, some of the intriguing stories of extended development (10 to 50 year life cycles) and fantastic responses of woodborers to smoke and heat were discussed. Humorous stories included *Melanophila* spp. attacking cigarette-smoking fans at a UC-Berkeley football game in the 1930's and an active DOD-funded research project based out of UT-Austin that is attempting to develop a biosensor for heat-seeking missiles based on the long-range heat detection of *Melanophila* spp. for forest fires.

Feeding Ecology of Woodboring Cerambycidae

Kevin Dodds, Department of Forest Science, Oregon State University, Corvallis, OR

In studies conducted in pine stands infested with southern pine beetle (SPB) in Alabama and throughout the South, Dodds and his co-workers asked how various species of Cerambycidae (*e.g Monochamus titillator*, *M. carolinensis*, and *Acanthocinus nodosus*) might impact SPB populations. In areas infested with SPB, the cerambycids are ubiquitous with high densities of oviposition pits in the SPB-infested trees. The pits sometimes cover the entire length of the stem of the tree. At the outset of their study, the cerambycids, who have a quick, 45- to 50-day life cycle in the South, were thought to perhaps be involved competitively with SPB, and might carry out incidental predation of SPB larvae and pupae as a consequence of their own feeding activities in the phloem-xylem interface. However, in "phloem-sandwich" studies of *M. carolinensis* with *Ips calligraphus*, it appears that cerambycids go through a range of behaviors that target bark beetle larvae for attack and cache the prey for later consumption. Combining these observations with a life cycle duration that matched that of bark beetles, it appears that the cerambycids may be more closely tied to SPB in a predator/prey relationship. Dodds described this as "facultative intra-guild predation."

Relationship of Woodborers to Disease Transmission

Mark Schultz, USDA Forest Service, Forest Pest Management, Juneau, Alaska:

Dr. Schultz reported on woodboring insects that might be associated with declining yellow cedar, *Chamaecyparis nootkatensis*, in the southern Alaskan panhandle. The trees are generally growing on very poor sites where only blueberries grow and the year rings of the cedar are sometimes only two or three cells thick. Nonetheless, the declining trees can stay upright for 80 years with sapwood degrading, but leaving a very valuable and inert heartwood. The wood normally sells for $900/MBF to the Japanese market, but even woodborer- and fungal-degraded wood can sell for $600 to $700/MBF. Schultz and others have noted two species of dark staining fungi imbedded in the wood of the yellow cedar. These fungi, related to blue stain fungi, have been found compartmentalized in wood in year rings of 40, 200, and even 300 years ago. The fungus appear to have grown more longitudinally than radially in the wood prior to being walled off. Often, the fungal staining is associated with the frass-packed galleries of some woodboring insect. The fungus can be isolated from imbedded areas as old as 200 years and is easily culturable. Evidence to-date suggests that a woodwasp (Siricidae) and a roundheaded borer (Cerambycidae) tunnel in the sapwood of yellow cedar. However, only the siricid has been found near and intersecting fungal-stained areas. The siricids bore galleries about 1.5 cm deep and 10 cm long in the wood, while the cerambyicid does not tunnel nearly that far and does not appear to reach the stained areas. Schultz has also reared the siricids from newly declining trees and hopes to isolate the dark-staining fungus from newly emerged adults. One participant noted the consistent association of 2 spp. of siricid with cold-stressed lodgepole pine in Banff National Park in Alberta. Finally, Schultz noted the interesting contrast between this siricid in Alaska, which may be vectoring a staining fungus, and the siricid, *Sirex noctilio*, which is vectoring a decay fungus (*Amylostereum*) in Australia.

Relationship of Woodborers to Fungal Transmission of Pitch Canker, *Fusarium circinatum*, in Monterey Pine in California

Andrew Storer, Division of Insect Biology, University of California, Berkeley , CA

Pitch canker is a disease that has been affecting pines on the central coast of California since 1986. The most widely affected species is Monterey pine, *Pinus radiata*. The disease is vectored to branches and branch whorls by cone beetles (*Conophthorus* spp.), twig beetles (*Pityophthorus* spp.), and an anobiid (*Ernobius punctulatus*). The disease is also vectored to the main stem by *Ips* spp. There is a risk that pitch canker will be introduced into the Sierra Nevada of California through movement of infested woody materials from coastal areas. Wood is moved by travelers as well as through commerce to inland mills. One question is: If one waits until the bark beetles have left the wood, could the wood be safely moved inland or are there deep wood insects that could potentially infest trees in new areas of California? Alternatively, are there deep wood or other insects in the Sierra Nevada that could infest this slightly older woody material from the coast and then infest new trees?

Storer and colleagues have begun a study to determine whether or not deep-wood-infesting insects could emerge from diseased *P. radiata* to carry the pathogen. They cut trees at different times of year and left them out in the field for different periods of time and then brought the logs to Berkeley to rear insects from them. Based on the literature, they expect 3 species of Siricidae and up to 6 species of Cerambycidae to be associated with *P. radiata*. Preliminary results indicate that only woodwaps (Siricidae) have emerged from the logs and these siricids were not carrying the pathogen.

Future studies include plans to trap cerambycids in the field and attempt to isolate the pathogen from them. Another plan is to take "pathogen-free" bolts of *P. radiata* to the Sierra Nevada to see what indigenous woodborers could colonize the bolts and potentially pick up the pathogen. A discussion of how the life cycle of woodborers is involved in pathogen transmission followed and it was noted that woodborers could pick up the pathogen "at the last minute" when they vacate the host through bole-cankered areas, that some borers could pick up the pathogen during their phloem feeding activities, or that they could pick up or transmit the pathogen when they feed on needles and injure twigs as adults (Cerambycidae and Buprestidae).

Chemical Ecology of Wood Borers—Responses to Bark Beetle Semiochemicals

Jeremy Allison, Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada

Woodboring cerambycids have the potential to respond to bark beetle semiochemicals because as early larvae, the cerambycids feed in the same substrate as bark beetles and the cerambycids nearly always have overlapping or even broader host ranges as the bark beetles. Also, the cerambycids need a moribund tree for a host and tree-killing bark beetles can provide the dying tree for the cerambycids. Allison and colleagues tested a blend of nine candidate bark beetle pheromone components that might be antennally and/or behaviorally active with *Monochamus* spp. cerambycids. All nine compounds were antennally active in EAD studies with both sexes of *M. obtusus*, *clamator*, and *scutellatus*. For funnel trapping studies in the field (logging yards in the Okanagon Valley) the nine compounds were grouped into two groups according to the threshold of the EAD response [Strong blend: (1 to 10 ng/liter threshold, MCH, frontalin, ipsenol, and ipsdienol) and Weak blend: (10 to 100 ng/liter threshold, *cis*- and *trans*-verbenol, *exo*- and *endo*-brevicomin, and verbenone)]. All materials were racemic. There were six treatments in the experiment: 1) blank trap; 2) host blend (= alpha-pinene and ethanol released at an ultra high release rate); 3) strong blend; 4) weak blend; 5) host blend + strong blend; and 6) host blend + weak blend. Results were variable, but the response to the host blend + strong blend was generally significantly different from and greater than the response to the blank, to the host blend, or to the host blend + the weak blend. Surprisingly, the response to the host blend + weak blend was generally lower than the response to the blank trap. Whether males or females responded in higher numbers depended on the species of *Monochamus*. *Monochamus scutellatus* responded in greater numbers than the other species in these experiments. In similar experiments with the two groups of pheromone components without the host blend, again the strong blend was more attractive than the weak blend or the blank trap. Preliminary results with the pheromone components tested individually and not in the two groups suggest that verbenone may be interrupting the response of the cerambycids.

A review of the literature shows that some other odors (*e.g.* floral scents like benzyl acetate) are attractive to cerambycids in the field. Most pheromone studies with the Cerambycidae have taken place in Asia or Germany. For example, pheromones have been identified from the old house borer, *Hylotrupes bajulus*, by a German group. In only three cases has a volatile pheromone been reported; in most cases contact sex pheromones are reported to be involved. Many scientists present for the discussion reported the response of cerambycids to funnel traps baited with bark beetle pheromones. The responses were sometimes rather large and to a variety of bark beetle semiochemicals. However, in the experience of others, cerambycid responses have been rather low, perhaps due to the efficacy of the Lindgren funnel trap for this type of insect.

Trapping Techniques for Capturing Cerambycidae

Pete Katinic, Simon Fraser University, Burnaby, BC, Canada

To improve the trapping efficacy for cerambycids, Katinic and colleagues have taken a variety of approaches. The first thing that they considered was that to catch more cerambycids, they had to trap where the beetles occur in abundance—particularly if they were trying to show differences between treatments. For example, in logging yards, the population densities of cerambycids may be 10x higher than in the forest, so logging yards are where most of their experiments have been done. Secondly, cerambycids escape easily from the dry collection cups or from collection cups filled with propylene glycol, so they have been using soapy water in the cups and the cerambycids sink to the bottom and die in 30 seconds. Thirdly, they have realized that a trap for cerambycids should probably have a really large silhouette to provide an attractive visual stimulus for these beetles. Some of the traps that they have tried include the pan trap, which is an open container of non-scented soapy water with baits strung over it; a 6-inch drainage pipe for a silhouette over a pan trap; and a modified Lindgren trap consisting of plant pots to give larger funnels and a larger silhouette. Plant pots of different sizes can be used to test the effect of silhouette size. They have also tried cross-panel or cross-vane traps made of black plexiglass that has been perforated to allow odors to pass through the panels. The panels rest over a pot of soapy water. Results of a comparison of these traps for *M. scutellatus* made between July and September 1999 with the Phero Tech woodborer bait (ultra-high release alpha pinene and ethanol—2 grams per day), show that the pan trap is a little better than the wet Lindgren funnel trap and that the plant pot and cross-panel traps are much better than the pan trap. Similar comparisons with the zebra beetle, *Xylotrechus longitarsis*, and the sculpted woodborer, *Chalcophora virginiensis* (Buprestidae), also show that the cross-vane trap with the collection bucket of soapy water under it was the most efficacious trap. Plans for future modifications include a large funnel at the base of the cross-vane to better collect falling beetles and a black bucket to prevent escaping in response to light.

Management Challenges in High Elevation Ecosystems

Moderator: Lorraine Maclauchlan, BC Ministry of Forests, Kamloops, BC, Canada

High elevation, or many northern ecosystems, are predominated by Subalpine fir, *Abies lasiocarpa* (Hook.) Nutt., mixed with Engelmann spruce, *Picea engelmannii* Parry ex Engelm., white spruce, *Picea glauca* (Moench) Voss, or their hybrids. Subalpine fir and spruce are found in areas of heavy snowfall, high moisture, long winters and cold temperatures and, stands leading in *A. lasiocarpa* may experience frost any time of the year. However, some insects have adapted well to these harsh conditions and add to the challenges already facing forest managers in these ecosystems.

Some of the forest health issues facing these subalpine fir/spruce forests are highlighted in the papers presented by Jennifer Burleigh, Kathy Bleiker, René Alfaro and Lorraine Maclauchlan.

The Response of Fast- vs. Slow-Growing Subalpine Fir to Inoculation with a Bluestain Fungus Associated with Western Balsam Bark Beetle

Kathy Bleiker, University of Northern British Columbia, Prince George, BC, Canada

It is widely believed that trees with increased vigor have a greater ability to resist attack by bark beetles. During the summer of 1998 three stands of subalpine fir, *Abies lasiocarpa*, were examined to determine the relationship of recent radial tree growth to attack success of western balsam bark beetle, *Dryocoetes confusus*, in the interior of British Columbia. Results show that beetle attack was more likely to be successful in slow-growing trees and the beetles preferentially attacked slow-growing trees. Unsuccessful attacks occurred in trees with moderate recent radial growth, while fast-growing trees suffered no attacks by beetles. Beetles may select slow-growing trees due to weaker host defenses.

Many bark beetles carry pathogenic bluestain fungi, which they inoculate into the host tree upon entry. The fungus may contribute to overcoming host defenses, by cutting off translocation in the tree. During the summer of 1999, slow- and fast-growing trees were inoculated with a bluestain fungus, *Ophiostoma* sp., that was consistently isolated from beetles and attacked phloem. Results show that fast-growing trees had a stronger defense response to the fungus, producing a hypersensitive lesion in a shorter period of time, than slow-growing trees. Both fast- and slow-growing trees produced larger lesions in response to fungus inoculation than to mechanical wounding.

Spruce Decline Syndrome in the Fort Nelson Forest District Following Prolonged Defoliation by the Eastern Spruce Budworm

Jennifer Burleigh, Simon Fraser University, Burnaby, BC, Canada

The term "spruce decline syndrome" applies to large areas of the northern Fort Nelson Forest District. A complex of secondary insects (cerambycids, buprestids, scolytids and siricids), and weak pathogens are attacking and killing white spruce which had been severely stressed from heavy defoliation by the spruce budworm, *Choristoneura fumiferana*.

Areas in the northern district have experienced 4-5 budworm outbreaks in the past century, while stands in the south end of the district have only had 2. Diameter losses in the most recent infestations were estimated with the use of stem analysis. Mean tree volume losses were extrapolated to a per hectare total to estimate the economic losses associated with the infestation. This translated to a mean diameter loss of 36.3 cubic metres per hectare in the southern sites and 22.7 cubic metres in the north. Although the northern site sustained less volume loss on a per hectare basis, this must be in context of it being at least the 5th outbreak over the stands history. The cumulative diameter and height losses, stem defects and woodborer damage substantially increases the losses in these northern stands. The term “spruce decline syndrome” is being used to describe those stands that have entered a general state of decline following the collapse of the last budworm outbreak in 1995.

Periodicity of Two-Year Cycle Spruce Budworm Outbreaks in Central British Columbia: A Dendro-Ecological Analysis

Qi-Bin Zhang, University of Victoria, Victoria, BC, Canada, and **René I. Alfaro** Canadian Forest Service, Victoria, BC, Canada

An outbreak of the two-year cycle budworm (*Choristoneura biennis* Freeman) has caused defoliation damage to interior spruce (*Picea engelmannii* Parry × *P. glauca* (Moench)) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) forests of north central British Columbia for more than ten years, and was still continuing in 1999. A sample of 429 increment cores from spruce, subalpine fir and lodgepole pine (*Pinus contorta var. latifolia* Engelm.) was collected in areas of chronic defoliation, and used in a dendro-ecological study. The objective was to develop accurately dated ring-width chronologies of each species and, by comparing growth rates of the budworm host tree species (spruce and fir) with those of the nonhost pine, to determine the past history of budworm outbreaks in this region. This history would help in estimation of the potential duration and severity of the current outbreak in the region.

Four periods of decade-long reduced growth, attributable to budworm defoliation were identified in the increment cores. These occurred in the mid-1890s to the early 1900s, the mid-1920s to the mid-1930s, the 1950s to the early 1960s, and the late 1980s to present (1999). Outbreaks recurred approximately every 32 years. The reduced growth period, indicative of past outbreaks, consisted of a growth reduction phase lasting 7 to 11 years in which rings generally exhibited a pattern of alternating wide and narrow rings (a “saw-tooth” pattern). This pattern was attributed to the biennial nature of the life cycle of this budworm, in which severe damage is caused every other year. The growth reduction phase was followed by a growth recovery phase lasting 3 to 5 years in which ring-width gradually returned to pre-outbreak levels. Thus, the entire growth loss period could last from 10 to 16 years, and cause an average annual loss in radial increment from 16 to 21%. The 32-year cycle of outbreak recurrence was attributed to changes in forest structure in which the forest evolves from a non-susceptible to a susceptible state as the proportion of subalpine fir present in the upper canopy increases relative to the spruce component. A two-year cycle budworm outbreak will selectively remove the subalpine fir component returning the forest to a less susceptible state. It was concluded that the two-year cycle budworm is an important disturbance agent of northern British Columbia forests causing significant growth loss.

Management Issues in Northern and High-Elevation Ecosystems

Lorraine Maclauchlan, BC Ministry of Forests, Kamloops, BC, Canada

Subalpine fir is susceptible to a wide variety of disturbance agents including various root and butt rots (e.g. *Armillaria ostoyae* and *Polyporus tomentosus*), stem rots (e.g. *Echinodontium tinctorium*, *Phellinus pini* and *Stereum sanguinolentum*), defoliators (e.g. *Choristoneura biennis*) and the western balsam bark beetle (*Dryocoetes confusus*). The western balsam bark beetle is responsible for substantial mortality in subalpine fir and is the primary agent of succession in these eosystems. This study looks at the role of *Dryocoetes confusus* in the stand dynamics of subalpine forests.

In the succession of a stand, it appears that smaller, suppressed trees die first with the larger diameter trees being the first to be attacked and killed by *D. confusus*. This lowers the density of these stands and may condition the stands for further bark beetle activity. Then stands reach a point (late phase) when they are very open, with a lower number of susceptible balsam and less suitable for *D. confusus*.

Attack dynamics of the western balsam bark beetle, *Dryocoetes confusus,* in natural stands and stand edges (newly created and old) was compared. Interior stands contained significantly more sub-alpine fir per hectare than stand edges. Stands near older cutblocks had a significantly lower ratio of dead to total trees than stands near more recent cutblocks. Both harvesting and incidence of *D. confusus* influences stand density.

There was a significant difference in the ratio of dead sub-alpine fir (killed by *D. confusus*) to total sub-alpine fir (live + dead) among treatment regimes (year of harvest) within interior stands and edges, respectively. Edges adjacent the oldest harvesting (1982-84) had a significantly lower ration of dead to total (0.202 ± 0.065) than edge stands adjacent more recent harvest (1993-96)(0.433 ± 0.59). The relation is not as clear when comparing interior stands among treatment regimes (time of harvest).

When all edge and interior stands were combined with time of harvest as the variable, the ratio of dead to total sub-alpine fir is significantly less in the oldest harvest regime (1982-84). When all treatments are combined, and the differences in the number of healthy or attacked (*D. confusus*) sub-alpine fir is compared within edge and interior stands, there are significantly fewer of both category on edges. The implication of this is that as stand density decreases due to harvesting and creation of stand edges, so does the overall frequency of *D. confusus* killed trees, or, perhaps the population is kept in the ever present blowdown on the edges of these harvested blocks.

Using MCH to Manage the Douglas-fir Beetle

Moderator: Darrell Ross, Department of Forest Science, Oregon State University, Corvallis, OR

This session was an informal discussion of the appropriate uses of MCH and methods of application. About 20 people attended the session. The participants shared their experiences and knowledge of using MCH to protect live high-risk trees from Douglas-fir beetle infestation during outbreaks. No notes were recorded and no abstract is available.

Douglas-fir Tussock Moth – Current Issues, Part III

John Wenz, USDA Forest Service, Pacific Southwest Region, Forest Health Protection, Stanislaus National Forest, Sonora, CA

Preliminary Results on the Efficacy of Stored TM BioControl-1

B. Kukan[1] , I.S. Otvos[1] , R. Reardon[2], and I. Ragenovich[3]

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Douglas-fir tussock moth nucleopolyhedrovirus (OpNPV) was produced and stored in various sized packages during the 1980s under the registered name of TM BioControl-1. This virus is an important component of the pest management system for this tussock moth. Preliminary results of a collaborative project between the USDA Forest Service and the Canadian Forest Service to test the efficacy or shelf life of the stored TM BioControl-1 were presented. Bioassays were done using one day-old third instar Douglas-fir tussock moth larvae inoculated with different concentrations of virus preparation. Comparisons of LD50 and LD90 values indicated:

1) A trend for higher values for samples stored for 6, 10 and 13 years than for virus that was stored for 4 years or was freshly produced.
2) Potency ratios (the ratio of equally effective doses) suggested a loss in potency with longer storage.
3) There appeared to be no difference in LD values or potency in samples from different package sizes from the same lot.

Comparisons of LD values for different strains of DFTM indicated that the LD values vary and some field strains required more OpNPV to achieve the same levels of mortality

Current Research on Douglas-fir Tussock Moth Virus

I.S. Otvos and N. Conder, Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada

The Goose Lake (laboratory strain) of Douglas-fir tussock moth was used in most of the bioassays because it provides a more reliable supply of eggs and can be reared almost year-round despite the cold storage requirements needed to break diapause. In addition, eggs from the laboratory strain are free of parasitoids and their viability (% hatch) is more predictable than those collected in the field.

Levels of egg viability, egg parasitism and incidence of virus were determined from egg masses collected in the field in British Columbia, Oregon, Idaho and California. This information was obtained in an effort to determine the threshold levels of these parameters to assist in making control decisions. For example, if the collapse of outbreaks can be accurately predicted, it would eliminate unnecessary sprays.

No parasitoids emerged from egg masses collected in California, Oregon or Idaho. Parasitoids also did not emerge from new infestations at two locations in British Columbia. In contrast, egg parasitism was high in an old infestation.

Success of larval hatch also appeared to be affected by the age of the outbreak. More larvae hatched from eggs collected from newer infestations than from older infestations. However, the length of cold storage had a critical impact on larval hatch. Eggs require a minimum of 90 days of cold storage at 4°C, and beyond 210 days egg hatch declines rapidly. The level of naturally-occurring virus was determined from egg masses collected in January, 1999, at five locations within the Sequoia King's Canyon National Park. Viral infection of larvae among these five sites ranged from 16.5% to 33.3%, averaging 21.8%.

This information, along with other factors, was considered by the appropriate people and the decision was made not to spray. The outbreak in this National Park collapsed. This suggests that if viral infection among hatching larvae is 16% or higher, Douglas-fir tussock moth populations are likely to collapse.

Future Work (2000/2001) with Douglas-fir Tussock Moth:

1. Will continue and finish bioassaying the remaining samples of stored TM-Biocontrol using the diet plug method.
2. Some bioassaying using foliage will also be done to verify that results are comparable with those from the bioassays using diet plugs.
3. Will determine the level of egg viability, egg parasitism and the level of incidence of naturally occurring virus from a sub-sample of eggs taken from egg masses collected in Oregon and Idaho. This information is likely to be used in the deliberation on control options to be used against the Douglas-fir tussock moth in 2000.
4. Depending on funding, may do DNA analysis of samples of TM-Biocontrol batches produced by the various companies to ensure that they are the same strain of virus. This information may be required if TM-Biocontrol needs to be re-registered.
5. If funding can be obtained, work will continue on the development of a virus detection kit for use in the field. The method will be faster, less complicated and cheaper than the currently available methods.

The following main points were made during the question and discussion period after the presentations:

1) It is desirable to determine egg parasitism, egg viability and level of naturally-occurring viral infection. This may confirm and/or refine the currently held hypothesis.
2) As the efficacy of *Btk* against the Douglas-fir tussock moth is not fully known, it would be highly desirable to do a small-scale (5-10 ha) test to evaluate it. If field testing is not practical, the efficacy of *Btk* should at least be done in the laboratory.
3) Pheromone trap data was used successfully for the first time in the United States to predict a developing Douglas-fir tussock moth outbreak. The next step is to predict the expected defoliation. The sequential egg-mass survey developed and used in British Columbia may provide this. However, it should be noted:
    a) British Columbia is the northernmost part of the range for the Douglas-fir tussock moth. This may influence the dynamics of Douglas-fir tussock moth outbreaks, therefore, all the values used in the British Columbia management system to reach a control decision may not be valid for the United States, and may need to be re-calibrated for use there.
    b) The sequential egg-mass survey system was developed for the Douglas-fir tussock moth on its principle host, the Douglas-fir (*Pseudotsuga menziesii*) in British Columbia. If circumstances permit, it should be tested on egg masses laid on both Douglas-fir and white fir (the latter is the more common/frequent host) in the United States.

   It was noted that the sequential sampling procedure was tried during the recent California outbreak and seemed to work reasonably well- data is currently being analysed.

Sucking Insect Response to Environmental Change

Moderator: Ann M. Lynch, USDA Forest Service, Rocky Mountain Research Station, Flagstaff, AZ

Most session attendees were interested in discussing the increasing spruce aphid (*Elatobium abietinum*) problems seen in the Pacific coastal forests and the Southwestern United States, and the session evolved into a review of that insect's biology, population behavior, and status, and a planning session for further investigations.

Spruce aphid has been known in North America since 1916, and is presumed to be exotic. In Pacific coastal areas it is a problem on Sitka spruce and white spruce. Dave Overhulser said that it causes occasional mortality on urban ornamentals in Oregon and Washington. Mark Schultz said that significant mortality can occur in Sitka spruce in Alaska, up to 40%. Ann Lynch indicated that mortality from the 1996/1997 outbreak in Arizona was observed on Engelmann spruce and Colorado blue spruce in 1999 plot assessments. She won't know the actual amount until the 1999 data is analyzed. Dave and Mark indicated that the severity of forest defoliation is increasing in their areas, with defoliation further inland and at somewhat higher elevations in Oregon and Washington, and becoming more extensive and severe in

Alaska. Ann said that René Alfaro reports activity in British Columbia similar to what Dave has seen.

Discussion on the biology reported that the life history in the Northwest is parthenogenic, as no alates have been seen. Populations build up and defoliate Sitka spruce in the spring, with populations declining as the season warms. The population decline is presumably due to predators, including avian predators. Ann reported that Southwestern populations are very high in the late fall and winter, and that she has seen alates in December. There were a lot of alates in samples sent from the Cornado N.F. in southeastern Arizona; perhaps 30% of the December sample were alates. She and Jill Wilson have looked for aphids in the spring and summer in the Arizona White Mountains and not found any. The group thought that the alates would be sexual, but no one was certain. We also could not explain why the life cycle would be different between the two regions. Ann said that the literature from Europe indicates that their populations are almost always parthenogenic, and that they get alates in the spring very rarely, every 10 or 12 years. The Europeans are pursuing foliage nutrition as a possible explanation for alate production. Given the differences in hosts between the Northwest and the Southwest, that might explain why the Southwestern populations produce alates. Possible explanations for why the Southwestern alates are produced in early winter were more difficult, although we thought it probably ruled out photo-period as a possible explanation. We discussed the possibility that spring and autumn alates might be different forms, and would therefore have different triggers.

The recent outbreak in the Southwest appears to be much more extensive and severe than what has been seen in the Northwest, with the possible exception of Alaska. Some extensive defoliation has been seen in Alaska, with up to 60% tree mortality. Although the data hasn't been analyzed, plot data and air surveys indicate that the White Mountains outbreak in Arizona covered the majority of the host type. Region 3 and Ann's project jointly funded a color-infrared photography flight in 1997, but it took over a year to get funding for the interpretation. The interpretation is being done by a Ph.D. student of Dave Kulhavy at Stephen F. Austin State University, but it will take at least a year to make real progress on that study. Hopefully, the interpretation data will allow us to identify topographic and vegetation risk factors. Ann reported that the plot data is alarming, as there were a lot of trees completely defoliated. She was also concerned because they had recently discovered a new population in the Pinaleño Mountains in southeastern Arizona. She and Jill Wilson have found spruce aphid in the White Mountains and Pinaleño Mountains in Arizona, and in the Mogollon Mountains in western New Mexico (just east of the White Mountains). Dave Conklin reports spruce aphid in the Sacramento Mountains in southern New Mexico. Jill and Ann looked for, but did not find, spruce aphid in the Chuska Mountains in northeastern Arizona and in the Sierra Anchas in central Arizona. That means the population has expanded from one mountain range (the White Mountains) and one urban area (Santa Fe, New Mexico) to four mountain ranges since 1996. Another factor to consider is that the Southwestern populations are incurring outbreaks under temperature regimes that are colder than what the European literature and the Northwestern experiences indicate that the populations can survive.

The group next discussed what investigations are being conducted and should be pursued. Ann reported that she was initiating as much work as possible, since it appears that this is going to be a major problem in Region 3. Most of her work is damage and impact assessment-related, and attempting to relate weather patterns to defoliation episodes. It appears that Southwestern outbreaks might be associated with warm winters or La Niña patterns. Life history and population dynamics work is difficult because of the travel distances involved. The Flagstaff group (Forest Health Protection and Research), don't want to do any work with live insects in Flagstaff for fear of introducing the insect to the San Francisco Peaks. They have been handling live material coming into the lab as a hazardous material, and Ann was concerned about the cost of hazmat disposal to her budget.

The Pacific Northwest people were happy that a scientist was finally working on spruce aphid, as they said that they have made several requests for research on the problem, which was getting worse. Discussion then moved to research priorities, although no one was present from the interior west extension groups. We generally agreed that the highest priority was determining the life history of the insect in the different areas, including comparisons between the coastal and interior populations. Second priority would go to quantifying damage and impact. Dave said that spruce aphid has become a chronic problem in his area, and that mortality accumulates gradually but significantly. Ann asked if there was any long-term data, and Dave indicated that all he knew about was the State's air survey maps. Third priority should be looking at population dynamics modeling, especially with respect to temperature regimes. Ann said that she can look at year-to-year patterns with the type of data she is collecting, but that actual population growth and reduction modeling would require more funding than she has available. Other work that needs to be done is investigating natural enemy and chemical control strategies, projecting tree population dynamics with various speculated frequencies of defoliation, and looking at seed and cone production.

Douglas-fir Beetle: Recent Research and Management

Moderator: Darrell Ross, Department of Forest Science, Oregon State University, Corvallis, OR

Participants: About 20-25 people attended this session including – Jim Vandygriff, Tim McConnell, Kevin Dodds, Jim Hadfield, Sandy Kegley, Carol Randall, Darek Czokajlo, Ladd Livingston, Bernie Ryan, Joel McMillin, Bruce Hostetler, Bruce Thompson, Jane Hayes, Don Goheen, Kristen Baker, Steve Kohler, and Jaime Villa-Castillo.

Four speakers presented the results of recent research or management projects aimed at reducing the negative impacts of Douglas-fir beetle-caused tree mortality.

Douglas-fir Beetle Response to Pruning for Dwarf Mistletoe

Jim Hadfield, USDA Forest Service, Wenatchee National Forest, Wenatchee, WA

(Abstract not available)

Monitoring of Douglas-fir Beetle Populations in Down Wood

Bruce B. Hostetler, USDA Forest Service, Westside Technical Center, Sandy, OR, and **Darrell W. Ross**, Department of Forest Science, Oregon State University, Corvallis, OR

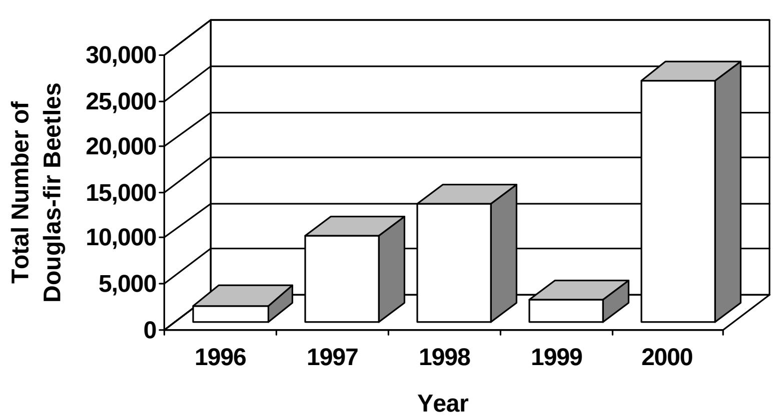
Douglas-fir beetle populations are being monitored in and near long-term ecosystem plots in the Oregon Coast Range near the town of Hebo. Plots are located on the Siuslaw National Forest and consist of treatments which are designed to accelerate the development of late successional characteristics in Douglas-fir plantations which are about 90 years old. The treatments are:

- Leave 30 trees per acre in overstory; underplant with hardwoods; leave 20 trees per acre on the ground as coarse woody debris.
- Leave 30 trees per acre in overstory; underplant with conifers; leave 20 trees per acre on the ground as coarse woody debris.
- Leave 60 trees per acre in overstory; plant openings with confiers; leave 20 trees per acre on the ground as coarse woody debris.
- Leave stand as is (i.e., no tree cutting)

Harvesting of all but the residual standing trees and those trees left to serve as coarse woody debris were felled in early 1998. Trees left as coarse woody debris were felled during Sepember and October 1998. As you can see in Table 1, actual residual tree densities were somewhat different than targeted densities.

The relative beetle populations for the area have been monitored starting in 1996 by trapping using attractant semiochemicals (frontalin, seudenol, ethanol) placed in Lindgren funnel traps. Three traps were placed at each of four sites outside but within the general area of the long-term ecosystem plots. Trap catches were low in 1996 and increased in 1997 and again in 1998 (Fig. 1). In 1999 numbers of beetles decreased, most likely competition provided by the 20 trees per acre cut and left on the ground on approximately 150 acres in the general area. In 2000, the numbers of beetles caught increased to more than double any of the previous year's catches, probably because of the many beetles emerging from the down trees infested in Spring 1999.

Figure 1. Total numbers of Douglas-fir beetles collected in 12 pheromone-baited traps near Pollard Cedar Timber Sale from 1996 through 2000, Hebo Ranger District, Siuslaw National Forest



In September 1999, bark samples were collected from lower, mid, and upper portions of the boles of 10 down trees within each of the 9 treatment areas which had 20 trees per acre cut and left as coarse woody debris. There seems to be no obvious correlation between beetle attack density on down logs and number of residual trees per area remaining in the overstory (Table1). In addition, a cursory look at brood production data showed no obvious correlation with overstory density. Apparently the intensities of thinning used in this study did not create significant differences in habitat quality, even though others have reported significant differences in both attack density and brood production between logs in partial shade and those in full sunlight.

Numbers of residual trees attacked and killed by Douglas-fir beetle will be evaluated in early summers of 2001 and 2002. Population sampling using pheromone traps will continue for at least through 2002.

Table 1. Numbers of residual trees, residual basal area, and Douglas-fir beetle (DFB) attacks per area on down logs Hebo Restoration Study Long Term Ecosystem Productivity Integrated Research Sites Hebo Ranger District, Siuslaw National Forest.

Block	Treatment	Unit Number	Target Residual TPA (TPH)	Actual Residual TPA (TPH)	Actual Residual Basal Area sq ft/acre (sq m/ha)	DFB Attacks per sq ft (per sq m)
I	C	72	No thinning	187(462)	288(66)	--
I	E	73	30(74)	56(138)	109(25)	0.51(5.5)
I	M	74	30(74)	41(101)	77(18)	0.41(4.4)
I	L	71	60(148)	69(170)	130(30)	0.72(7.7)
II	C	81	No thinning	128(316)	258(59)	--
II	E	82	30(74)	44(109)	102(23)	1.04(11.2)
II	M	83	30(74)	25(62)	54(12)	0.32(3.4)
II	L	84	60(148)	50(124)	117(27)	0.53(5.7)
III	C	92	No thinning	178(440)	310(71)	--
III	E	94	30(74)	37(91)	113(26)	0.20(2.2)
III	M	93	30(74)	47(116)	125(29)	0.10(1.1)
III	L	91	60(148)	69(171)	141(32)	0.41(4.4)

TPA = trees per acre; TPH = trees per hectare

Treatments:

C = Control

E = Start over with hardwoods (early seral)

M = Start over with conifers (mid seral)

L = Work with existing stand (late seral)

Analysis of Douglas-fir Beetle Population Dynamics from Aerial Survey Data Using Group Size Analysis

Carol Randall, USDA Forest Service, Forest Health Protection, Coeur d'Alene, ID

More information about the course of a DFB outbreak can be obtained by considering size (numbers of faded trees) and abundance of DFB groups across the landscape as recorded in aerial detection surveys (ADS) in addition to numbers of acres infested and numbers of faded trees traditionally reported. Group assessment allows for a more meaningful exploration of DFB trends in a particular area, emphasizes the group nature of DFB mortality, gives indications about distribution of beetles (1 5,000+ tree groups mapped vs. 1,000 5-tree groups), and it is more likely to yield information about beetle population trends in the absence of complete ADS.

Group analysis also provides managers with important information about distribution and size of mortality patches. Numbers of groups in each size class may be used by different resource specialists to determine impacts DFB mortality may have on resources and on treatment options. For example, larger groups may make salvage economical or regeneration harvests feasible if groups are very large. Mortality levels of 1 or 2 trees per acre may impact few resources, but concentrated mortality that creates significant openings in canopies may impact many resources.

Though ADS information is not as precise as ground survey information, and because it is always one year old, it is better suited to yielding information on the way that DFB acts across a landscape. Aerial detection surveys also provide more cost-effective coverage than current ground survey methods, and can be completed in a more timely fashion. Ground survey data will compliment ADS information.

Preliminary Douglas-fir Beetle Pheromone Trapping Results Northern Idaho 1999

Sandy Kegley, USDA Forest Service, Forest Health Protection, Coeur d’Alene, ID

A very large Douglas-fir beetle outbreak in northern Idaho provided opportunities to test pheromone based strategies to minimize negative impacts of the beetle outbreak. A number of pheromone studies were conducted on the Idaho Panhandle National Forest in 1999 cooperatively with Oregon State University, USDA Forest Service Pacific Northwest Research Station, and USDA Forest Service Northern Region Forest Health Protection, State of Idaho, and private citizens and landowners. Preliminary Douglas-fir beetle trapping results for three different pheromone trap studies are reported. The three studies are: 1) Comparison of IPM technologies panel trap and multiple-funnel trap, 2) Comparison of 8-, 12-, and 16-unit funnel traps, and 3) Effect of number of traps and lure strength on efficacy of mass trapping Douglas-fir beetles. Preliminary results reflect trap catches processed through the end of June 1999 and have no statistical analysis.

In the comparison of the panel trap and funnel trap, 16 pairs if traps were deployed with one panel and one funnel trap per pair located 10 meters apart and at least 50 meters from all other pairs. In half of the trap pairs, lures were replaced every 4 weeks. After trap placement it was discovered that the panel traps were assembled inside out. Additional panel traps correctly assembled with the right side out were also placed at the trap sites approximately one month later than the others. Preliminary results are shown in table 1.

Table 1. Comparison of IPM panel trap and multi-funnel trap.

Trap Type	# DFB caught	# Clerids caught
Panel trap	17,419	1,583
Panel trap/bait replaced	22,635	1,937
Total for panel traps	**40,054**	**3,520**
Funnel trap	5,403	2,518
Funnel trap/bait replaced	14,862	2,301
Total for funnel traps	**20,265**	**4,819**
Panel trap right side out	12,623	912

For the comparison of different numbers of funnel units in funnel traps on the efficacy of trapping Douglas-fir beetles, an 8-, 12-, and 16- unit funnel traps were deployed on 10 different sites. Preliminary results are shown in table 2.

Table 2. Comparison of 8-, 12-, and 16-unit funnel traps.

Trap Type	# DFB caught	# Clerids caught
8 funnel	12,830	1,473
12 funnel	16,510	2,098
16 funnel	21,309	2,473

In the study of number of traps and lure strength on the effectiveness of mass trapping Douglas-fir beetle, 3,6, and 12 traps were placed per site with single, double, or 4 times the amount of pheromone released per day. There were five treatments replicated five times (table 3). Some of the lures used in this study did not release at the appropriate rate and were replaced during the Douglas-fir beetle flight season. The affects of these faulty lures on the study are not known. Preliminary results are shown in table 4.

Table 3. Treatment summary for the study on effect of number of traps and lure strength on efficiency of mass trapping Douglas-fir beetle.

Treatment number	# of Traps	Frontalin (mg/day)	Seudenol (mg/day)	Ethanol (mg/day)	Pheromone/ Trap group
1	3	30	15	300	X
2	6	30	15	300	X
3	12	30	15	300	X
4	6	60	30	600	2X
5	12	120	60	1200	4X

Table 4. Effect of number of traps and lure strength on efficiency of mass trapping Douglas-fir beetle.

Treatment Number	**# DFB caught**
1	24,172
2	70,747
3	57,295
4	28,560
5	41,111

Final results of these studies will be reported at a later date. Results may suggest the most effective mass trapping strategy for Douglas-fir beetles.

Insect Responses to Fire

Moderator: Ken Gibson, USDA Forest Service, Forest Health Protection, Missoula, MT

Introduction: Fire-Bark Beetle Interactions in the Northern Region

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

In the Northern Region, we have had several incidents, within the last decade or so where significant bark beetle outbreaks were precipitated by major wildfires. Ones most well-remembered, perhaps, were the fires in Yellowstone NP in 1988. Gene Amman and others did some follow-up studies which showed fire-weakened trees were, indeed, conducive to bark beetle outbreaks--the most notable being in Douglas-fir and Engelmann spruce stands. As an aside, DFB outbreaks following those fires have only recently subsided; and spruce beetles populations were epidemic in the area around Cooke City for several years following the fires. Pine engraver populations, which we believe built to epidemic proportions in fire-damaged lodgepole pine, were a management concern in the Park and the surrounding Gallatin NF for almost 5 years after the fires of 1988. To be sure, conditions were exacerbated by abnormally dry weather for several years after the '88 fire season; but beetle populations began building rapidly in fire-weakened trees in 1989.

One of our next notable examples was the Thompson Creek fire on the Gallatin NF. DFB populations had built to epidemic levels following a blow-down event in 1988. Beetle populations were beginning to subside when the Thompson Creek fire began in late July, 1991. Availability of fire-weakened trees pretty much coincided with late-season beetle flights, and DFB populations rebounded and remained high for another 2-3 years.

Another "banner year" for wildfire in the Region was 1994--especially on the Kootenai and Flathead NFs in northwest MT. Fires that year resulted in several areas where trees in Douglas-fir and/or Engelmann spruce stands were damaged enough to attract beetles, but not enough to destroy their cambial-layer food supply. The result was DFB outbreaks which, I believe, were still around to a higher-than-normal extent when the winter of 1996-97 produced incredible amounts of wind, snow and ice damage--and lots of beetle brood sites in spring 1997. The result is our current DFB outbreak, one of the most damaging ever recorded in our Region.

A well-documented incident, on which I reported in Breckenridge, was the Little Wolf Fire on the Flathead NF in MT. The fire began in late-August on the Kootenai NF, but by the next day had spread to the adjacent Flathead NF. Of 19,000 acres ultimately burned, 14,000 were on the Flathead. I was asked to help assess bark beetle potential about a month after the fire was out. We noted many areas where Engelmann spruce and Douglas-fir were just girdled by the fire, producing likely brood sites for beetles the next year. Many of those trees blew down during winter 1994-95, making them even more attractive to flying beetles in spring '95.

To summarize, more that 2,000 acres were found to contain some level of down and infested Engelmann spruce in late summer, 1995. Despite extensive salvage efforts, there were still many beetle-infested spruce on the ground in 1997 that were not going to be removed, either at all, or before beetle flight. In 20 sites, we hung 10 pheromone-baited funnel traps each. In other selected sites some trap trees were dropped. And in others, salvage continued. At the end of the season, trap trees had been removed, some infested trees had been salvaged, and we had trapped an estimated 200,000 spruce beetles. As a result, we found no infested standing spruce anywhere in the fire-affected area, and populations are now endemic.

That same year, however, in other parts of the burn area, we began finding more standing Douglas-fir which had been attacked by DFB. We realized that those populations had grown larger than we had anticipated. In response, in 1998, we elected to once again influence flying beetles with pheromone funnel traps. We hung 175 traps in 20 locations--as close as practicable to infested Douglas-fir, but far enough away from large-diameter, green Douglas-fir to avoid “spill-over” as much as possible. At season's end, we had caught approximately 860,000 DFB, and had about 125 trees attacked near trap sites--which were removed later that winter. We believe we significantly reduced DFB populations in that area. Elsewhere on the Forest, DFB populations are high, as they are in much of western MT; but in the Little Wolf area, they appear to be no higher than pre-fire levels.

In conclusion, we have observed that the right types of fire--somewhere between light enough so the tree's inner bark is not charred, but heavy enough to girdle the tree at ground level--will indeed predispose a tree to bark beetle attack. On occasion, I've seen wood borers attack fire-damaged trees so heavily they successfully out-competed bark beetles for that limited resource; but I believe that is unusual.

So far, I have addressed "wild-fire" effects. Most of our fire/beetle interactions have been associated with those types of fires. I have, however, seen negative results from prescribed under-burns, following partial cuts. That is another matter entirely—and Sheri will address that more in her presentation.

Effects of Fire on Species Diversity of Bark Beetles and Wood Borers in Boreal Forests

Skeeter Werner (retired), USDA Forest Service, Pacific Northwest Research Station, Fairbanks, AK

Disturbances of spruce ecosystems in Alaska have a direct impact on the diversity of species of scolytid bark beetles and buprestid and cerambycid wood-boring beetles. Fire and timber harvest are the two major disturbances that alter these forest ecosystems. Both types of disturbance provide habitats in which population densities of bark beetles and wood borers increase the first year after the disturbance. Beetle populations and diversity remain high for up to five years after the fire, then decrease as hardwood stands replaced spruce in the burned areas.

Fire removed most of the host trees inhabited by scolytids and cerambycids; however, scorched trees provided habitat for buprestid species. Trees in the fringe area surrounding the fire, whose roots and lower bole were partially burned, or whose needles were damaged by smoke, provided excellent habitat for breeding populations of bark beetles and wood borers.

Preliminary Results of Bark Beetle Activity Following Two Prescribed Fires in Northeastern California

Sheri Smith, USDA Forest Service, Forest Health Protection, Susanville, CA

Sheri presented Pat Shea's (retired Research Entomologist, PSW) data from the Butte Lake prescribed fire and her data from the Columbo prescribed fire. Butte Lake is within Lassen Volcanic National Park in primarily eastside pine type. White fir has encroached into the stands as a result of fire exclusion. The objectives of the Butte Lake project were to: 1) reduce dead and down fuel, 2) allow for duff consumption of 50% and 3) allow for white fir mortality of 70% in thickets. The overall goals were hazard fuel reduction and boundary protection. The fire burned approximately 458 acres between September 22 and October 11, 1995. Data were collected during the fall of 1996 on every tree within 12 transects (transect = 1 chain wide by 30 chains long). In total, about 7% of the burned area was sampled.

A total of 2,317 trees were sampled of which 1,558 were white fir, 380 were ponderosa pine, 365 were Jeffrey pine and the remaining 14 trees were lodgepole pine. Size classes of the sample trees were as follows:

	Number of Trees			
Species	6-12"DBH	13-20"DBH	21-30"DBH	>30"DBH
WF	763	561	171	63
PP	133	76	72	99
JP	146	84	51	84
LPP	7	7		

Bark scorch data was collected on the trees to provide further documentation that it is not a good criteria to use in salvage marking guidelines as an indicator of subsequent mortality. Fifty-seven percent of all sample trees were categorized as having a high amount of scorch damage, which might typically indicate that the trees should die from their fire-related injuries; however, only 15% of the total number of trees were dead one year after the fire. Some additional mortality likely occurred after the first year but not at the level that may have been predicted based on scorch damage alone.

The sample trees killed as a result of their fire injuries totaled 349 trees. White fir trees made up the majority of these (81 %), but this was only 18% of the total number of white fir trees sampled. Yellow pine mortality directly related to the fire (9% of the total 745 trees sampled) exceeded the desired outcome. The number of trees attacked by primary Scolytids was only 3% of the total with the majority of these being ponderosa or Jeffrey pine. Several additional pine trees (32% of the total sampled) were attacked by red turpentine beetle, *Dendroctonus valens*.

Observations from this prescribed fire indicate that red turpentine beetle, *Dendroctonus valens,* attacks on pine species should be expected following prescribed fires. Entomologists in California commonly observe *D. valens* attacks following wildfires as well, but conifer mortality associated with these beetles alone is quite rare. Over all, a very low percentage of the total number of trees sampled were attacked by primary bark beetles (3%), indicative of the relatively vigorous condition of the trees prior to the fire. The fire-related white fir mortality of the sample trees did not meet the desired outcome of 70%; however, the Park land managers realize that to kill a high percentage of white fir would result in far more pine mortality than desired, as was the case anyway for this prescribed fire.

The Columbo prescribed fires took place during the spring and fall season over two consecutive years, 1996-1997. The stands in the Columbo area are mixed conifer and are dominated by high quality tree growing sites with dense understories. The objectives of this fire were to: 1) remove up to 50% of the brush species; 2) remove ground fuels less than 3" in diameter; 3) remove small suppressed trees <5 ft. tall and 4) remove needle cast. The range of acceptable results based on these objectives included removing 40-70% of the brush composition and ground fuels up to the 6" DBH class and allowing trees up to 30 feet tall to be scorched or consumed. In addition, they expected to experience some mortality (<5%) of trees greater than 12" DBH. The goals were to open the area up for deer migration, keep the canopy layers intact for California spotted owls, lower the fuel loading to reduce fire hazard ratings and to reintroduce fire as a positive force in the ecosystem.

A total of 1,250 acres were burned in increments ranging between 50 to 250 acres at time. FPM installed 1/3-acre plots following the fires to monitor fire and subsequent bark beetle-related mortality. Five permanent plots each were installed in the spring burn, the fall burn and in a control no burn area. Data has been collected annually for up to three years. Statistical analyses have not been conducted on these data so Sheri summarized the following observations. There has been no bark beetle-related mortality to date in the **fall burn** plots. There was no mortality from fire injuries in the >6" DBH class the first year, but they did observe 8 dead trees two years following the fire. In the **spring burn plots** there were 45 pines trees >6" DBH attacked by western pine beetles within the first year following the fire. Since then, attacks have not been observed. Higher levels of mortality related to fire injuries has been observed following the spring burns compared to the fall burns. A total of 47 trees >6" DBH were killed by the fire the first year and 16 the second year following the fire. Similar fire-related losses, in terms of numbers of trees <6" DBH, were observed in the burned plots, regardless of season of burn. There was a minimal amount of bark beetle-related mortality in the control plots the first year following the burn, but none has been observed since. Similar to the Butte lake burn, red turpentine beetles have been observed following the Columbo burns. It appears at this point that they are more prevalent in the spring burned plots.

Precipitation, or lack thereof, is the most significant factor related to conifer mortality in California. Mortality tends to increase whenever winter precipitation is less than about 80% of the long term normal. Trees stressed by inadequate moisture levels have their normal defense systems weakened to the point that they are highly susceptible to attack by bark, engraver and wood boring beetles. Above normal moisture levels have been recorded in northern California since 1995. The relatively good vigor of the trees prior to the Columbo and Butte Lake burns combined with a general downward trend in bark beetle-related mortality in both areas were important factors in the overall relatively low levels of bark beetle activity observed to date. It is likely that observations, for obvious reasons, would be very different if these fires had been conducted under drought conditions, both in terms of fire and bark beetle-related mortality.

Insect Activity After the 1994 Payette Fire Complex

Phil Mocettini and Julie Weatherby (deceased), USDA Forest Service, Forest Health Protection, Boise, ID

History

In the summer of 1994 over 200,000 acres burned on the Payette National Forest
Areas burned ranged from dry site ponderosa pine and Douglas-fir up to the high elevation spruce fir sites.
A study to follow tree survival the following year was installed.

Methods

In the summer of 1995 over 480 trees were tagged in a total of 4 areas.
The trees had to meet 2 criteria

1) Some green needles
2) Some scorch, either bole or crown

Death was defined by the absence of green needles.
Only after death was a destructive sample taken to determine the cause.

Results

Subalpine fir

Total trees:	Survive 5 years	Beetle killed	Fire killed
41	12	0	29
Mean diameter (inches)	7.9		9.4

Engelmann spruce

Total trees:	Survive 5 years	Beetle killed	Fire killed
49	11	7	31
Mean diameter (inches)			

Lodgepole pine

Total trees:	Survive 5 years	Beetle killed	Fire killed
82	32	9	41
Mean diameter (inches)	13.6	16.0	13.9

Grand fir

Total trees:	Survive 5 years	Beetle killed	Fire killed
101	41	27	33
Mean diameter (inches)	15.9	15.9	17.4

Douglas-fir

Total trees:	Survive 5 years	Beetle killed	Fire killed
211	109	64	38
Mean diameter (inches)	14.9	22.6	13.8

Ponderosa pine

Total trees:	Survive 5 years	Beetle killed	Fire killed
42	32	5	5
Mean diameter (inches)	23.8	33.9	21.6

Poster Presentations

Attraction of *Scolytus unispinosus* Bark Beetles to Water-Stressed Branches of Douglas-fir Containing Ethanol

Rick G. Kelsey, USDA Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR, and **Gladwin Joseph,** Department of Forest Science, Oregon State University, Corvallis, OR

Three similar-sized branches on each of seven Douglas-fir (*Pseudotsugae menziesii* [Mirb.] Franco) trees with a southern exposure were selected randomly to receive a water-stress, defoliation, or control treatment. Their exposure to the sun was maximized by removing branches overhead on the south side of the bole. Water-stressed branches were prepared by freezing them at the base with dry ice thereby causing the xylary water column to cavitate while under tension from transpiration through the needles. After cavitation, the tissue water content in these branches slowly declined. Defoliated branches were also frozen with dry ice, but all secondary branches and needles were removed immediately to eliminate tension from transpiration, thus minimizing cavitation and subsequent water loss. All water-stressed branches were attacked by *Scolytus unispinosus* LeConte at 12 to 24 days after imposing the treatments, resulting in a significantly higher mean density of gallery holes (107 m^{-2}) than in the defoliated or control branches, which were not attacked. Needles and woody tissues from stressed branches, sampled after being attacked, contained significantly higher ethanol concentrations (ranging from 2.91 to 15.26 Φmol g^{-1} fresh wt.) than tissue from defoliated or control branches (0.005 to 0.12 Φmol g^{-1} fresh wt.). Ethanol concentrations did not differ between defoliated and control branches. The water content in woody tissues and needles of stressed branches was 40.9 and 28.1% of the amount in control branches, respectively, when sampled for ethanol analysis. Woody tissues in defoliated branches remained moist, with 91.3% of the water in controls. Drying needles from water-stressed branches also lost 18.3 to 33.7% of their total monoterpenes compared to needles on the controls. The mechanism for ethanol synthesis in water-stressed branches appears to be distinctly different from that of logs overwintering on the forest floor. Ethanol synthesis in stressed branches probably was initiated by cytoplasmic acidification as a result of damage to cellular membranes from drying and heating. The ethanol that accumulated in needles and woody tissues of stressed branches functioned as a primary host attractant for *S. unispinosus* at our Willamette Valley, Oregon, site. Other forest insects might also use ethanol as a primary host attractant for detecting severely water-stressed trees.

Impacts of Douglas-fir Beetle on Forest Overstory and Understory Conditions of the Greater Yellowstone Area

Joel D. McMillin and Kurt K. Allen, USDA Forest Service, R2 Forest Health Management, Rapid City, SD

Douglas-fir beetle (*Dendroctonus pseudotsugae*) infestations frequently result from disturbance events that create large volumes of weakened Douglas-fir (*Pseudotsuga menziesii*) trees. Although research has focused on determining the susceptibility of forest stands to Douglas-fir beetle and predicting the amount of tree mortality caused by Douglas-fir beetle infestations following disturbance events, there has been an inadequate amount of work on consequent changes in both the overstory and understory. In the early 1990's, populations of Douglas-fir beetle increased in fire-scorched trees and then infested undamaged neighboring stands on the Shoshone National Forest, Wyoming, U.S.A. In 1999, transect sampling (32 km) and 25 pairs of previously infested and uninfested plots were used to quantify changes in forest stand conditions and subsequent responses in the understory caused by Douglas-fir beetle infestations. Significant effects of the Douglas-fir beetle infestation included: 1) Basal area was reduced by 40 - 70 percent, average tree diameter decreased by 8 - 40 percent, and the Douglas-fir component of the overstory decreased by more than 15 percent. 2) Conifer seedling regeneration increased nearly four-fold in the infested plots and 90 percent of the regeneration was Douglas-fir. 3) The understory vegetation (forbs, grass, and shrubs) had a three-fold increase in the infested plots compared with uninfested plots. In addition, basal area of Douglas-fir killed by the Douglas-fir beetle was significantly correlated with initial Douglas-fir basal area and percent of Douglas-fir, but not tree diameter or trees per hectare. Significant inverse relationships were also found between post-infestation basal area and the abundance of forbs, grass, shrubs, and understory height. Douglas-fir beetle infestations are causing significant short-term impacts in both the overstory and understory and contributing to the mosaic in forest structure observed in the Shoshone National Forest.

Decline in the Boreal Forest

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An economically based Decision Support System (DSS) for long-term forest development planning in the boreal forest is being developed. Impetus for this DSS comes from forest licensees in the Ft. Nelson Forest District, BC, where substantial economic losses are occurring as a result of Spruce Decline Syndrome (SDS). SDS is a term coined to describe the general state of decline of overmature spruce stands after continued defoliation by the eastern spruce budworm *Choristoneura fumiferana* (Clems), followed by extensive attack by destructive secondary insects.

Recent groundwork indicates that SDS is currently stressing standing timber inventories. 50% of sampled stands had >20% host mortality, when examining the number of stems of spruce and balsam, with many of these stands having mortality levels as high as 80%. Opportunistic secondary insects such as bark and wood boring beetles are taking advantage of stressed timber, resulting in rapid decline of affected stands. Infestation rates in standing timber were as follows: *Dryocoetes confusus* 3.4%; *Dendroctonus rufipennis* 3.4%; *Ips* spp. 3.2 %; ambrosia beetles 1.7%; and woodboring beetles 16.1%. These results indicate extensive timber quality degrade is occurring from woodborer activity in the standing trees, and since a portion of this activity is occurring in green trees, no inference regarding timber degrade can be made from aerial survey data. As well, due to constraints of winter-only harvesting, log inventories are often stored for a year or more post harvest. This storage time allows woodborer activity to continue in the logyard. Bugbusters logyard management program surveys indicate woodborer infestation rates in decked inventory reached 77% by August 1998. A mill study conducted in April of 1999 in conjunction with HALCO Software, examined economic losses and decline rates resulting from wood borer activity. HALCO's SAWSIM® Sawmill Simulation Program assessed degrade with the following conclusions. Sawlogs, which were attacked three years previously by woodborers and those attacked in the logyard were downgraded from the Japanese Agriculture Standard (J.A.S.) to "Stud", with economic losses totaling, \$62.94/1000m^3 and \$936.77/1000 m^3, respectively. Due to operational difficulties veneer products were not analyzed, however, this is where the highest losses were expected. It is hoped that veneer analysis will be rerun in 2000.

A relational database has been constructed to allow forest managers to query economic losses, in a given cutting permit. A susceptibility model for the risk of forest decline and economic loss is also being developed, in conjunction with risk maps. The DSS will thus create an opportunity to proceed with long-term forest development, while mitigating the risk of economic losses resulting from forest decline. This system will be especially valuable to licensees in the boreal forest, where overmature stands will need to be stored on the stump for many years.

Model Analysis of Mountain Pine Beetle Seasonality

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The mountain pine beetle, *Dendroctonus ponderosae* Hopkins, is a natural disturbance agent of considerable consequence in western pine forests. This economically and ecologically important insect has a strong requisite for maintaining a strict seasonality. Given this ecological requirement, it is somewhat surprising that no evidence for diapause or other physiological timing mechanism has been found. Seasonality and phenological timing for this species are apparently under direct temperature control. We investigate the consequences of direct temperature control by first constructing a computationally efficient phenology model based on previously published temperature dependent developmental data. We then explore the dynamical properties of this model when subjected to observed micro-habitat temperatures representing a range of thermal habitats from one region of the mountain pine beetle distribution. We also investigate the consequences of global climate change on phenology and seasonality. Our results indicate that an adaptive seasonality is a natural consequence of the interaction between developmental parameters and seasonal temperatures. Although this adaptive phenology appears to be resilient to temperature fluctuations, changes in climate within the magnitude of predicted climate change under a CO_2 doubling scenario are capable of shifting a thermally hostile environment to a thermally benign environment. Similarly, increasing temperature by the same amount resulted in phenological disruption of an previously favorable thermal habitat. We discuss the implications of these results for restricting the current distribution of mountain pine beetle, and the potential for shifting distribution due to global climate change.

The Red Gum Lerp Psyllid - A New Pest of *Eucalyptus* in California

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The red gum lerp psyllid, *Glycaspis brimblecombei* (Homoptera: Psylloidea; Spondyliaspididae) a new pest on California's eucalyptus trees, was discovered in 1998 in Los Angeles County and has currently spread throughout much of the state. The psyllids, small insects that suck sap from leaves, are, like the eucalyptus, native to Australia. They are causing leaf damage and drop which may stress trees and make them susceptible to attack by other insects. Psyllids also produce a sticky substance called honeydew, which drops to the ground on cars and sidewalks.

The initial 6 months of the red gum lerp psyllid biological control project have resulted in a significant increase in our understanding of this new and destructive pest. We have implemented two sampling techniques, sticky traps for adults and foliage sampling for all stages, and are testing them for effectiveness as monitoring methods. We are currently sampling in four areas of the state: San Francisco bay area, (two sites), Monterey area (two sites) Los Angeles basin area (8 sites), and San Diego area (two sites). All of these areas have damaging levels of lerp psyllids, but the highest levels so far observed are in the Los Angeles area. In August of 1999 Dahlsten explored in Australia for natural enemies of the lerp psyllid in three areas that are similar in climate to California coastal areas: Sydney, Melbourne, and Adelaide. Eight species of *Psyllaephagus* (encrytid parasitoid wasps) were reared from lerp psyllid mummies in our quarantine facility at UC Berkeley. These wasps are being reared in quarantine and are being tested for suitability as biological control agents against the lerp psyllid. If one or more of these wasps proves to be safe (i.e. does not negatively impact other psyllids such as *Boreioglycaspis melaleucae*), we will release them in the year 2000 at California field study sites and determine their success in controlling the red gum lerp psyllid.

Edge-Effects on Ground Arthropod Species Composition and Community Structure in Old-Growth Forests

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(Abstract not available)

Moisture and Saprotroph Effects on Respiration from Coarse Woody Debris

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We studied the interactive effects of manipulated moisture content and insect and fungal community composition on respiration from decomposing Douglas-fir logs during the first 2 yrs on the ground at the HJ Andrews Exp. Forest. We cut fresh 9-15 cm diam. x 1.6 m long logs and assigned them to 6 saprotroph x 2 moisture treatments at five replicate sites. Saprotroph treatments involved drilling sterile holes to different depths to simulate beetle penetration through phloem (treatment 2) or sapwood (treatment 3), and inoculating sapwood holes with non-decay fungi only (treatment 4), decay fungi only (treatment 5) or both fungal groups (treatment 6), with an unpenetrated control (treatment 1). Moisture treatments involved clear plastic shelters over treated logs to reduce wood moisture 20%. Saprotroph functional diversity apparently had only a minor short term effect on respiration, although logs inoculated with decay fungi generally showed higher respiration rates. Respiration was significantly higher in logs with reduced moisture content during the entire period, reflecting inhibited decomposition in wood saturated much of the year in this region. These results indicate that climate change or forest management practices that reduce wood moisture in this region will increase carbon flux to the atmosphere.

Canopy Arthropod Communities among Douglas-fir Forests in the Pacific Northwest

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Species distribution of invertebrates is commonly limited by climate. As such, insects can serve as responsive indicators of climatic patterns and environmental conditions. Invertebrates are very species rich, and they play key roles in nutrient recycling, tree growth, regulation of foliage area, and evapotranspiration. To examine landscape patterns of invertebrate assemblages, arboreal arthropods were collected during two seasons (spring and summer) by bagging branch tips from the lower, middle and upper canopy levels from Douglas-fir at nine locations in Washington and Oregon. Detrended Correspondence Analysis was used to assess partitioning of arthropod communities by region and tree age (H. J. Andrews). Indicator species analysis were used to distinguish significant differences in the abundance of individual taxa among forests and between tree age classes. Our data show regional separation of canopy arthropod assemblages along a 270-km N-S latitudinal gradient and between old-growth and mature Douglas-fir. Changes in the spatial patterns of richness and abundance of invertebrate assemblages can be used to predict changes in invertebrate assemblages under warming climate scenarios.

Arthropod Community Structure in Regenerating Douglas-fir Forests: Influence of Tree Diversity, Density, Apparency, and Quality

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(Abstract not available)

Development and Implementation of Integrated Pest Management for the Elm Leaf Beetle in a Large Urban Area (Sacramento, CA)

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The elm leaf beetle (ELB), *Xanthogaleruca luteola*, is the most commonly treated pest of elms and is ranked as the second most important urban tree pest in the western United States. In 1995 the Sacramento Tree Foundation, the City of Sacramento Neighborhood Services and the University of California began a co-operative effort to develop and implement an integrated pest management program for the elm leaf beetle in Sacramento. This program was based on work previously completed by Dahlsten *et al* and adapted a user friendly monitoring technique to locate areas of beetle activity or "hot spots". Control efforts could then be directed toward these "hot spots" instead of treating all trees on a calendar basis. Between 1995 and 1999 progressively larger areas of the city were set aside to be managed under the monitoring program and by the 1999 season all susceptible street trees in the city were being monitored totaling over 2200 trees. Trees were sampled at the egg peak of each generation as determined by a degree day model and only those trees with beetle populations high enough to defoliate trees above the acceptable damage level were treated. By using this monitoring program we were able to reduce the number of trees treated from 100% of susceptible trees to less than 10%.

Several control measures compatible with the monitoring program were evaluated. Releases of a new strain of the egg parasitoid *Oomyzus gallerucae* were largely unsuccessful as the parasitoid does not appear to overwinter well in California. Foliar applications of *Bacillus thuringiensis* var. San Diego combined with horticultural oil have provided adequate control when applied twice per generation spaced one week apart. Systemic injections of Vivid (abermectin) and Imicide (imidacloprid) provide good control and are compatible with the monitoring program.

Resistance of Elms (*Ulmus* sp.) and Elm Hybrids to Elm Leaf Beetle (*Pyrrhalta luteola*) Under Field Conditions in East Central Arizona

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The elm leaf beetle (ELB), *Pyrrhalta luteola*, is an introduced insect that causes considerable defoliation of urban elms throughout their range in the US. Siberian elm (*Ulmus pumila*) is the most widely planted elm in the high elevation areas of Arizona and especially east central Arizona. Siberian elm is also highly susceptible to ELB, extensive defoliation and damage occur in Arizona each year.

A cooperative research program was initiated to field test the environmental tolerance and ELB resistance of 23 elm species or hybrids. Based on field screening trials from 1996 - 1999, several popular hybrids developed for resistance to Dutch elm disease, including 'Regal', 'Sapporo', 'New Horizon', and 'Homestead' are susceptible to ELB. *Ulmus parvifolia*, *U. japonica*, *U. wilsoniana*, and hybrids including these parents were generally resistant to ELB. Continued testing of these 23 genotypes should allow for the selection of elms that best optimize environmental tolerance and ELB resistance. This work will provide more elm planting options for a region in Arizona that is currently limited to the planting of the environmentally tolerant, but highly ELB susceptible,
Siberian elm.

Pupal Diapause of *Coloradia pandora*: Thermal Constraints on Successful Pupation

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The pupal phase of the pandora moth generally lasts 12 to 13 months (from June through July the following summer in central Oregon) of a 2-year life cycle. Pupae overwinter under approximately 6 cm of soil. For the purpose of rearing adults in the lab, we were interested in minimizing the duration of the pupal phase. To determine the minimum length of cold storage required to break diapause, we held pupae at 5 ^{o}C for 8 to 24 weeks, then incubated them at 25 ^{o}C and measured the time until adults emerged. Incubation time declined linearly with increasing time in cold storage: for each additional week at 5 ^{o}C, incubation time decreased by 3 days. Thus, more time in cold storage increased the overall duration of the pupal phase. Emergence rates formed a classic bell curve over time in cold storage with a threshold between 8 and 12 weeks, and a maximum (87.5%) between 14 and 18 weeks. Cold storage in excess of 20 weeks limited successful pupation to <40%.

Extended or prolonged diapause (beyond 1 year) has been reported to occur in <5% up to a substantial proportion of pandora populations. To better quantify the extent of pupal diapause in central Oregon pandora moths, we tracked emergence over 3 years for a sample population of 1000 pupae in field enclosures. Seventy-two percent emerged after one year, but only 0.6% successfully prolonged diapause through a second year. We also monitored soil temperature at pupal depth and found it fell at or below 5 ^{o}C for ≥21.7, 22.9 and 25.1 weeks over the 3 consecutive winters. Based on results from the cold storage experiment, the 72% emergence rate for Year 1 was higher than expected for ≥21.7 weeks of soil temperatures ≤5 ^{o}C. However, the soil temperature profiles indicated that pupae used in the cold storage experiment probably were exposed to several weeks of cold in the field prior to collection. In this case, emergence rates in the lab and field experiments would correspond. Below the soil surface, pandora pupae are buffered from extreme cold temperatures (the lowest temperature recorded over 3 years was –2 ^{o}C). However, pupae remain vulnerable to winter mortality caused by extended duration of cold. Based on the bell curve of emergence rates, less than 40% of pupae in their first year of diapause would be expected to survive a winter such as Year 3 with 25.1 weeks of soil temperatures at or below 5 ^{o}C. The difference between 72% and <40% successful pupation is large, suggesting that duration of cold during the pupal phase is a variable, but potentially significant, mortality factor for pandora moths in central Oregon.

North American Forest Insect Work Conference 2001

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(Abstract not available)

Scolytidae and Associated Insects in Ponderosa Pine Stands Under Different Structural Conditions in Northern Arizona

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The objective of this study was to explore the association between the structure of ponderosa pine (*Pinus ponderosa* Dougl. ex Lawson) forests of the Coconino Plateau in northern Arizona and the diversity of Scolytidae and other important bark inhabiting insects. Although many dense stands with unhealthy conditions occur in this area, no significant bark beetle outbreaks have occurred for several decades. Four stand conditions were evaluated: 1) Dense stands with no management during the past 20-30 years, 2) Thinned mature even-age stands with >30% of basal area (BA) removed between 1987-94, 3) Thinned mature even age stands with >30% of BA area removed by thinning with a prescribed burn 3 to 4 years after thinning, and 4) Formerly dense stands with no management which had been burned by stand replacing wildfires with >90% of BA removed by fire. Bark beetles and associated insects were sampled with Lindgren funnel traps baited with attractants (1998-1999). *Dendroctonus frontalis* and *D. brevicomis* were found in this study; however, population levels of this species seem to be insufficient to cause outbreaks. *D. valens* and *D. approximatus* were present in low levels in all stand types as well as *Ips pini*. Wood borers (Coleoptera: Cerambycidae) were more abundant in unmanaged and thinned only stands. Several insect predators were well represented in all stands. Our preliminary results indicate a low diversity of bark inhabiting insects and suggest either: lack of suitable hosts or high efficiency of natural enemies. The lack of bark beetle attacks on

susceptible stands could mean tree stagnation, interruption of natural disturbances, and poor habitat diversity.

Ground Beetle Community Structure as Indicator of Forest Health in *P. ponderosa* and *P. hartwegii* stands

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(Abstract not available)

Monitoring Wood Imports and High-Risk Sites for Exotic Pests

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(Abstract not available)

Photographs

Photo 1. L to R. Front: Bruce Thompson, Bruce Hostetler, Kevin Dodds, Kathy Sheehan, Dave Wood. Rear: Jon Bell, Kathleen Johnson, Ken Gibson, David Beckman, Carol Randall, Gary Daterman.

Photo 2. L to R. Front: Kristen Baker, Diana Six, Mike Wagner, Steve Seybold, Terry Rogers. Rear: Sandy Kegley, Steve Kohler, Eric Smith, Les Koch, John Dale.

Photo 3. L to R. Front: Darrell Ross, Peter Katinic, Peter DeGroot, Jeremy Allison, Barbara Kukan. Rear: Chris Hanlon, Tim Paine, Nancy Rappaport, John McLean, Dean Morewood, Lorraine MacLauchlan.

Photo 4. L to R. Front: Jim Hadfield, Mike Johnson, Iral Ragenovich, Hugh Barclay, Yuri Baranchikov. Rear: Imre Otvos, Don Scott, Everett Isaac, Bernie Ryan, Carroll Williams, Andrew Storer.

Photo 5. L to R. Front: Bob Setter, Keith Deglow, Roy Mask, Brett Schaerer, Ann Lynch. Rear: Tim McConnell, Terry Shore, Hideji Ono, Andy Eglitis, Don Goheen, Dave Schultz.

Photo 6. L to R. Front: Roger Burnside, Doug Wulff, Nicole Jeans-Williams, Cindy Broberg, Skeeter Werner. Rear: Mary Ellen Dix, Jack Stein, Mark Schultz, Ladd Livingston, Jennifer Burleigh.

Photo 7. L to R. Front: Alan Mudge, Karl Puls, Guillermo Sanchez-Martinez, Jaime Villa-Castillo, Boyd Wickman. Rear: Sunil Ranasinghe, Darek Czokajlo, Kathy Bleiker, Jim Hanula, Peter Hall, Temple Bowen.

Photo 8. L to R. Front: Steve Cook, Jan Volney, John Spence, Jesse Logan. Rear: David Wakarchuk, Barbara Bentz, Liz Hebertson, Jim Vandygriff.

Photo 9. L to R. Front: Maureen Duane, Joel McMillin, John Borden, Kurt Allen. Rear: René Alfaro, Paul Bosu, Tom Eager.

Photo 10. L to R. Manny, Moe and Jack. Otherwise known as John Wenz, Bill Schaupp, and Don Dahlsten.

Photo 11. Members of the special subcommittee, "Building Friendships Across Borders" – L to R. Don Dahlsten (U.S. representative) and Les Safranyik (Canadian representative).

List of Registered Attendees

The information on the following pages was taken from the registration forms completed by the attendees at the conference with a few exceptions. In several cases, registration forms were not filled out completely, so information is missing or was obtained from websites. In several cases, attendees provided updated information after the conference. No attempt was made to verify all of the contact information prior to printing the proceedings. Undoubtedly, some of the information has changed. In particular, soon after the conference, most USDA Forest Service employee email addresses changed to: (initial letter of first name)(lastname)@fs.fed.us. For example, Jane Doe's email would be: jdoe@fs.fed.us. This may not be true for all Forest Service employees. In most cases, current contact information for an attendee can be obtained by connecting to the website for the organization where that person is employed.

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