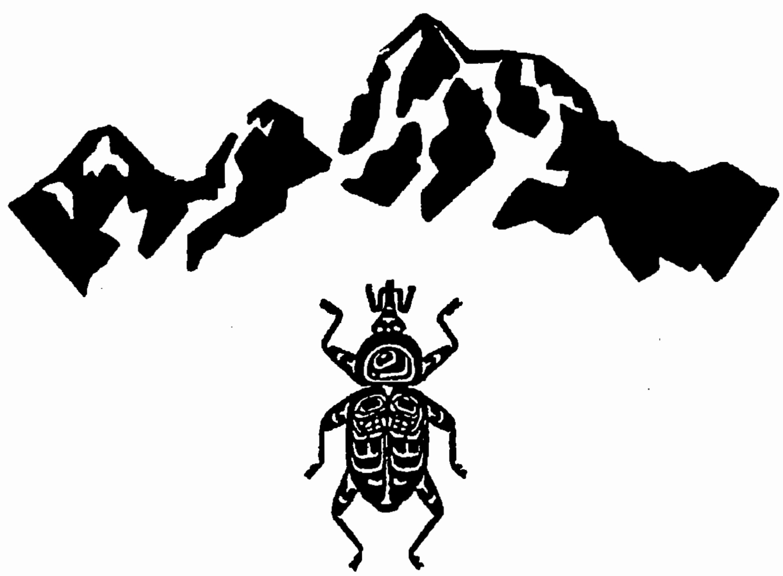
Proceedings

of the

49th Annual

Western Forest Insect

Work Conference



Jackson, Wyoming

March 2–5, 1998

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Acknowledgments

We are pleased to provide this copy of the 1998 Western Forest Insect Work Conference proceedings. These manuscripts and workshop summaries provide a valuable, current state-of-the-art for forest entomology in the western United States. The broad view of forest entomology presented in these proceedings was by design, with representation on the Program Committee by all major participatory groups in Forest Entomology.

As in past volumes of these proceedings, submissions were not edited. They appear as submitted by the author; however, all submissions were imported to a common word processor.

The Program Committee appreciates and thanks the contributors to these proceedings. We also thank Louise Kingsbury, and her staff at the Publishing Services office, Rocky Mountain Research Station, for compilation of these proceedings.

Program Committee:
Steve Burke (Industry)
Ladd Livingston (State Forestry)
Jesse Logan (Chairman, USDA Forest Service, Research)
Steve Munson (USDA Forest Service, Forest Health Protection)
Timothy Paine (University)

Contents

Executive Meeting 1
Initial Business Meeting 1
Report of the WFIWC History Committee
April 1997–March 1998 2
Opening Comments and Welcome 3
The Changing Perception of Forest Health 4
Salvage Marking Criteria 6
The Yellowstone Fires 9
Fire Disturbance and Associated Impacts on Forest Values:
Some Implications of Fire Exclusion 11
Fire and Insect Interactions 13
Forest Insects and Global Change 17
New Concepts in Host and Non-Host Volatiles 17
Ethical Dilemmas in Forest Insect Management 18
Insects as Agents of Ecosystem Change 20
Assessing Bark Beetle Attack Effects on Forest Structure in Nevado de Colima
National Park, Mexico 20
Role of Insects and Disturbance in Boreal Forests: Spruce Beetle 21
Disturbance Effects on Soil Arthropods 24
The Role of Disturbance in the Determination of
Vegetative Patterns and Dynamics in Intermountain
Spruce-Fir Forests 25
Impact of Insect Infestations on Recreation 26
Insect Impacts on Wildlife and Recreation Values: Forest Management
for the Northern Goshawk 26
Review of Published Studies Involving Forest Management and Insect Impacts 28
Geographic and Genetic Variation in Insect Populations 28
Using Mycangial Fungi as Indicators of Bark Beetle Population Isolation 29
Variability Between Florida and Louisiana Isolates of a Mycangial Fungus of the
Southern Pine Beetle 29
Geographic Variation in Chemical and Morphological Characters of the
Pine Engraver, *Ips pini* (Say) (Coleoptera: Scolytidae) 30
Reproductive Success of *Pissodes strobi* as a Function of Mate Sex Ratio 31
Student Reports 31
Forest Insect Pest Incidence Report for 1997 33
Beyond Forest Pest Management 39
The Evolving Concept of "Multiple Use" 40
The Transformational Nature of Cultural Values 41
Landscape Strategies to Mitigate Insect Impacts 45
Biological Control: Risks and Benefits 46
Pheromone Implementation: Why it Works and Why it Doesn't 47
Association of Pitch-Eating and Pales Weevils with *Leptographium* spp. in
Loblolly and Longleaf Pine 50
Augmentative Biological Control of Southern Pine Beetle 51
Estimating Extent of Mortality Associated with the Douglas-fir Beetle in Central and Northern Rockies 51
Stand Hazard Rating for Central Idaho Forests 52
Advances in Risk Rating for Spruce Beetle 53
Rating Risk of Mountain Pine Beetle Attack in Ponderosa Pine 54
Posters 55
Assessing Risk for Introduced Insects: Political Imperative or Biological Reality? 58

Invasive Pests: Threats to Forest Biodiversity, Management and Commerce 59
Pest Priorities or Top Ten Pests 59
Assessing Pest Risk from Importation of Wood Products into the United States 60
Assessing Risk for Introduced Insects: Political Imperative or Biological Reality?
Interceptions and Establishments of Non-indigenous Bark- and Wood-boring Beetles in British Columbia 66
Forest Pest Management and the Urban-Forest Interface 71
The Pitch Canker Task Force 71
Mountain Pine Beetle in Colorado's Vail Valley: Lessons Learned in the Wildland-Urban Interface 72
History Workshop: Glimpses of the Past—Remembering and Preserving Them 74
Biological Control of Exotic Forest Weeds 75
Increasing Public Awareness and Support of Forest Entomology 76
Re-evaluation of Techniques and Policies 79
Special Technology Development Program 79
Aerial Surveys 80
Use of Bark Beetle Pheromones in British Columbia 81
Pine Slash Treatments and Susceptibility to Attack by *Ips Paraconfusus* 81
Monocultures, Exotic Tree Species and Bioengineering: Impacts on Insects, the Environment, and Management Practices 82
Farming Poplar in the Oregon Desert 82
Fiber Farming and Pest Management Opportunities in the South 83
Bioengineering of Plant Defense Responses 84
Are Monocultures of Exotic Tree Species More Susceptible to Pest Outbreaks? 84
Pests Associated with Exotic Monocultures of Monterey Pine in Chile 85
Pinyon Insects Workshop 85
Research Summaries 88
Recent Activities in Regeneration and Seed and Cone Insect Management 89
Attendees 93
Attendees' Address List 97

49th Western Forest Insect Work Conference

Jackson, Wyoming
March, 1998

SUNDAY

5:00 - 7:00 pm	Registration	*Lobby*

MONDAY

8:00 - 11:00 am	Registration	*Lobby*
2:00 - 7:00 pm	Registration	
9:45 am - 4:00 pm	**Field Trip 1** - Teton Wildlife and Teton Science School *Ryland Gardner, Teton Science School* Meet in Main Lobby at 9:45 am (lunch provided)	
7:30 am - 4:00 pm	**Field Trip 2** - Alpine Ski Naturalist Tour, Jackson Ski Area *Jim Ozenberger, Forest Ecologist, Bridger-Teton National Forest* Meet in Main Lobby at 7:30 am (lunch on your own)	
8:30 am - 3:00 pm	**Field Trip 3** - Nordic Ski Tour, Teton National Park *Adrin Villaruz, Wildlife Biologist, Bridger-Teton National Forest* Meet in Main Lobby at 8:30 am (bring plenty of food and water)	
5:00 - 7:00 pm	**Executive Meeting**	*Summit I*
7:00 - 9:30 pm	**No-Host Mixer** *Jackson Room, Wort Hotel, 50 N. Glenwood Downtown Jackson*	

TUESDAY

7:30 - 11:00 am	Registration	*Lobby*
1:00 - 3:30 pm	Registration	
8:00 - 9:20 am	**Initial Business Meeting**	*Grand*
9:20 - 9:30 am	**Welcome To Jackson** *Tom Puchlerz, Forest Supervisor, Bridger-Teton, National Forest*	*Grand*
9:30 - 10:00 am	**The Changing Perception of Forest Health** *Ann Bartuska, Director, Forest Health Protection, WO*	*Grand*
10:00 - 10:30 am	Break	*Mezzanine*
10:30 am - 12:00 pm	***Panel*: Fire Disturbance and Associated Impacts on Forest Values** Moderator: Ladd Livingston, Idaho Department of Lands Don Despain, Montana State University Julie Weatherby, Forest Health Protection, Boise, ID Steve Arno, Forest Service Research, Missoula, MT Kevin Ryan, Forest Service Research, Missoula, MT	*Grand*
12:00 - 1:30 pm	**Lunch**	

Tuesday (cont.)

1:30 - 3:00 pm	*Concurrent Workshops*	
	Forest Insects and Global Change Moderator: Ann Lynch, Forest Service Research, Flagstaff, AZ	*Timberline III*
	New Concepts in Host and Non-Host Volatiles Moderator: John Borden, Simon Fraser University, BC	*Teton*
	Ethical Conflicts with New Technology Moderator: Iral Ragenovich, Forest Health Protection, Portland, OR	*Timberline I*
	Insects as Agents of Change in Forest Ecosystems Moderator: Tim Schowalter, Oregon State University	*Rafferty's*
3:00 - 3:30 pm	Break	*Mezzanine*
3:30 - 5:00 pm	*Concurrent Workshops*	
	Insect Impacts on Wildlife and Recreation Values Moderator: Dayle Bennett, Forest Health Protection, Boise, ID	*Timberline III*
	Geographic and Genetic Variation in Insect Populations Moderator: Diana Six, University of Montana	*Rafferty's*
	Student Presentations Moderator: Darrell Ross, Oregon State University	*Timberline I*
	Significant Pest Incident Reports: Hot Topics on Big Bugs Moderator: Steve Burk, Phero Tech Inc., BC	*Teton*
7:30 -9:00 pm	State Forest Entomologists Meeting	*Timberline III*

WEDNESDAY

8:30 - 10:00 am	**Panel: Changing Human Perception of Forest Values: Implications for Forest Entomology** Moderator: Jesse Logan, Forest Service Research, Logan, UT Tim Paine, University of California, Riverside Dave Iverson, Economist, Region 4, Forest Service, Ogden, UT	*Grand*
10:00 - 10:30 am	Break	*Mezzanine*
10:30 am - 12:00 pm	*Concurrent Workshops*	
	Landscape Strategies to Mitigate Insect Impacts Moderator: Darrell Ross, Oregon State University	*Timberline I*
	Biological Control: Risks and Benefits Moderator: Don Dahlsten, University of California, Berkeley	*Rafferty's*
	Pheromone Implementation: Why it Works & Why it Doesn't Moderator: Steven Seybold, University of Nevada, Reno	*Teton*
	Advances in Risk Rating Systems Moderator: Tom Eager, Forest Health Protection, Gunnison, CO	*Timberline III*
12:00 - 12:30 pm	***Photo Session***	
12:00 - 1:30 pm	**Lunch**	

Wednesday (cont.)

1:30 - 7:00 pm	**Poster Displays**	*Mezzanine*
1:30 - 3:00 pm	**Panel: Assessing Risk for Introduced Insects: Political Imperative or Biological Reality?** Moderator: Dawn Hansen, Forest Health Protection, Ogden, UT Vic Mastro, Methods Development Center, APHIS, Otis, MA Bill Wallner, Forest Service Research, Hamden, CT Borys Tkacz, Forest Health Protection, Flagstaff, AZ Lee Humble, Forestry Canada, BC	*Grand*
3:00 - 3:30 pm	Break	*Mezzanine*
3:30 - 5:00 pm	*Concurrent Workshops*	
	Forest Pest Management and the Urban/Forest Interface Moderator: Dave Schultz, Forest Health Protection, CA	*Teton*
	Glimpses of the Past: Remembering and Preserving Them Moderator: Mal Furniss, University of Idaho, Retired	*Rafferty's*
	Biological Control of Exotic Weeds Moderator: George Markin, Forest Service Research, Bozeman, MT	*Timberline III*
	Increasing Public Awareness for the Need of a Scientific Based Management Moderator: Steve Burke, Phero Tech Inc., BC	*Timberline I*
5:00 - 5:30 pm	***Photo Session***	
6:00 - 7:00 pm	**No-Host Mixer and Poster Discussions** *Poster Authors will be Present*	*Mezzanine*
7:00 - 9:00 pm	**Banquet Dinner and Guest Speaker** **Yellowstone Ecosystem: Wildlife and Biopolitics** *Tom Segerstrom, Great Plains Wildlife Institute*	*Grand*

THURSDAY

8:30 - 10:00 am	**Final Business Meeting**	*Teton*
10:00 - 10:30 am	Break	*Mezzanine*
10:30 am - 12:00 pm	*Concurrent Workshops*	
	Re-Evaluation of Techniques and Policies Moderator, Sheri Smith, Forest Health Protection, CA	*Teton*
	Monocultures, Exotic Tree Species and Bio-engineering: Impacts on Insects Moderator, Ron Billings, Texas Forest Service	*Timberline I*
	Insects Associated with Pinyon & Juniper Moderator, Jill Wilson, Forest Health Protection, Flagstaff, AZ	*Rafferty's*
	Recent Advances in Regeneration and Seed & Cone Insects Moderator, Nancy Rappaport, Forest Service Research, CA	*Timberline III*
12:00 pm	**ADJOURN**	

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	5:00 - 7:00 pm	**Executive Meeting**
	7:00 - 9:30 pm	**No-Host Mixer**
TUESDAY		
	7:30 - 11:00 am	Registration
	1:00 - 3:30 pm	Registration
	8:00 - 9:20 am	**Initial Business Meeting**

Executive Meeting

Report not available.

Initial Business Meeting

Report not available.

Report of the WFIWC History Committee April 1997–March 1998

Jim Hall, Corvallis, OR — son of Ralph C. Hall (1899-1996) — has arranged with M. Furniss to transfer his father's records to the WFIWC holdings. Included is a 6-page biographical account by Tom T. Terrell, who was hired by Jim Evenden at the Coeur d'Alene Forest Insect Lab in 1926. Tom was one of three prominent western employees of the Bureau of Entomology who were not college trained, but who became classified as professional forest entomologists, on merit alone. His account was sought for use in the history workshop at this meeting.

M. Furniss recently visited Ron and Laurie Stark at Sandpoint, ID. Ron was the first chairman of the history committee after its formation at the Eugene meeting in 1984. He has begun writing his biography, which he intends to have "published" posthumously, in order that he may identify, with impunity, the personalities and characters portrayed during his positions at Calgary, University of California, University of Idaho, and the Douglas-fir tussock moth and spruce budworm R&D programs.

The biography by Furniss entitled: "**Walter J. Buckhorn, legendary forest entomologist, not of the classroom kind**," was determined (after 22 months) by the Oregon History Quarterly to be "much stronger as forest history than as cultural history or biology" (i.e. rejected), and will be resubmitted to another northwest outlet, such as "Columbia." Finding good outlets for such publications is a struggle. The American Entomologist is an outstanding exception, and we have learned that an article, by Gene Amman and Jesse Logan, entitled "Silvicultural control of mountain pine beetle: Prescriptions and the influence of microclimate" has just been accepted by that journal.

Boyd Wickman continued to utilize historical photos, maps and reports filed at Forestry Sciences Labs in La Grande, OR and Albany, CA to document effects of earlier outbreaks in those states. He has recently reviewed and provided photos for a MS thesis, "**A dendrochronological record of pandora moth outbreaks in central Oregon**," by James Speer, Laboratory of Tree Ring Research, U. Ariz. He is coauthor of a manuscript based on that study.

Boyd also deposited in the Oregon History Soc. a set of excellent 4x5 B&W photos of the Tillamook burn salvage logging activities, taken in 1938-39 by R. L. Furniss, while studying rate of decay of fire-killed Douglas-fir in relation to wood borer infestation.

Publications, such as those mentioned, emphasize the growing value of the old Bureau of Entomology files. The photo file, located at the Berkeley Forest Insect Laboratory at the time of our employment there, ca 1950, is now located at Albany, CA, and is the subject of a manuscript by us, entitled: "**Photographic images of forest insect investigations on the Pacific Slope, ca 1910-1953**." It has been sent to the American Entomologist. These photo files will be discussed by Boyd at the workshop on Wednesday afternoon.

In preparation for the history workshop at this meeting, M. Furniss sought 50 unpublished reports of the Coeur d'Alene Forest Insect Lab, dating from ca 1922, that relate to infestations and control projects in Yellowstone N.P. and environs. Most of these reports were located with the help of Larry Stipe and Carma Gilligan (Forest Service Region 1, Missoula), and by Dave Fellin (INT, retired), who has been very helpful in acquiring other important historical resources, as well. Additional reports were found in the PNW files at La Grande, OR, aided by Torgy Torgersen, who is also arranging to have 200 glass-plate negatives copied onto 35mm film for safekeeping. Your history committee hopes to photocopy these scarce, unpublished, reports for the WFIWC archives. Some of them were illustrated with maps and photos which will be displayed in the workshop.

We belatedly acknowledge acquisition of two important reports by Ed Holsten, Forest Service, R-10, Anchorage. One is titled: "**Spruce beetle activity in Alaska, 1920 - 1989**," the other is a **Bibliography of forest insect and disease reports and publications in Alaska, 1919 - 1994.**

Report submitted by M. M. Furniss and B. E. Wickman

9:20 - 9:30 am	**Welcome To Jackson**
	Opening Comments And Welcome **49Th Western Forest Insect Work Conference** **Jackson, Wyoming March 3, 1998**

Opening Comments and Welcome

Tom Puchlerz, Forest Supervisor Bridger-Teton National Forest

Good morning and welcome to Jackson Hole. I'd like to congratulate you on your choice of Jackson as a meeting place for the 49th Western Forest Insect Work Conference. I note by your agenda that some of you came in for registration on Sunday and some had the opportunity for field trips on the National Forest and in Grand Teton National Park yesterday. I trust that your field trips to the Teton Science School, Jackson Hole Ski Area and cross country skiing in Grand Teton National Park were enjoyable and stimulating to set the stage for your active agenda this week.

As you may have already noticed, Jackson Hole is a scenic place that has been frequented by travelers throughout its history. This was true of the summer visits by Native Americans, early fur trappers, ranchers and other early settlers beginning about 1880 or the more recent 3 million visitors that pass through the Valley annually. They are all seeking for a part of what Jackson Hole has to offer to them. We welcome you to do the same during your stay here with us.

In visiting with the coordinators of this conference the theme of collaboration and partnership is apparent. There are participants from Colleges, Universities, various Federal agencies, various State agencies as well as individuals from the private sector located in the United States and Canada.

As ecosystem health continues to be one of our agencies top priority/emphasis areas, the need for sharing of information and an ongoing dialogue/debate is extremely important. As each of you have travelled here be it by car or by aircraft you may have seen (despite the depth of snow that we have this year) the evidence of current and past insect activity throughout the Yellowstone Ecosystem. This observation could start by looking out of the windows of this room up onto the slopes of Snow King Mountain and to the east up the Cache Creek drainage where it is quite easy for you to see the dead Douglas-fir from Douglas-fir bark beetles. If you had looked at these hillsides in the summertime, during the decade of the 1980's, it would have been apparent to even the casual observer that Western Spruce Budworm defoliation was active with about 250,000 acres on the National Forest affected for several years. Those that visited the Jackson Hole Ski Area yesterday, may have been able to see some evidence of both Douglas-fir beetle mortality and mortality in subalpine fir that has accelerated greatly on the National Forest and other surrounding lands in the past few years.

On the Bridger Teton we have a long history of utilizing prescribed fire in the management of our Forested ecosytems and I am pleased to see time on your agenda for fire disturbance and its impacts on various Forest Values. Those that went on the tours yesterday to Grand Teton National Park and the Teton Science School were able to see the some results of wildfires close around the town of Jackson in the 1980's and 1990's. Insect infestations, particularly by the mountain pine beetle in lodgepole pine, helped set the stage for these fires that only awaited the climatic conditions conducive to larger burns. The impacts of forest insects on our forested ecosystems is readily apparent.

As throughout the Western United States, societal change makes our work more and more complex and no less divisive when we discuss management of our Forests. The Jackson Hole area is somewhat unique in that a large majority (over 90%) of the land area in Teton County is in public ownership. This has made private land at a premium. A characteristic of the changing face of Jackson Hole, is the increased construction of high value residences, many of which are adjacent to federal lands which have insect populations. This has caused concern from private landowners for the safety of their dwellings from dead trees and increased fire risk. It has also created a spin off industry for those that treat trees by various methods to protect highly valued landscape trees. Some of the new technologies, involving such things as trapping or pheromones could have direct application in this local environment.

Many of the issues that you will be discussing this week at your conference are important to those of us who are involved with land management. As we join together with our various partners in State and Federal Agencies, Colleges and Universities, along our collegues in the private sector, the impacts of insects on our forested environments can be more closely assessed, evaluated and action coordinated.

Have a good time in your sessions this week and I look forward to seeing good things come from your time together. Thank you for the opportunity to extend a hearty Jackson Hole welcome to you.

9:30 - 10:00 am **The Changing Perception of Forest Health**

The Changing Perception of Forest Health

Ann M. Bartuska
Director, Forest Health Protection
USDA Forest Service

There are two views of forest health as I see it from my position in Washington, DC. In Congress, we are hearing that "I don't want to hear about forest health any more". But there is also the view from the rest of the U.S., as gleaned from the press coverage where forest health continues to be reported on and discussed. This difference captures a real issue. Within the Beltway, the concept of forest health has become "politicized", first through the salvage rider and the fallout from that, then you have Babbitt's "burning the forest down" as he encourages the increased use of prescribed fire, and most recently the development and debate on Senator Craig's and Representative Smith's forest health bills. But among the broader public, forest health continues to be a readily understood concept. So how should WE, as forest health professionals, convey the issue?

In preparing for this meeting, I went back to the *Cooperative Forestry Assistance Act of 1978*, which authorizes Forest Health Protection. Section 8 begins:

> "(a) In General - The Secretary may protect trees and forests and wood products, stored wood, and wood in use directly on the National Forest System and, in cooperation with others, on the other lands in the United States, from natural and man-made causes, to —
>
> (1) enhance the growth and maintenance of trees and forests;
> (2) promote the stability of forest-related industries and employment associated therewith through the protection of forest resources;
> (3) aid in forest fire prevention and control;
> (4) conserve forest cover on watersheds, shelter belts, and windbreaks;
> (5) protect outdoor recreation opportunities and other forest resources; and
> (6) extend timber supplies by protecting wood products, stored wood and wood in use."

The good news is that the Act addresses trees and forests as a focal point for protection; the bad news is that it reflect a bias toward protecting the production of wood and wood products. There is no reference to the ecological components of ecosystems. Therefore, historically our Suppression activities have largely related to protection of trees and forests to ensure a timber supply. This view was mirrored in the initial focus of the Forest Health Monitoring where there was a recognized tree bias in the measurements used; this has changed in the last couple years.

Speed up a few years to the 1993 Strategic Plan - Healthy Forests for America's Forests, and the definition of forest health embedded in that plan.

> A desired stare of forest health is a condition where biotic and abiotic influences on the forest do not threaten resource management objectives now or in the future.

The definition takes a broad look at forest health and addresses changing ecological condition. There is a clear recognition of <u>broad scale disturbance</u> as part of a functioning ecosystem. However, there is also a clear tie to <u>management objective</u>. This definition was attacked in some press coverage on forest health in 1994, and again in 1996, as putting timber production above all other uses.

The 1994 wildfires brought an incredible amount of attention to forest health as an ecological condition, effectively an integrator of multiple ecosystem components — absence of fire, altered stand structure and composition, susceptibility to stress, and an increased probability of insect and disease activIty. There was also the increased recognition of the threat of <u>non-native invasive weeds</u> to all ecosystems, not just rangelands. For a brief period, forest health was recognized in it's broadest sense, both in Washington, D.C. and in the rest of the U.S. Even so, many argued that forest health was not consistent with ecosystem management— what about rangeland ecosystems? riparian areas? fisheries? Good comments all! If we are concerned about ecosystems, how can we then divide up these ecosystems. I argued then - and now - that forest health, even forest ecosystem health, is a more readily understood concept by the broader public then ecosystem health alone. BUT we must continue to emphasize that forest health is more than just tree health. The team that worked to develop a forest health policy in 1995/96 captured this perspective in their definition:

> "A healthy forest is one that maintains the function, diversity, and resiliency of it's components at a landscape scale."

There was an attempt to disconnect forest health from manager's objectives, to emphasize the fundamental ecological functions of ecosystems. At the same time, the linkage to management objectives may best be captured by former Chief Jack Ward Thomas, who frequently asked "healthy enough for what?" The increasing tension between an ecologically driven concept vs a use-driven concept was crystallized by the effects of the salvage rider in 1996. The level of acrimony and rhetoric against FS management, both inside and outside government, reached an incredible level. Based on the results of the interagency salvage review, it was clear that some forests did go beyond the intent of the legislation and used forest health as the reason to cut a lot of green trees. The phrase "forest health" really got a black eye as a result. Working with other agencies at the Federal and state level, we have tried to move beyond the negativity engendered by the salvage rider to develop a definition and approach to forest health based on fundamental ecological principles..

So where are we now? Forest health as a concept is alive and well, but more than ever embedded in a broader ecosystem concept. Consider:

(1) NASF has just published their forest health policy, which considers ecologial conditions of forests and management objectives;
(2) The Santiago Agreement on Sustainable Forest Management, signed by the President in 1993, has given give a push for domestic application by the forestry community. Of the seven Criteria to be used to assess sustainability, Criteria 3 addresses *Maintenance of forest ecosystem health and vitality;*

(3) Chief Dombeck was given a charge by the Secretary of Agriculture to develop a Natural Resource Agenda. The Agenda integrates forest health issues into a broader watershed health approach, and goes on to say "...I believe our first priority must be to maintain and restore the health of our watersheds. " The agenda is strongly based on the work done in the defining and describing a forest health policy, begun in 1995. In fact, the agenda includes the following:

"Ecosystem health is a condition characterized at the landscape scale by ecological integrity - that is, the degree to which the ecosystem's components and their relationships are present, functioning, and capable of self renewal. Ecosystem health has two parts: (1) ecological integrity, which encompases the biophysical aspects of ecosystems, and (2) the needs and values of human."

We need to get on with taking action. I personally am tired of defining forest health and want us to get on to doing the job. We have the tools and we know the array of activities that managers have at their disposal to accomplish the job. The most difficult first step may be to prioritize where our energy is best placed. Forest health professionals are central to that effort.

Tuesday (cont.)

***Panel*: Fire Disturbance and Associated Impacts on Forest Values**
Moderator: Ladd Livingston, Idaho Department of Lands

Salvage Marking Criteria

Julie Weatherby, Forest Health Protection, USDA Forest Service

Thank you for inviting me to share some of the work that the Boise Field Office of Forest Health Protection (USDA-FS) has been doing concerning tree survival after wildfires. We first started looking seriously at fire damage and its relationship to subsequent beetle attacks and tree survival in 1989 after the Lowman Fire on the Boise National Forest. This fire burned in ponderosa pine and xeric Douglas-fir habitat types. We installed plots and monitored survival for 5-years post fire. Our results indicated that ponderosa pine trees with less than 25 percent green crown were likely to die as a result of fire damage. This criterion is well supported in the literature (Fischer 1980, Herman 1954, Lynch 1959, Salman 1933, Weatherby et al. 1994).

Douglas-fir beetle was by far our most frequently encountered bark beetle in damaged trees within the Lowman Fire boundary. In addition most of the Douglas-fir beetle activity was noted in large diameter Douglas-fir trees which were predicted to survive the fire based upon the 25 percent green crown criterion.

When the Payette National Forest experienced their wildfires in 1994 I was asked to help Forest personnel develop salvage criteria for trees which were likely to die during a 5-year period after the fire. We wanted to incorporate the observations from the Lowman Fire and from field personnel who had considerable experience with fires in similar habitat types. Frequent observations and comments were: 1) If we use the less than 25 percent green crown criterion as our indicator of predicted mortality, we under estimate Douglas-fir tree mortality; 2) Douglas-fir beetle frequently moves into fire scorched trees; 3) Dead cambial quadrants may be a better indicator of Douglas-fir death (Ryan et al. 1988); 4) There is very little data from wetter Douglas-fir and grand fir habitat types. Working together we developed salvage marking criteria which attempted to incorporate these types of observations. We decided to do this in the form of a dichotomous key for each species (Figure 1).

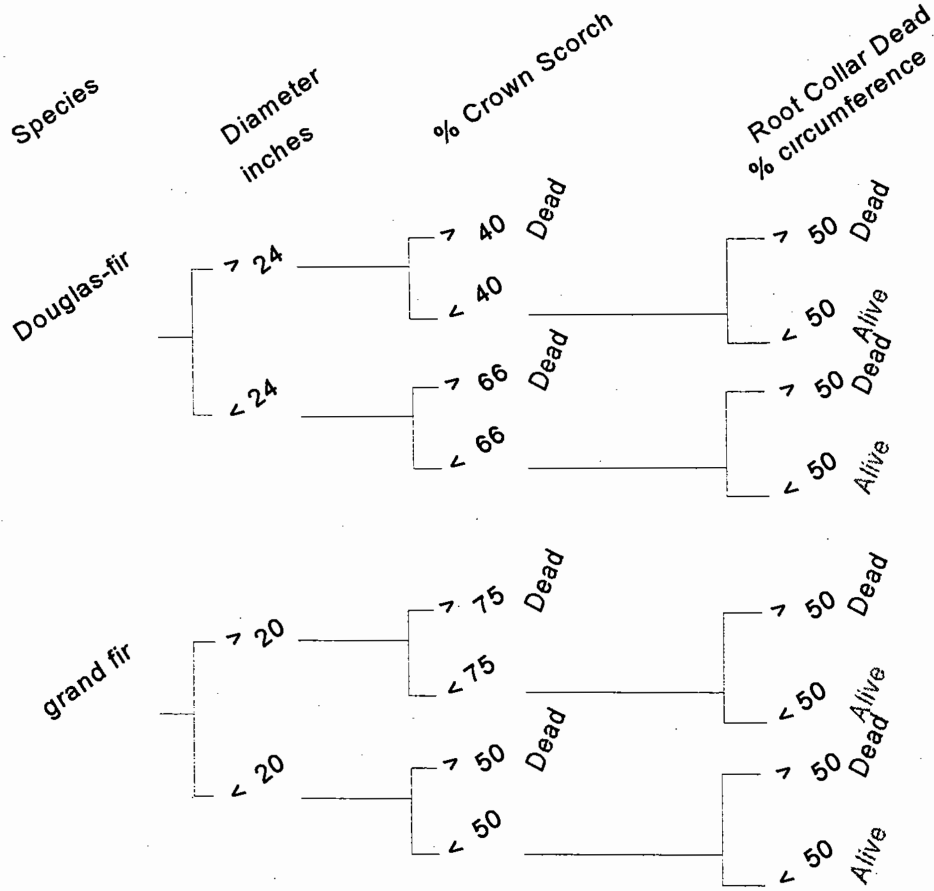

Figure 1—Salvage marking criteria used during salvage operations after the 1994 wildfires on the Payette National Forest.

After we had developed our salvage marking criteria, we installed some 5-year survival plots to monitor how well these guidelines predicted the actual survival in the field. We worked in Douglas-fir and grand fir habitat types. For the most part the Douglas-fir and grand fir types were wetter habitat types and probably had more developed litter and duff layers which might make a difference in terms of root collar damage. We monitored individual trees; and in addition to recording species, DBH and vigor, we took ocular estimates of percent crown scorch, increment cores from all 4 quadrants of the root collar and increment cores from all 4 quadrants of the trees at DBH. We attempted to determine if the cambium was dead or alive, which in some cases even 1 year after the fire was difficult to tell. We revisited these trees in 1996 and 1997 and we will continue this study through 1999. We are following 119 grand fir trees and 259 Douglas-fir trees within areas which were underburned by the 1994 wildfire. As of 1997, 35 grand fir trees and 59 Douglas-fir trees have died.

Thirty eight percent of the grand fir trees predicted to die using our salvage criteria have died as of August 1997. We expect some additional mortality in 1998 and 1999 but mortality rates should start to decline. Little information is available in the literature to indicate the relationship between fire damage and death of grand fir trees. Scott, Szymoniak and Rockwell (1996) state that "when true firs incur root damage from smoldering duff... or by long-duration burning of large woody fuels over root systems, yet show little or no sign of bole or crown injuries (although the phloem has dried out), they may still have functioning xylem taking water to the crown, but non-functioning phloem, thereby preventing the return of carbohydrate to the lower bole and roots. Oftentimes the blackened ring around the base of the tree has resulted in complete girdling of the phloem of the tree or killing of the cambium all around the bole at this location. Trees injured in this manner, though they may appear to be alive with green crowns, are unable to make needed repairs to root tissues damaged by fire and eventually succumb to these injuries."

Mortality attributed to wildfire can be directly caused by fire damage or indirectly caused by other disturbance agents such as bark beetles. Fir engraver beetle (*Scolytus ventralis*) is active in our plots. This beetle is one of the least aggressive bark beetles and frequently continues to re-attack grand fir trees until the trees finally die.

Thirty two percent of the Douglas-fir trees predicted to die using our salvage criteria have died as of August 1997. Douglas-fir beetle has been very active in these plots. Thirty three of the 59 Douglas-fir trees which died were infested by Douglas-fir beetle which attacked fire injured trees in 1996 resulting in tree mortality in 1997. An additional 9 trees are currently attacked and will die by our 1998 visit. The ratio of 1996 attacks to 1997 attacks (33:9) suggests that the beetle pressure may be declining.

Three years after the fire, 53 percent of the 259 Douglas-fir trees were classified correctly as either alive or dead using the sampling methods described previously and the salvage marking criteria. Likewise, 51 percent of the 119 grand fir trees were classified correctly. If we use the same DBH breaks, the same percent crown scorch breaks but change the percent circumference of dead root collar (>=50%) to the percent of circumference of dead root collar (>=50) plus the % of circumference for dead cambium at DBH (>=50), we improve the classification accuracy to 76 percent for Douglas-fir and 73 percent for grand fir. In may opinion 50 percent classification accuracy is not very good but 70+ percent is probably about as good as we can hope for considering the complexity of the system.

One of the greatest sources of error is our inability to accurately estimate in the field the amount of root collar mortality without destructively sampling a tree. We have not been successful at estimating percent of the circumference with cambial mortality from a subjective estimate of bark charring; nor have we been very successful at estimating percent of the circumference with cambial mortality by taking one core per quadrant and determining if the cambium of that core is dead or alive. When we required that 50 percent of the circumference of both the root collar and the DBH had to be dead we improved the accuracy to what I believe is an acceptable level. This predictive improvement probably occurred because trees with both root collar damage and bole damage sustained a much higher level of damage than trees which only had root collar damage. We will continue to monitor these trees and hopefully use this information to improve future salvage criteria.

In summary, I would like to make one more plea that we move away from salvage sales based solely on individual tree predictions which are very difficult at best; and move more to stand salvage prescriptions. If our predictive criteria indicate that the stand has been significantly impacted by a disturbance like wildfire then write a prescription which is best for the stand. These prescriptions may involve leaving dead trees to ameliorate the site or maybe removing dead and green shade tolerate species in order to encourage regeneration of fire resistance seral species like larch and ponderosa pine.

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The Yellowstone Fires

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The fire season of 1988 will be remembered by many as the year Yellowstone burned. During that summer many were decrying the destruction of this famous national treasure. Predictions were common in the news media that the park would be desolate for tens if not hundreds of years because of the intensity and size of the many fires that raced across the landscape from late July until snows came in early November. Burned vegetation and soil litter and duff covered hundreds of thousands of acres and were often ten to twenty miles across. Some observers at the time predicted that several years or decades would be required for plants to migrate from the remaining unburned areas back into the centers of the burned areas. Ten years later the effects of those fires can be readily observed and the predictions evaluated.

Fire burns in a variety of ways and intensities. It is an interaction between ignitions, fuels and weather. Natural ignitions come from lightning strikes but only a few strikes have the correct characteristics to ignite the fuels available. Over two thousand strikes have been recorded in a single day in Yellowstone. The most common process by which lightning initiates a fire begins when the strike hits an old spruce (*Picea engelmannii* Parry) or fir (*Abies lasiocarpa* (Hook.) Nutt.) with accumulated lichens (mostly *Bryoria spp.*) in the crown. The lichens provide the very fine fuel that can ignite during the brief duration of the strike. This sustains flames long enough to ignite the needles of the trees. As the crown burns, numerous bits of burning lichen and small dead twigs fall to the ground as firebrands. If the firebrands land on dry fuels, they will ignite a fire that can burn long enough to find suitable surface fuels and can develop into a forest fire. There has not been a year without lightning caused fires in Yellowstone since 1930 when good fire record keeping began. The number of lightning caused fires ranges from 2 to 53 per year, averaging about 17 fires per year,

Forest fires will only develop when fuels are available, dry and properly distributed. In Yellowstone, plant succession creates the fuels. Dense shade under lodgepole pine (*Pinus contorta* Dougal.) keeps most other plants from growing during the first 100 to 200 years after the canopy closes. Surface fuels are largely limited to 1 to 3 cm. of accumulated needles on the forest floor and infrequent dead and down trees. When firebrands fall into these fuels, any fires that develop burn very slowly and do not produce sufficient heat to involve tree crowns. This type of fire is common in the park but does not account for a significant portion of the burned acreage in most fire years. These types of fires create mosaic stands of lodgepole pine comprised of two or sometimes three age classes.

When the older lodgepoles start to die allowing more light to reach the forest floor and soils will support spruce and fir seedlings, enough fuels accumulate to generate crown fires. This usually occurs about 200 to 300 years after the last fire. Firebrands drop out of the column of smoke and hot gases into surrounding fuels and the fire increases rapidly in size. Winds tip the smoke column causing the firebrands to fall further downwind. Fires originating from these firebrands have been recorded as much as a mile downwind, but distances of one-fourth to one half mile are more common. Spread rates of 2 to 5 miles per hour are common under these conditions. Obviously these fires account for most of the acreage burned in Yellowstone. Once a fire has covered 50 to 100 acres, it has encountered enough rotten logs and deep organic material that the fire can override the light rains of summer thunderstorms. Only the top of these fuels gets wet while the fire continues to smolder in the bottom. When the fuels dry out the fire can develop into a crown fire again.

When crown fires in older stands meet the younger stands, they usually stop after burning only a short distance into the younger stands. Firebrands falling into the younger stands burn patches in the needle mat and scorch or burn trees above larger fuel accumulations. Crown fires can only propagate in the crowns alone as long as wind tips the flames into new crowns or slopes place crowns in the path of the flames. This requires steady high winds, usually over 12 mph. When this occurs the forest floor is showered with firebrands and it also burns.

If fuels are of sufficient quantity and in the proper arrangement, fire development will not occur until weather conditions are right. Ignitions do not develop into fires under normal weather conditions in Yellowstone. It takes long drought periods to dry out the fuels enough that dead fuels will sustain burning. It takes even longer to dry out the soil moisture so that live plants can sustain fires. This results in large fires burning only during drought years and only later in the summer. Since 1972, when fires were first allowed to burn in the park, 80% of the fires have gone out before they burned one acre. Before 1988, the most acreage burned in one year was about 20,000 acres in 1981 and 18,000 acres in 1931.

The winter of 1987-88 was drier than normal, but spring precipitation was much wetter than normal. However, the rains stopped in mid-June and no rain fell until late August, which was not enough to make a significant impact on the fires. The dry winter may have contributed to soil moisture dropping below critical values early in the burning season. Lightning fires began to occur in late June and early July. The fire season was progressing very similar to the 1981 season. By July 21, approximately 17,000 acres had burned. Normal summer cold fronts continued to cross the area but no rain resulted from them. However, the winds accompanying them were stronger and lasted longer than usual. Between July 27 and September 15, 75% of the days had steady winds over 12 mph and during 10 days steady winds rose above 20 mph. Gusts over 60 mph were recorded. On September 9, over 220,000 acres burned and on each of three other days more than 100,000 acres burned. During this time period fires also spread rapidly on many nights when relative humidity did not rise enough to slow the fires. By mid-September the days were getting cool and short enough that the fires had little time to burn. About 20,000 acres burned between then and early November when snow fell and the fires were finally out. In total, approximately 1,600,000 acres burned in the Greater Yellowstone area with about 794,000 acres in Yellowstone National Park.

The fire behavior and changing weather produced a mosaic pattern on the landscape. Within Yellowstone, 41% of the fire was canopy burn where all the needles and forest floor organic matter were consumed. About 35% was mixed burn where the needles of some trees were consumed, others only scorched and the forest floor was burned in patches. The remaining area was a mixture of nonforest burn and an estimate for places where some of the forest floor burned but none of the trees were killed by the fire.

New growth began in the wet areas almost as soon as the ground cooled off. New growth began in the rest of the burned area the following spring, after the melting snow had moistened the soil. Killing temperatures did not go deeper than about 1-3 cm. into the soil in most of the area. Below that level there were many seeds, root crowns, tubers and rhizomes that quickly produced new plants to cover the ground. Lodgepole pine seedlings began growing from seeds deposited on the soil from cones left in the trees. Trees with serotinous cones can release 20 to 30 years accumulation of seed while trees with nonserotinous cones only release one year's seed crop. Where serotinous coned trees were a major portion of the stand, the seedling density is about 600,000 per ha. Seedling densities are much lower where serotinous trees were rare in the forest. There are only two to five seedlings per acre where spruce and fir were dominant and lodgepole only scattered through the stand. The trees have continued to grow and many are now reaching five to six feet tall and are in a rapid growth phase during which they will increase about 30 cm. per year. Where soils are poor and dry, growth is not so fast.

Seeds of a few species require exposure to high temperatures before they germinate. Buckbrush (*Ceanothus velutinous* Dougl.) seeds germinated in several areas under former Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco.) forest. This browse species will provide winter forage for ungulates for several decades. Bicknell's geranium became a common sight for two years often in areas that had not burned in over 200 years. Then this biennial flower went back into the soil seedbank and is waiting for the next fire. Dragon's tongue (*Dracocephalum parviflorum* Nutt.) flowered for a few years and then joined the Bicknell's geranium.

Ten years after the fires the forest floor vegetation is growing as much as the soil moisture and increased nutrient supply will allow. Lodgepole pine and Douglas-fir forests are beginning their normal succession. This will eventually produce the old-growth forests that will again support the spectacular, high energy crown fires that burned in 1988, whenever the required weather conditions occur.

Fire Disturbance and Associated Impacts on Forest Values: Some Implications of Fire Exclusion

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Prior to the early 1900's, fires swept through the landscape of the inland West on an impressive scale. Among the different forest types, fires ranged from non-lethal underburns, to mixed-severity fires that killed some but not all trees, to high-intensity stand-replacing fires (Brown 1995). Fires of variable severity were a primary force shaping composition and structure of North American vegetation for thousands of years (Pinchot 1899, Pyne 1982, Agee 1993). Based on a detailed review of fire history information, Barrett and others (1997) estimate that in the interior northwestern United States an average of six million acres burned annually prior to 1900. Today, the combination of prescribed fire and wildfire covers only a small fraction of that historic fire acreage. Even the biggest wildfire years of this century (1910, 1919, 1988, 1994) burned no more than half of the historic average in the inland Northwest. Moreover, there are great differences between historic and modern fire regimes in terms of the characteristic severities of burning. These differences in extent and severity of fires have major implications for the role of forest insects and for maintaining forest values.

Let us look briefly at some of the differences between the historical and modern fire regimes. Barrett and others' (1997) concluded that about two-thirds of the historic burn acreage (about four million acres in an average year) occurred in sagebrush and bunchgrass vegetation types. Burns sweeping through sagebrush and grass covered intermountain valleys allowed fire to spread from one area of mountain forest to another. Today, the former expanses of sagebrush-grass fuels have been heavily altered and interrupted as a result of livestock grazing, cultivation, and various kinds of development. Thus, they no longer ensure rapid development of landscape-scale fires.

The second largest component of historic fire acreage in the northwest was in ponderosa pine forests, which burned at a rate of 1.2 million acres per year (estimated conservatively), mostly as low-intensity "underburns" (Agee 1993, Barrett and others 1997). Since the early 1900's, annual area burned in ponderosa pine, including both prescribed fire and wildfire, has been only a small fraction of the pre-1900 average. As a result, we have a shift from open-growing ponderosa pine forests maintained by frequent low-intensity fires to dense forests developing without frequent fires. During the last 20 years, severe wildfires have become increasingly common in ponderosa pine forests, occasionally burning hundreds of thousands of acres in a given year. Unlike historic fires, today's large wildfires are high-intensity, stand-replacing events (Williams 1995). These wildfires create large amounts of woody fuels (dead trees) and often give rise within 15 to 25 years to a dense stand of shrubs and saplings. The young stands, in turn, form fuelbeds conducive to burning in another high-intensity wildfire. Efforts by the USDA Forest Service and a few other land managers to return low-intensity fire on a large scale in ponderosa pine forests, though laudable, are hampered by major constraints such as high costs of application, briefness of suitable burning periods, related manpower shortages, need for prepatory thinning, and concerns about liability and smoke (Mutch 1997).

Fire history studies in a variety of moist forest types--including interior Douglas-fir/larch, lodgepole pine, and western redcedar/hemlock/white pine--reveal that variable levels of fire severity were common in many areas (Barrett and others 1991, Smith and Fischer 1997). Today, in contrast, fires of appreciable size occur only in large high-intensity fires which escape suppression efforts. In the post World War II period through the 1980's, large-scale clearcutting and other intensive harvesting and fuel reduction treatments were conducted on federal forest lands. In some ways these treatments partially substituted for the historic role of fire as a landscape scale disturbance. During the 1990's, however, and into the forseeable future, the extent of timber management on federal forest land has declined to become virtually insignificant as a substitute for historic fires.

It seems, then, that most national forests and other federal timberlands will continue to develop into dense stands of trees growing under increasing competitive stress. This generally suggests major opportunities for epidemics of insects and diseases. Although prescribed burning will, hopefully, increase, this is offset by reductions in timber management treatments compared with pre-1990 levels. A de facto policy of largely excluding fire will continue due to suppression of most natural fires and constraints on using prescribed fire and silvicultural treatments (Arno and Brown 1989, Agee 1993, Pyne 1982, Mutch 1997). The probable outcome will be a continuing replacement of historic low-severity and mixed-severity fire regimes by an expansion of the high-severity fire regime (Quigley and others 1996).

Much of the legislative and administrative guidance for management of national forests and other federal forestlands assumes that a semblance of natural forest communities will be maintained. Without enough prescribed fire and other suitable treatments to substitute for historic fires, such an ideal is not achievable. The result will in many cases be a great distortion of historic ecological conditions (Keane and others 1990, Botkin 1990, Quigley and others 1996, Hartwell 1997). Specifically, in many forest types this suggests prolonged site occupation by unusually dense stands of competitively stressed trees, with increasing abundance of shade-tolerant species. In the prolonged absence of fire, these dense stands will presumably become more susceptible to major outbreaks of pathogens and insects. Entomologists will keep busy!

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Fire and Insect Interactions

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Background:

Through out the West there is increasing concern about an apparent decline in forest health. Numerous severe wildfires in recent years have reduced large swaths of forests to charred spires. Insect and disease outbreaks have browned many hillsides. Forest scientists and managers understand the underlying processes causing these problems. In the case of fire it is the historic suppression of fire, the concomitant increase in fuels, periodic drought and urban intrusion. In the case of insects it is the increasing stand density, competition, and stress. However, concerned publics are less interested in causes than results. The majority of Americans want forests to continually look like "healthy" forests, not like stump fields, not like fields of blackened toothpicks, and not sickly brown. In trying to meld the ecologic, economic, and aesthetic forest managers face an *undaunting* task.

Recognition that fire played an important role in the development of many western forests, increasing loss of life and property, and the need to reduce fuels and catastrophic fires has led to a new Federal Fire Policy (U.S. Department of Interior and U.S. Department of Agriculture 1995). It is now proposed to expand prescribed burning seven-fold in western states. In many forests prescribed burning will, and should, kill some trees. These forests are overstocked and the trees are stressed by the intense competition. It is essential to remove some trees to reduce the potential for stand-destroying crown fire and to provide more growing space for residual trees. Some stands require mechanical thinning prior to burning because they cannot safely be burned in their present condition. Regardless of how good we get at prescribed burning a portion of the desired residual trees will die. Many of these are old and ill suited to withstand additional stress of fire injury. As trees die invariably one or more species of insects will attack. Managers often do not recognize this fact and rarely is the public informed of what to expect. If we reintroduce fire with the stated purpose of improving forest health and fail to inform the public to expect increases in insect activity we run the risk of destroying our credibility.

Fire and insect interactions are complex and poorly understood. In some cases the attacking insects may be no more than opportunists attacking a mortally injured tree. In other cases they will be the cause of death. With the new emphasis on forest health, ecosystem sustainability, restoring fire, and disturbance processes the need for increased understanding of fire and insect interactions is considerable. In an attempt to improve our knowledge of fire and insect interactions Gene Amman and his colleagues initiated two studies following the 1988 fires in the Greater Yellowstone Area (GYA). The objectives of this paper are to review the results of these studies, to make some general observations regarding fire injury and insect interactions; and to suggest some future research on fire and insect interactions.

Intensive Study:

In 1988 crown fires burned roughly 350,000 hectares in the GYA, while surface fires burned roughly 200,000 hectares (Greater Yellowstone Post-Fire Resource Assessment Committee, Burned Area Survey Team 1988). After the 1988 fires Gene Amman and I initiated an intensive study of infestation in relation to fire injury (Amman and Ryan 1991, Ryan and Amman 1994, 1996). The objectives of the study were to: determine the species of insects associated with varying degrees of fire injury and the way insect attack and tree survival changed over time. Twenty-four permanent plots were established in stands that had been burned by surface fires. In many plots the fire had not uniformly burned the surface and several trees were either only burned on a portion of their circumference or were unburned. Plots were in stands dominated either by lodgepole pine (*Pinus contorta*) or

Douglas-fir (*Pseudotsuga menziesii*) but contained an occasional Engelmann spruce (*Picea engelmannii*) or subalpine fir (*Abies lasiocarpa*). We determined the percent of crown scorched and the percent of the basal circumference killed by heating. We observed insect activity from 1989 through 1992 and classified insects according to whether or not they were primary or secondary bark beetles, wood borers, or other.

By August 1992, 79 percent of the 125 the Douglas-fir had been infested by one or more species of insects (primarily the Douglas-fir beetle) and 77 percent had died. Sixty-two percent of the 151 lodgepole pines had been attacked (primarily by the pine engraver) and 61 percent had died. In addition 94 percent of the 17 Engelmann spruce were infested (primarily by spruce beetle); and 71 percent of the 17 subalpine fir were infested (primarily by wood borers). All but one of the Engelmann spruce died and all of the subalpine fir died. Douglas-fir beetles preferred trees with more than 50 percent basal girdling and less that 75 percent crown scorch. Pine engraver preferred lodgepole pine with more than 75 percent basal girdling and less than 50 percent crown scorch. Fourteen of the spruce and 16 of the subalpine fir were completely girdled at the root crown and dead before 1991. The two remaining Engelmann spruce were 90 percent girdled and heavily infested with spruce beetle in 1991. Primary and secondary bark beetles initially attacked moderately crown-scorched and heavily girdled trees in 1989 and 1990 then attacked less injured trees in subsequent years. Other beetles and wood borers attacked trees after primary and secondary beetles were established except in severely damaged trees where primary and secondary bark beetles did poorly.

Extensive Study:

In response to the intensive study observations and out of concern for what appeared to be an increase in primary and secondary bark beetles attacking unburned trees Gene Amman initiated an extensive survey in the Greater Yellowstone Area (Rasmussen et al. 1996). By 1991 when this survey began most trees that suffered severe crown scorch or severe bole injury had died. Survey plots were located in areas adjacent to burned forests that still contained some green trees. The number of plots examined were 321 in 1991, 198 in 1992, and 127 in 1993. The 1993 data indicated very little new bark beetle activity so the survey was suspended. Because it was not possible to determine crown scorch three years after the fires the survey focused on measuring the circumference girdled. Dead cambium, resinosis and the absence of insect galleries beneath charred bark indicated fire-caused injury. In trees killed in previous years foliar characteristics were used to determine year of death and gallery characteristics were used to determine attacking species.

Of the 1,012 Douglas-fir trees in the survey 31.7 percent died. Fifty-eight percent of the dead trees were completely girdled at the root crown by heat. Their deaths were attributed to fire. The death of 40 percent of the trees (partially girdled) was attributed to insects, primarily Douglas-fir beetle. Infestation of Douglas-fir beetle in green trees was around 5 percent in 1989, 1990, and 1991 but jumped to 12 percent in 1992. Of the 4,758 lodgepole pine in the survey 51.6 percent died. Thirty-one percent of the surveyed lodgepole pine were completely girdled, 18 percent were partially girdled and died from subsequent insect attack, primarily pine engraver. Mountain pine beetle (MPB) did not attack many trees, showed no preference for any injury class, and did not build up populations in the trees it attacked. Infestation of lodgepole pine was highest in 1989 (17 percent), decreased to 2 percent by 1991 and rose to 7 percent in 1992. Of the 439 Engelmann spruce in the survey 41 percent died. Of these 78 percent were completely girdled by fire. Twenty-nine trees were partially girdled, attacked by insects (primarily spruce beetle) and died. Infestation of spruce by spruce bark beetle was zero to 2 percent from 1989 to 1991 but jumped to 8 percent in 1992. Roughly one-third of the subalpine fir and whitebark pine (*Pinus albicaulis*) died and roughly half of these were completely girdled.

Generalized Fire Injury-Insect Attack Response:

In both the intensive study and the extensive survey a general pattern emerged in that primary and secondary bark beetle infestation was positively related to the percent of the circumference girdled by fire. Infestation increased approximately linearly with girdling up to 60 percent of the circumference. It then either leveled off or decreased somewhat. Wood borers and other bark beetles were uncommon in lightly girdled trees but increased continuously with girdling. Trees with heavy crown scorch appear unattractive to primary and secondary bark beetles (Figure 1). This observation is provisional for all species except Douglas-fir because burning conditions associated with high crown scorch will generally kill phloem and cambium in the lower 6 feet of the bole in thin-barked species like lodgepole pine, Engelmann spruce, subalpine fir, and whitebark pine. Thus this sample contains few highly scorched trees.

The Yellowstone fires provided a good opportunity to observe natural processes of fire and insect interaction. We were able to observed delayed mortality for up to four years following the fires. Bark beetles acted as opportunists in attacking mortally injured trees. But they also were a significant source of additional delayed mortality of lightly injured trees. And beetles leaving injured trees successfully attacked significant numbers of unburned trees.

Research Needs:

There is currently considerable research underway at the Intermountain Fire Sciences Laboratory to better understand and predict crown scorch and stem injury. We are also attempting to better understand the physiological consequences of fire injury. We are actively developing prescriptions for how to restore fire to fire-dependent forests. However, the application of fire is still as much an art as a science, and is likely to remain so for some time.

In an attempt to better understand fire and bark beetle interactions, and with the hope that managers might one day have access to post-fire treatments to modify insect attack Gene Amman and I initiated a pilot study of pheromones (Amman and Ryan 1994). Twenty plots were located in lodgepole pine stands in the Sawtooth National Recreation Area, Idaho. Plots consisted of four similar MPB-suitable lodgepole pine with a MPB bait on a stake at plot center. Four treatments were applied: 1) control-uninjured, no pheromone; 2) 70 percent basal girdling by fire, no pheromone; 3) 70 percent basal girdling by fire plus two verbenone CAPS; and 4) 70 percent basal girdling by fire plus two verbinone CAPS and two ipsdienol. Tests showed that pheromones significantly affected MPB behavior. As for fire injury the results were inconclusive but MPB appeared to do somewhat better on fire-girdled trees.

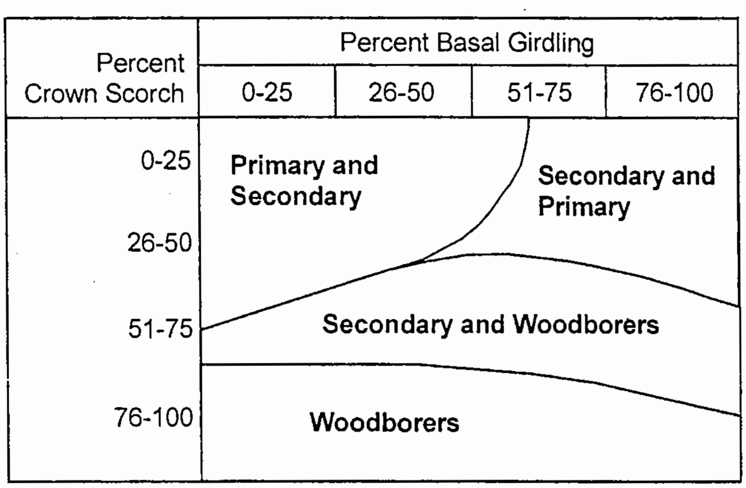

Figure 1—Classes of insects initially attacking fire injured trees.

More studies are needed to better understand how tree physiology changes with fire injury. There is a general hierarchy for carbon allocation in a tree (Waring and Schlesinger 1985). In general allocation to defensive chemicals is a relatively low priority for allocation. While it is reasonable to expect fire-caused defoliation (crown scorch) to reduce the amount of carbohydrate produced by a tree the associated reduction in water use has a compensatory effect. Simulations by Ryan (1990) indicate that defoliation both reduces the amount of photosynthate and delays the seasonal onset of growth-limiting water deficits. This can have two possible consequences. First the total amount of carbon available for insect defense may be reduced. And, second, the timing of the shift from growth-dominated development to the production of secondary metabolites (Lorio 1986) including defensive chemicals may be delayed. The latter may lead to a situation where trees are relatively undefended during the early part of beetle flight.

Basal girdling and root injury often go hand in hand as both are caused by the burning of smoldering duff around the base of the tree. It is therefore difficult to separate the effects of the two injuries. Both occurred in the GYA studies. Basal girdling occasionally occurs without root injury such as when log burns at the base but the duff is too moist to smolder. In a controlled injury study Ryan (1993) found that partial basal girdling alone did not appear to effectively cut off the flow of carbohydrates to the subtending roots until more than 90 percent of the circumference is girdled. And it did not affect seasonal water relations during the two years following injury. However, if bark beetles or woodborers attack a partially-girdled tree it seems reasonable that lower attack densities would be sufficient to complete the effective girdling of the stem. Fire-caused root injury is difficult to assess, particularly in the Rocky Mountains. Little is known about its influence on physiology or host susceptibility. However, simulations (Ryan 1990) and pipe theory considerations lead to the expectation that increasing root pruning by fire should lead directly and immediately to a proportional increase in water stress unless a similar proportion of the crown was defoliated.

The studies outlined here raise a number of interesting researchable questions. How much crown scorch, root injury or girdling can a tree withstand if no insects attack? How do multiple injuries affect host susceptibility and survival? Can pheromones be employed to prevent attack until trees can repair the physiological damage? How does the sequence of attack or attack density affect the outcome? Learning the answers to these questions will go a long way towards successfully reintroducing fire.

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12:00 - 1:30 pm	**Lunch**
1:30 - 3:00 pm	*Concurrent Workshops* **Forest Insects and Global Change** Moderator: Ann Lynch, Forest Service Research, Flagstaff, AZ **New Concepts in Host and Non-Host Volatiles** Moderator: John Borden, Simon Fraser University, BC

Forest Insects and Global Change

Report not provided.

New Concepts in Host and Non-Host Volatiles

John H. Borden, Chair

There were no invited discussants among the 25 participants in this workshop, the objective being to explore an exciting subject in a spontaneous, informal manner. Six of seven potential subjects outlined by the chair were actually considered in a discussion that focussed exclusively on scolytid beetles.

In response to a question on technological advances by Steve Burke, Steve Seybold described new solid state capture methodology. This consists of a minute adsorptive "finger" housed in a metal sleeve. When exposed to headspace vapors in a confined space, it acquires volatiles rapidly. It can then be withdrawn, and next exposed in the injector port of a gas chromatgraph. It provides a rapid, solvent-free qualitative method for analysis of minute amounts of volatiles. The chair briefly described the principle of coupled gas chromatographic-electroantennographic detection analysis (GC-EAD) which allows simultaneous recording of chromatographed volatiles on a flame ionization detector and an insect antennal preparation. The antenna acts as a filter, identifying only those volatiles that it can smell and are of potential behavioral importance. Behaviorists can then focus their investigations on these compounds.

Considerable interest was expressed in Dezene Huber's description of the use of GC-EAD to identify frontalin in red and Sitka alder bark volatiles, and conophthorin in the bark volatiles of trembling aspen, black cottonwood, bigleaf maple and paper birch (12% of the bark volatiles in the latter species). Discussion focussed on how the trees and sympatric scolytid species might have evolved to use the same compounds, e.g. originally as repellent plant compounds and secondarily as bark beetle pheromones. A plea was made for Steve Seybold to compare the biogenesis of these semiochemicals in insects and plants. The additive and redundant disruptive effect of non-host angiosperm bark volatiles, which would allow coniferophagous bark beetles to recognize and avoid any angiosperm tree was in contrast to the system described by Tiffany Neal in which Douglas-fir beetles avoid western larch apparently through the perception of a single volatile monoterpene, 3-carene. She described the strong disruptive effect of 3-carene on the response to attractant-baited traps by Douglas-fir beetles, and the markedly higher toxicity of 3-carene than other monoterpenes. Interest was also expressed in the recent discovery by an atmospheric scientist of the release of large amounts of methybutenol (a well known bark beetle pheromone) by the foliage of lodgepole pine.

A discussion of the competing hypotheses of long-range perception of non-host species, and the "stop and taste" perception method led Kimberly Wallin to describe her work on laboratory bioassays for host acceptance by spruce beetles and pine engravers, definitely a test involving phagostimulants. Acceptance is demonstrated by a beetle boring into a medium laced with various test compounds representing different host types. Of particular interest was the finding that spruce beetles from non-outbreak populations were more discriminating in host acceptance than those from outbreak populations, suggesting a genetic difference between the two. Support for such an hypothesis was presented by Ron Billings who recalled work on mountain pine beetles, wherein non-outbreak beetles concentrated their attack on pheromone-baited trees, while outbreak beetles attacked baited trees and those surrounding them with equal frequency.

The subject of response by bark beetles to vertical silhouettes shifted attention to Brian Strom's research on the additive effect of antiaggregants and white-painted traps or trees on disrupting the response to attractants by the southern pine beetle. Brian defended a challenge that white color simply caused a silhouette to lack apparency, by explaining that white sticky Plexiglas panels captured fewer beetles than clear panels, which in turn captured fewer beetles than black panels. While the clear panels may lack apparency the white color was clearly disruptive. However, no measures of reflectancy have yet been made.

The chair concluded the discussion with a brief summary of the disruptive effects of green leaf volatiles (now demonstrated in seven species of bark beetle and three ambrosia beetles), the fact that 1-hexanol has been found to be a multifunctional pheromone in *Pityogenes knechteli*, and the discovery of four antenally-active green leaf volatiles (two aldehydes and two alcohols) in the bark volatiles of non-host angiosperm trees.

Attendees (in order of sign up) were: Ron Billings, Nancy Sturdevant, Tiffany Neal, Dezene Huber, Jack Stein, Steve Seybold, Julie Weatherby, Lia Spiegel, Rick Kelsey, Suzanne Kühnholtz, Tom Eager, Rory McIntosh, Dave Schultz, Brian Strom, Kimberly Wallin, Kier Klepzig, Richard Reardon, Alan Dymerski, Vic Mastro, Steve Burke, Robert Peck, Don Dahlsten, Kevin Ryan, Lee Humble and Jane Hayes.

1:30 - 3:00 pm **Ethical Conflicts with New Technology**
Moderator: Iral Ragenovich, Forest Health Protection, Portland, OR

Ethical Dilemmas in Forest Insect Management

Workshop Moderator: Iral Ragenovich
USDA Forest Service, Pacific Northwest Region

Participants: About 12 people.

A workshop on ethical conflicts had the potential to cover a host of topics. To focus the workshop, several topics were identified for discussion. The two topics that were discussed were: responsibility for use and misuse of new technologies, and expert witness.

Responsibility for Use and Mis-Use of New Technologies

Once a technology has been developed, where does the responsibility lie for its proper and appropriate use. Bill Schaupp, (USDA Forest Service, Rocky Mountain Region) led the discussion by presenting a case which had occurred in Colorado. Bark beetle pheromone baits are primarily used for population monitoring and in some cases to manipulate bark beetle populations by pulling them into specific areas, where the attacked trees can then be easily removed. Pheromone baits are viewed as environmentally friendly, and therefore, often provide a desirable alternative to insecticide or silvicultural management. Pheromone baits do not need to be registered by the EPA, and therefore, a certified applicators license is not required for use; however, appropriate use of the baits requires knowledge of bark beetle behavior. It was Bill's opinion that the time that recommendations from a private consultant, improper use and follow-up removal resulted in the mountain pine beetle population buildup in a visually sensitive corridor.

There is also the opportunity for the intentional misuse of pheromone baits. Lorraine Maclauchlan discussed such a possibility for such a situation within the forest management practices in British Columbia. Forest Health actions do not require the preparation of management plans and sign-off by a certified forester that is required for regular timber harvest and forest management. Operators could use baits to create outbreaks or draw beetles in to kill additional trees and create more available volume within desirable timber areas and be able to harvest them under the guise of "forest health", thereby avoiding management plans. As a result, B.C. developed Forest Practices Regulations that require baiting and contingency plans, and anyone using behavior-modifying treatments must ensure prompt action is taken to reduce target insect populations.

The question: who has the responsibility for the proper use of this technology? We discussed the roles of the various players.

The manufacturer: The responsibility of the vendor lies with providing good information and instructions on the appropriate use; once it has left the facility the manufacturer may no longer have control over product use. A company can reduce the risk of improper use by managing product distribution and sale, such as by only selling to board certified entomologists, and by not selling to the general private sector.

Entomologists in the Public Sector: Monitoring or regulating the use of pheromone baits in the private sector, is beyond the scope and ability of the cadre of forest entomologists in the public sector; however, in many cases they may have to deal with the consequences of improper use. Public awareness and education, and education of the private consultant sector, on the use of the baits is one of the primary areas where public employees can influence use. They can monitor and assure appropriate application on public lands that fall within their area of responsibility. They can also influence forest practices regulations that would make improper use more difficult.

Private Consultants: Most recommendations to the private sector are made by consultants. There are very good private consultants; well-intentioned private consultants who lack the knowledge needed for appropriate technology application; and unfortunately, some whose primary objective is to sell services based on unsubstantiated claims. The good private consultants can provide the standard and service so private individuals can compare options. All consultants need to make sure they are familiar with all aspects of a product or technology they are using, i.e. educate themselves fully.

Good education of the public, the examples and recommendations of good consultants, forest practices regulations, and manufacturer control of product sales are some of the ways that we discussed to counteract the effects of potential misuse of pheromone bait technologies.

Expert Witness

Often professional entomologists, are called to be an expert witness or provide expert advice that may conflict with another expert witness. Being an expert witness can result as a matter of an individuals employment, and sometimes individuals are paid to be expert witnesses. Steve Munson described his experience as an expert witness regarding proposed forest management to mitigate the impact of a spruce beetle outbreak in Utah. Differing opinions between expert witnesses are valid, based on each individuals experience and perception of a particular situation, as long as the witnesses maintain their professional integrity. We all can respect professional differences of opinion. The dilemma arises when honest differences of opinion are used, often in conjunction with misleading information and pictures, in an attempt to discredit the opposing side.

We decided it was best not be in a position of being an expert witness, however, when and if that should be the case,:

—Then be honest and present your professional opinion.
—Your professional opinions are valid;
—Remember, it is the job of the plaintiffs lawyer to try to discredit you—most likely they have nothing against you personally.
—Do not allow yourself to be dragged into the game of one professional being pitted against another—continue to respect each others professional opinions even though they may not agree.

1:30 - 3:00 pm	**Insects as Agents of Change in Forest Ecosystems** Moderator: Tim Schowalter, Oregon State University

Insects as Agents of Ecosystem Change

Tim Schowalter, Oregon State University, Moderator

Speakers: Jaime Villa-Castillo (Northern Arizona University), Ed Holsten (USDA Forest Service, Alaska), and Nancy Rappaport (USDA Forest Service, California)

41 attendees

Schowalter introduced the session:

Insects have long been recognized as agents of ecosystem change. We have a deeply-ingrained perception of the destructive capacity of insect outbreaks. However, this perception is undergoing a transition as appreciation grows for the potential role of insects as regulators of ecosystem processes in a changing environment. New studies are indicating that insects and related arthropods respond to changing conditions in ways that reduce variability in ecosystem processes. Our view also is broadening to consider linkages between canopy herbivores and forest floor detritivores that together influence nutrient cycling processes in forest ecosystems.

This session includes two case studies by Jaime Villa-Castillo and Ed Holsten that examine regulation of forest productivity by bark beetles. The third presentation by Nancy Rappaport addresses litter arthropods, a group only recently recognized by forest entomologists for their importance to regulation of litter decomposition and nutrient turnover.

Assessing Bark Beetle Attack Effects on Forest Structure in Nevado de Colima National Park, Mexico

Jaime Villa-Castillo, Northern Arizona University

Bark beetle (*Dendroctonus adjunctus*) damage to *Pinus hartwegii* forest in Nevado de Colima National Park, Mexico has been recorded consistently since the 1960s. However, from 1981 to 1996 the higher rates of mortality due to bark beetle attack prompted several sanitation programs which were carried out in 1982, 1987, 1993, and 1996. The sanitation treatment was a salvage operation consisting of logging all dead and currently infested trees, and debarking, piling and burning residual material. Overstocked conditions have been considered to be the main factor driving bark beetle outbreaks because no silvicultural treatment has been practiced in that forest since 1942 when it was declared a National Park. This study was designed to evaluate bark beetle impact on forest structure based on records gathered during the four sanitation events above.

Thirty plots were established to reconstruct stand structure before insect attack and to estimate residual forest structure after beetle attack. Vigor of attacked trees was estimated from stumps by the ratio of the periodic growth before insect attack. Vigor of residual trees was estimated from core-increments for the year of insect attack in each site. The ratio of periodic growth before and after attack was estimated.

Most attacked trees had poor vigor when they were attacked. We did not evaluate if non-attacked trees were more vigorous at the time of attack, but many of those trees increased vigor after beetle attack. Attacked sites had an average of 30 m^2 of basal area before insect attack. Insects killed trees that accounted for 70% of original basal area, leaving multi-storied sites with about 10 m^2 after each successive outbreak. Regeneration of pine species was present in attacked sites but slope accounted for 30% of variability. We conclude that bark beetles in Nevado de Colima National Park Mexico are acting as disturbance agents promoting growth and regeneration of sites.

Role of Insects and Disturbance in Boreal Forests: Spruce Beetle

Edward Holsten, Research Entomologist, USDA Forest Service, Alaska

A key premise of ecosystem management (based on natural variability) is that native species have adapted to, and in part, evolved with natural disturbance events. Species loss and ecosystem change have been observed in areas where "natural" disturbance regimes have been substantially altered. Disturbances, large and small, are responsible for the way current landscapes appear and function today. Disturbances of various kinds and intensities will determine the structure, composition, and function of future landscapes. To most of us, forests appear stable. This common perception is due to our relatively short observation time. Nearly all forest ecosystems are in some stage of recovery from one or more prior disturbances. Alaska ecosystems are shaped/produced by disturbances. Just note the effects of glaciation, earthquakes, tidal waves, fire, flooding, etc. Disturbance events such as fire, insect and disease outbreaks create and maintain a shifting mosaic of landscape patterns. Both fire and flooding are responsible for spruce and birch regeneration in south-central and interior Alaska; large scale windthrow is important in southeast Alaska. Fire burns across the landscape in an irregular and uneven manner. The burned surface may or may not be essentially the same as the pre-burned surface. Succession after fire in Alaskan forest ecosystems is complex and related to site, fire, climate, type and age of the vegetation present before fire, and plant species available for sprouting or invasion after fire.

Alaska insect communities, probably one of the largest components of forest ecosystems, are also "creatures" of disturbance as well as agents of disturbance. Arctic/boreal insects are characterized by having few species and large population numbers. These insects are opportunistic in their behaviors. They respond quickly to disturbances in climate, food, and breeding material. The spruce beetle (*Dendroctonus rufipennis*) for example, responds quickly to large scale blowdown, fire scorched trees, or spruce impacted by flooding. Large beetle populations can be produced by such breeding material, leading to potential outbreaks.

As agents of disturbance, spruce beetles are one of the most important mortality agents of mature spruce stands in Alaska. In the last five years, more than 2 million acres of boreal forest have been impacted by spruce beetles to some degree. In south-central Alaska, there are many pure stands of white, Lutz, and Sitka spruce which have "lost" more than 80% of the spruce component in 2-3 years! There are a variety of changes associated with spruce beetle outbreaks to forest resources, both timber and non-timber. These changes, in the short term, are socio-economic in nature and are viewed as either positive or negative depending on the forest resource in question. In the long term, however, these same changes are biological or ecological in nature and are neither good or bad. Both viewpoints are valid but disagreements are common depending upon one's time-scale. Some of the impacts associated with spruce beetle infestations include, but are not limited to:

(1) Loss of merchantable value of killed trees: The value of a spruce as saw timber is reduced within three years of attack in south-central Alaska as weather checking and increased sap-rots occur. A product recovery study recently conducted on the Kenai Peninsula indicated that an additional 15% or more defect for saw-timber is apparent if they are not harvested within three years of death. The value of a beetle killed tree as houselogs, chips, or firewood continues for some time, up to 50 years for chips if the beetle-killed tree remains standing.

(2) Long term stand conversion: To optimally regenerate both spruce and birch, a site disturbance (i.e. fire, windthrow, flooding, ground scarification, etc.) is required which results in a seed bed comprised of bare mineral soil with some organic material. If there is adequate seed source, such site disturbances provide excellent sites for germination and establishment of tree species. However, what is occurring on many sites in south-central Alaska after spruce beetles have "opened up" the canopy is a scarcity of spruce regeneration. Under post-outbreak conditions, blue-joint grass (*Calamagrostis canadensis*) and other competing vegetation quickly invade the site and delay future re-establishment of tree species.

(3) Impacts to wildlife habitat: The effects of a spruce beetle outbreak on each wildlife species depends on the species' requirements and the intensity and extensiveness of the infestation. If only a few trees are infested on 1-2 acres (<1 ha), changes could be insignificant. If the outbreak reaches the intensity and extensiveness of many of those on the Kenai Peninsula or White River-Colorado, then significant changes could be expected. For example, populations of those Alaskan wildlife species that are dependent upon live, mature spruce stands for habitat requirements could decline. We expect to see decreases in red squirrel, spruce grouse, Townsend Warblers, and possibly Marbled Murrelet populations in those areas severly impacted by the spruce beetle. On the other hand, those wildlife species such as moose, small mammals and their predators, etc., that benefit from early successional vegetation such as willow, birch and aspen, may increase as stand composition changes.

Most of the following information relates to major outbreaks. From the results of studies conducted elsewhere, we can expect that with 50-70% canopy removal wildlife diversity may increase. With 80-100% canopy removal, wildlife diversity may be expected to decrease. Since trends in mammal and bird populations have not been adequately studied, much of the expected changes are developed from expert opinions based on knowledge of the animals' requirements. Established wildlife-habitat relationships may be used to predict expected response(s) of individual species to habitat changes associated with spruce beetles. For example, of the 92 bird species that may be expected to occur on the Kenai Peninsula, 37 will decrease in abundance (e.g., spruce grouse, grosbeaks, Townsend's warblers) and 24 will increase in abundance (e.g., warblers and sparrows associated with shrubs). Eleven will have mixed or unknown response and 20 would be expected to not change in abundance (i.e., those not associated with forested habitats). Of the 39 mammal species expected to occur on the Kenai Peninsula, 13 may be expected to decrease in abundance following spruce beetle infestations (e.g., red squirrels, porcupines, flying squirrels) and 8 may increase (e.g., hares, voles). Eight will probably have mixed or unknown responses and 10 would be expected not to change in abundance (i.e., those not associated with forested habitats). Associated human uses of wildlife (e.g., hunting, viewing) will also be expected to change.

(4) Impact to scenic quality: Recent studies have demonstrated that there is a significant decline in scenic quality of spruce beetle impacted stands and that scenic beauty is an important forest resource. In back-country areas, however, surveys have shown that publics are evenly divided as to whether spruce beetle outbreaks are a problem or not. Along scenic corridors such as National Scenic Byways, maintaining or enhancing scenic quality necessitates minimizing impacts from spruce beetle infestations.

(5) Fire hazard: There is concern that fire hazard of spruce beetle impacted stands will increase over time as dead trees fall and dry grass accumulates, thus increasing fuel loading. Recent fires on the Kenai Peninsula have substantiated this concern. After an outbreak, percent grass cover in impacted stands increases from less than 5% to more than 50%. Blue-joint grass cover provides a fine, flashy fuel. Fire spreads rapidly through this grass because of the large volumes of fine dry litter present in the spring and possible increases in lower level winds due to a "reduction" in the windbreak characteristic of a green forest. Recent Alaska studies have shown that more than 100 tons per acre of large woody debris can accumulate on the forest floor 5-10 years after a spruce beetle outbreak. In contrast, approximately 2 tons per acre of large woody debris accumulates in uninfested stands. Sound wood, which makes up 65% of the total fuel tonnage, is the heaviest component of the fuels complex. They do not readily ignite, but once ignited they burn at higher temperatures for longer period. Observations from recent fires on the Kenai Peninsula have shown an increase in crown fires spread through spotting from beetle killed trees.

(6) Impact to fisheries: Major adverse impacts to the fishery resource can occur as a result of the extensive spruce beetle damage to spruce adjacent to streams. Impacts include loss of a future source of large woody debris for instream fish habitat and increased potential for erosion (mass and streambank) associated with the loss of root structure along steep slopes and streambanks.

There have been no specific studies concerning impact(s) to fisheries associated with spruce beetle outbreaks undertaken in Alaska. However, a recent report discusses some adverse impacts to Pink and Sockeye Salmon as well as Dolly Varden and Cutthroat trout in the Kachemak Bay Area of south-central Alaska. Increased streamflows associated with beetle-killed trees could inhibit returning adult salmon. Likewise, these infested watersheds could experience more extremes-higher peaks, etc. This could affect all salmon life stages (eggs, alevins, etc.).

(7) Impact to watersheds: Intense bark beetle outbreaks can kill large amounts of interceptive vegetation. The "removal" of significant portions of the vegetation will impact to some degree, dynamics of stream flow, timing of peak flow, etc. There have been no hydrologic studies in Alaska quantifying or qualifying impacts associated with spruce beetle outbreaks. Impact studies, however, have been done elsewhere. In the Rocky Mountains, streamflow increased up to 22 % annually for a watershed in the White River spruce beetle outbreak. The increase was attributed to reduced rainfall interception and transpiration due to changes in vegetation cover. In lodgepole pine stands in Idaho that have been impacted by the Mountain Pine Beetle, a 15-21% increase in water yield; a 2-3 week advance in post-epidemic hydrograph; and a 10-15% increase in higher flows have been documented.

When logged areas are compared to uncut areas, length of the snowmelt season remains the same, but snowmelt increases early in the season and increases in the latter part. Peak streamflows do not increase appreciably when 40% or less of the watershed is patch cut. Evaporation is greater from snowpacks in logged areas than from uncut forest. Evapotranspiration and interception losses are reduced in proportion to amount of forest cover removed. Water yields are highest where the openings are kept to less than eight tree heights in diameter.

On a watershed basis, the redistribution of snow into clearings increases runoff because less water is needed to satisfy soil moisture deficits due to reduced transpiration loss after tree removal. The increase in water yield will last for 30 years or longer depending on how soon the forest cover density reaches its maximum value.

The effect of an outbreak on water yield is probably similar to changes that occur after logging with minor differences caused by the standing dead trees. How similar a beetle-infested area is to a harvested watershed depends on the extent and intensity of the infestation.

There are a variety of techniques that can be used to prevent, mitigate, or reduce impacts associated with spruce beetle infestations. However, before pest management options can be developed, the resource objective(s) for a particular stand, watershed, landscape, etc. must be determined. The forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered because population levels will determine the priority of management actions and the type of strategy to be invoked. The key to forest ecosystem management is to manage vegetational patterns in order to maintain species diversity, both plant and animal, while providing for a multitude of resources such as recreation, fisheries, wildlife, and the production of wood fiber. Properly applied silvicultural practices as well as fire management in south-central and interior Alaska, can maintain the forest diversity needed to provide the range of products and amenities available in the natural forest for now and in the future.

Disturbance Effects on Soil Arthropods

Nancy Rappaport, Research Entomologist, USDA Forest Service

Why should we be concerned about soil arthropods? Because soils are the global storage reservoir for carbon; soil is where the important carbon and nitrogen transformations take place, making nutrients available for plant growth. Living microbes, fungi, and invertebrates are responsible for accomplishing those transformations, but the soil biota can be disrupted by harvests and fire (biodiversity losses can equal losses of important ecosystem functions). The essential ecosystem functions performed by soil arthropods are litter decomposition, nutrient cycling, bioturbation of soil, and regulation of soil bacteria and fungi (the primary decomposers).

Soil is an opaque, dense medium that is extremely variable and difficult to study. The soil environment is characterized by a very high degree of spatial and temporal heterogeneity, posing unique sampling difficulties. Soil arthropods are different from the above-ground fauna because of their greater diversity (ca. 10X more speciose), their small size, their abundance (up to half a million individuals per square meter), their functional redundancy, and the very poor state of current knowledge about them.

The soil environment, perhaps more than any other medium, is characterized by complex species interactions. The below-ground community consists of mycorrhizae and non-mycorrhizal fungi; bacteria; protozoans and nematodes; mites and collembolans; insects other than collembolans; spiders; myriapods; earthworms. Arthropod-microbe interactions, which are among the more important of the below-ground processes, include comminution of litter (increases surface area for microbial decomposition); inoculation of litter with bacteria and fungi; ingestion and exploitation of microbial enzymes; regulation of bacterial and fungal populations.

Effects of disturbance on soil biota are manifold, including reduction in surface organic matter; changes in temperature and moisture regimes that are lethal to most taxa; a shift in food resources from above-ground contributions (litter, coarse woody debris) to below-ground (decomposing roots); destabilization of the tight nutrient cycling that is typical of coniferous forests.

Many studies suggest that disturbance can have enduring effects on below-ground fauna and processes, but few past studies have been properly replicated and controlled, and few have been conducted over a sufficient period to assess recovery. Future studies must be properly designed and conducted on a sufficiently large spatial and long temporal scale to determine the long-term sustainability of forest soil productivity.

Schowalter concluded the session:

Our changing perspectives may require new terminology. For example, how do we discuss effects of insect outbreaks without focusing on "destructive" aspects? On the basis of disturbance characteristics, such as selectivity and severity of mortality, frequency and scale, insect outbreaks resemble disturbances such as fire and storm damage. However, shifts in functional organization, such as addressed by Nancy, reflect responses to environmental change that should make us think of insect outbreaks more as responses to environmental change than as destructive agents of change. As Jaime and Ed showed, insect responses to environmental changes may reduce variability in forest structure or facilitate succession to a community composed of species more tolerant of the altered conditions. If insects are capable of regulating ecosystem structure and function, in the sense of reducing amplitude of fluctuation in major attributes, then our terminology and responses must advance beyond suppression, or even tolerance, to acceptance of insect contributions to goals of forest resource sustainability. This may require consideration of ways in which insect activity can be used or modified to meet the new management objectives.

3:00 - 3:30 pm	Break
3:30 - 5:00 pm	*Concurrent Workshops* **Insect Impacts on Wildlife and Recreation Values** Moderator: Dayle Bennett, Forest Health Protection, Boise, ID

Workshop Moderator: **Dayle Bennett**, USDA Forest Service, Boise, Idaho
Presenters: **Mike Jenkins, Kent Traveller, Deb Bumpus, Eric Smith**
Participants: Approximately 25

The Role of Disturbance in the Determination of Vegetative Patterns and Dynamics in Intermountain Spruce-Fir Forests

Mike Jenkins, Department of Forest Resources, Utah State University, Logan, UT

In the Intermountain spruce-fir zone, abiotic and biotic agents of disturbance play important roles in the establishment of vegetative communities. Following a stand replacing fire, early successional communities including grasses, shrubs, and forbs, lodgepole pine, aspen, and Douglas-fir typically dominate burned sites depending upon the habitat variation and the species availability. Subalpine forests, however, have low fire frequencies resulting from the rarity of extreme burning conditions, and in the absence of large scale, high intensity fires, Engelmann spruce (*Picea engelmannii* Parry ex Engel.) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) gradually replace seral communities. These two species generally coexist as dominants in climax communities forming extensive stands on all but the most extreme sites. During the 300-400 years that may expire between major fire events, disturbances including spruce beetle outbreaks, blowdown, and snow avalanches primarily drive vegetative dynamics in spruce-fir forests. Such disturbances also contribute to the accumulation, arrangement and configuration of fuels contributing to fire risk and hazard. Under appropriate fire weather conditions the risk of stand-replacing fires in these forests increases. In very high elevation spruce-fir communities, snow avalanches and bark beetle outbreaks may act to maintain the late successional communities for long periods.

Impact of Insect Infestations on Recreation

W. Kent Traveller, Recreation Program Manager, Cedar City District, Dixie National Forest

Once an epidemic is underway it is difficult to respond to from a recreation/visuals perspective. However, the status quo is not an option. On the Dixie National Forest in southern Utah, outbreaks of both spruce and pine bark beetles are substantially altering the evolved tree stand compositions. The resulting changes are effecting many recreation settings and activities. Included in these are winter sports including an alpine ski area, developed campgrounds, and roads and trails. There is a temptation, even by some trained resource managers, to resist these natural processes and try to retain or return tree compositions to exactly what they were pre-epidemic.

There can be significant time and resource ($) impacts to deal with infestations. The impacts will usually subside in +/- ten years.

Spraying, removal/salvage of infected trees or shrubs, acceptance of an altered land base, or introduction of new uses or use patterns are all options. Response to infestations usually will involve some or all of these and possibly others.

The "cure", especially if one defines the cure as stopping or interfering with the evolving natural system, is often worse than the malady.

Public relations including public support is a critical part of dealing with wide spread outbreaks.

In places such as the eastern and mid-western US in the case of Dutch elm disease and Yellowstone and Flaming Gorge NRA with beetle epidemics, significant impacts on recreation are still being felt fifteen to twenty years after epidemics subside.

The best cure is to take measures to reduce risk prior to insect or disease epidemics. This involves the implementation of some type of bio-physical approach to vegetation/landscape management and must be implemented using long term objectives and a number of years prior to the onset of insect or disease outbreaks.

Recognize that much of the work that we do with vegetation management in recreation areas and sites is politically and fiscally driven and is not science. Just recognize this as a force we are dealing with and try to leverage opportunities to educate both land managers and the general public about how natural systems function and how management activities might enhance those systems.

Insect Impacts on Wildlife and Recreation Values: Forest Management for the Northern Goshawk

Deb Bumpus, Threatened and Endangered Species Biologist, Sawtooth National Recreation Area, Sawtooth National Forest

Managing stands important to wildlife species in order to reduce the threats of insect infestations is becoming increasingly important to wildlife biologists. Historically, our most common management practice has been a "hands-off" approach. However, with a decline in the quality of habitat over the years, maintenance of stand characteristics essential to sustaining viable populations of the species is needed. In general, management objectives are to decrease stand density by thinning, which will result in reduced tree stress, a subsequent reduction in bark beetle caused tree mortality, and long term improved forest conditions specifically for mid to late seral stands.

The northern goshawk was recently petitioned for listing under the Endangered Species Act. The petition is due mainly to loss of habitat resulting from past management practices which favored clear cuts or overstory removals, large scale mortality due to catastrophic insect infestations, and fire suppression which has resulted in overstocked stands of small diameter trees.

It was necessary to collect site-specific stand data in order to be able to identify the stand characteristics that would classify an area as high value to northern goshawks. Goshawk nest stand data was collected during the summer of 1997 in the Sawtooth National Recreation Area of Central Idaho. The majority of these stands are lodgepole pine with a small percentage of Douglas fir and Engelmann spruce. The nest stands averaged 40-60% crown closure; the average dbh of the nest trees was 11 inches; and the average number of tree per acre exceeded 1,000. By comparison, nest stand data was collected on the Eagle Lake Ranger District of the Lassen National Forest in northeastern California. The nest stands here are mixed conifer (white fir, Douglas fir, Jeffrey pine, ponderosa pine); average crown closure is 70%; and the average dbh of the nest trees was 27 inches.

Because of the large territories of this species (up to 6,000 acres), suitable acres are often subject to catastrophic insects outbreaks and wildland fires. Stands impacted by these outbreaks are often overstocked with smaller diameter trees and/or overstocked with off-site tree species. Even for the larger foraging areas, these stands become marginally suitable because of the goshawks inability to navigate through them. The occurrence of dwarf mistletoe also results in less than optimal habitat conditions, most often by reducing the crown closure.

The goshawk territory is comprised of a nest stand (30-200 acres), a post-fledging area (420 acres), and a foraging area (up to 5,400 acres). Each of these areas has different requirements based on the needs of the species. Both the post-fledging area and foraging areas can be managed to provide sufficient hiding cover for the young birds and for a diversity of habitats which meet the needs of the goshawk prey species. Recommendations for these areas include:

- No management within nest stands.
- Manage for 50% crown closure and stand diversity to provide protection for young birds and provide a variety of prey species.
- Thin from below in a mosaic pattern.
- Create small openings in areas impacted by mistletoe (not to exceed 2 acres in size).
- Create more species diversity by leaving all Douglas fir and Engelmann spruce.

Management options for northern Sierra territories include:

- No management within nest stands.
- Maintain at least 60% of the acres with >60% crown closure through thinnings and creating openings of <1 acre. The remaining 40% can be thinned to 19-25 foot spacing with an emphasis on leaving biggest trees in clumps.
- Within the foraging area, create diversity in stand size by increasing thinnings to 19-30 foot spacing.

Timber management for northern goshawks to meet these objectives has been a low priority on most forests because of the small forest product that is made available to the public. Because of this low priority, the usual funding options have also been limited. The potential does exist to compete for Forest Pest Management funding with the objective of preventing and suppressing insect infestations within these important wildlife habitat areas.

Review of Published Studies Involving Forest Management and Insect Impacts

Eric Smith, USDA Forest Service, Forest Health Technology Enterprise Team, Fort Collins, CO

We have recently completed two reviews of published studies involving how forest management and insect impacts effect people's value of forest sites. "Nonmarket Economic Impacts of Forest Insect Pests: A Literature Review" (Rosenberger and Smith, PSW-GTR-164, Albany, CA: Pacific Southwest Research Station, USDA Forest Service) reviews 15 studies which used Travel Cost, Hedonic Pricing, and Contingent Valuation methods to estimate insect impacts on forest users' values. Although the studies involved different types of insect impacts, forest types, and users, general results were generally consistent. Respondents generally preferred well, but not overly stocked stands, visible mortality or defoliation lowered site value, large trees were highly valued, and mixed species stands were more highly valued. The paper also reviews valuation methods.

"Assessing Forest Scenic Beauty Impacts of Insects and Management" (Rosenberger and Smith, FHTET 98-08, Ft. Collins, CO: Forest Health Technology Enterprise Team, USDA Forest Service) reviews the Scenic Beauty Estimation technique and summarizes 34 studies which apply this technique to insect impact and forest management situations. The results from this technique were similar to those found in the previous summary of nonmarket insect impacts. Respondents generally preferred open stands with larger trees. They did not like evidence of recent harvesting, including slash and clear cuts. Prescribed burning was viewed as negative soon after the burn, but generally was seen as improving the pre-burn condition after a few years.

Many of the stand characteristics viewed by respondents in both of these studies are compatible with silvicultural practices that preserve forest health. Perhaps the two biggest challenges to managers are the negative reactions to slash and obvious insect damage to trees. There are several biological benefits of retaining slash on the site, and impacts from native insects are certainly not always undesirable. Other studies suggest that reactions can be changed when a context is provided for what is observed, so it is possible that educational efforts may improve the acceptability of these and other biologically desirable forest conditions.

3:30 - 5:00 pm	**Geographic and Genetic Variation in Insect Populations** Moderator: Diana Six, University of Montana

Geographic and Genetic Variation in Insect Populations

Moderator: Diana L. Six

Presenters: Diana L. Six (School of Forestry, University of Montana, Missoula), Kier Klepzig (USDA Forest Service, Pineville, LA), Steve Seybold (Department of Biochemistry, University of Nevada, Reno), and Kornelia Lewis (Forestry Canada, Victoria, BC)

Participants: Approximately 27 persons in attendance.

Geographic and genetic variation are important topics to anyone involved in insect research whether their focus is applied or basic science. Genetic population structure and substructure can have profound effects on insect behavior and implications in the efficacy of management strategies, both in the short term and the long term. Geographic and genetic variation may reflect local adaptation and influence the rates of evolution of insects and possibly of their host trees and natural enemies as well. This workshop covered several different areas of current research on variation in forest insect systems.

Using Mycangial Fungi as Indicators of Bark Beetle Population Isolation

Diana L. Six, School of Forestry, University of Montana, Missoula, and T. D. Paine, Department of Entomology, University of California, Riverside, CA

We investigated the population genetics of the Jeffrey pine beetle (JPB), *Dendroctonus jeffreyi* and its mycangial fungus, *Ophiostoma clavigerum*. This system looked promising for a study of two symbionts in tandem because (1) the beetle is monophagous and (2) possesses only one mycangial fungal associate. These traits allowed us to avoid the confounding effects of host tree on variation and also those of multiple mycangial partners. In this study we assessed (1) among and within population variation for the beetles and fungi, 2) the degree of gene flow occurring among these populations, and 3) the value of using mycangial fungi as indicators of population isolation of the host beetles. JPB attacks only Jeffrey pine and is predominantly a California species except for small populations in northern Baja California, Mexico. We collected beetles from 10 populations across California. Mycangial fungi were isolated from each beetle and then genetic variation in the beetle and fungus was assessed using isozymes and horizontal starch gel electrophoresis. Sixteen enzymes exhibiting 20 loci for the beetles and 16 enzymes exhibiting 19 loci for the fungi were asssayed. The beetle exhibited very low genetic variation. Only six out of 20 loci were polymorphic in one or more populations and average heterozygosity was only 4%. Two southern populations of the beetles were the most differentiated. Northern populations were not greatly differentiated from one another indicating that gene flow may be common. The fungi exhibited even less genetic variation than the host beetles. Only 2 out of 19 loci were polymorphic and average heterozygosity was only 1.4%. Genetic distance was slight among the populations of fungi. With the fungi, the southern populations were again the most differentiated, but this differentiation was so small as to be of questionable importance. Genetic variation in the fungi was also much too low to be useful as an indicator of population isolation in the host beetles; however, the approach of using symbionts in tandem to assess population isolation may have value in other bark beetle/fungal systems that exhibit higher degrees of variation and possess ore extensive geographic ranges.

Variability Between Florida and Louisiana Isolates of a Mycangial Fungus of the Southern Pine Beetle

K.D. Klepzig and D.L. Six

Isolates collected from a southern pine beetle (*Dendroctonus frontalis*) outbreak near Gainesville, FL were initially identified as *Ceratocystiopsis ranaculosus*. Upon further examination we observed a high degree of variability in isozyme patterns between these FL isolates and isolates from Louisiana. We subsequently observed differences in linear, mycelial growth rate (Fig. 1) and competitive ability with other SPB associated fungi (Fig. 2). These data indicate that the FL isolates may belong to a different species within the genus *Ceratocystiopsis*. Future work will concentrate on further comparisons (growth, genetic, etc.) of additional isolates of these fungi.

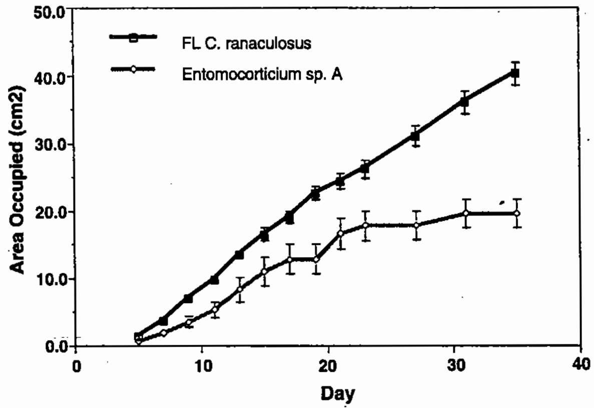

Figure 1—Growth of FL and LA isolates.

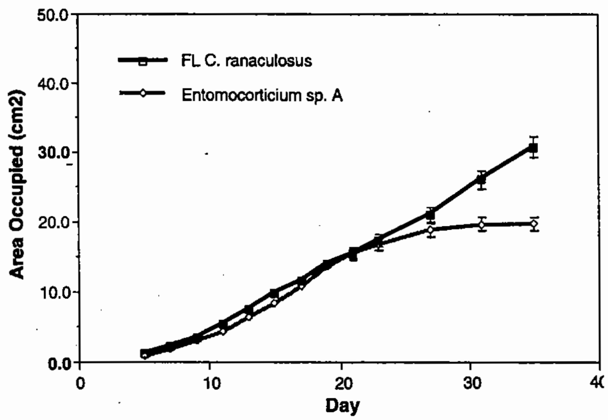

Figure 2—Competition of FL and LA isolates with a LA isolate of a SPB mycangial fungus.

Geographic Variation in Chemical and Morphological Characters of the Pine Engraver, *Ips pini* (Say) (Coleoptera: Scolytidae)

Steven J. Seybold, Department of Biochemistry, University of Nevada, Reno

The pine engraver, *I. pini*, is a transcontinentally distributed species whose current distribution has likely been determined by the effects of glaciation on the distribution of two of its hosts, jack pine, *Pinus banksiana*, and lodgepole pine, *Pinus contorta.* A geographic survey of the enantiomeric composition of the aggregation pheromone component ipsdienol produced by males suggests that *I. pini* exists as at least regional pheromone variants (Seybold et al., 1995). Surveys of cuticular hydrocarbon phenotypes (Seybold et al., unpublished) and DNA sequences for the mitochondrial gene, cytochrome oxidase I (Cognato et al., unpublished), both from a subset of the populations surveyed for ipsdienol, also indicate the presence of three regional variants.

Limited comparative morphological analyses were conducted on populations from two of the three regions (New York and California). The ultrastructure of the sound-producing organs (pars stridens and plectrum) from females originating from New York and California showed no differences in interstrial distances. Differences in these distances are key morphological discriminants for other closely related species of *Ips*. Preliminary morphological analyses of the ultrastructure of male and female antennal clubs from these two populations indicate differences in the distribution and abundance of chemosensory sensilla. Taken together, this morphological evidence supports olfactory, but not sonic, behavioral discrimination by these two interbreeding populations.

Seybold, S.J., Ohtsuka, T., Wood, D.L., and Kubo, I. 1995. The enantiomeric composition of ipsdienol: A chemotaxomic character for North American populations of *Ips* spp. In the *pini* subgeneric group (Coleoptera: Scolytidae). J. Chem. Ecol. 21:995-1016.

Reproductive Success of *Pissodes strobi* as a Function of Mate Sex Ratio

K.G. Lewis, R.I. Alfaro and Y. A. El-Kassaby, Forestry Canada, Victoria, BC

A breeding experiment using virgin white pine weevils, *Pissodes strobi* Peck, was conducted to determine the influences of multiple mates on reproductive fitness. Offspring number, body weight and successful colonization of the leader represented the reproductive fitness parameters under study. The experimental sex ratio varied from 1 female with each of 1, 2 or 4 males to 4 females with 4 males. Weevils were caged on individual Sitka spruce (*Picea sitchensis* (Bong.) Carr) trees. No significant difference in the mean number of offspring produced from a leader were observed among the various sex ratios in spite of differences in number of eggs laid between single and multiple females. This indicated that oviposition levels exceeded that required for successful brood production and that excess weevil larvae were eliminated through larval competition. A significant reduction in fitness, as measured by body weight, was detected in relation to the number of insects caged. Multiple females caged with multiple males produced the lightest offspring followed by single females caged with 4 males. It is hypothesized that when weevil populations are high more than 1 female is 'forced' to oviposit in a leader. This results in reduced offspring fitness and serves as a feed-back loop in controlling population numbers.

3:30 - 5:00 pm Moderator: Darrell Ross, Oregon State University
Student Presentations
Tiffany Neal
Maureen Duane
Tim Work
Sarah Bates
Brett Schaerer

Student Reports

Moderator: Darrell Ross, Oregon State University, Corvallis, OR

About 30 participants listened to 5 students describe their proposed or ongoing research projects. Each presentation was followed by enthusiastic discussion among the participants and the presenter.

Tiffany Neal, a graduate student in the Department of Forest Science at Oregon State University presented a research proposal to study western larch resistance to Douglas-fir beetle. The study will compare Douglas-fir beetle attack, colonization, establishment, and brood production in western larch and Douglas-fir. The study will also test the possible role that 3-carene, a monoterpene found in higher concentration in larch compared to Douglas-fir, may play in the observed resistance of larch to Douglas-fir beetle attack. The study will be conducted in stands containing western larch, Douglas-fir and a moderate to high Douglas-fir beetle population. In order to stimulate Douglas-fir beetle attacks, each experimental tree will be baited with aggregation pheromone. A completely randomized block design with five treatments will be used. The treatments will be: 1) aggregant baited, live western larch; 2) aggregant baited, felled western larch; 3) aggregant baited, felled Douglas-fir; 4) aggregant baited, live Douglas-fir; and 5) aggregant plus 3-carene baited, live Douglas-fir.

Maureen Duane, a graduate student in the Department of Forest Science at Oregon State University, presented a research proposal to study the response of coarse woody debris (CWD) arthropods to fire in southwestern Oregon. Coarse woody debris arthropods are important in decomposition and nutrient cycling, and serve as a food source for many wildlife species. Not a lot is known about the species distribution and habitat dynamics of this functional group or how they respond to various management practices. For these reasons, the species analysis team for the Northwest Forest Plan (NWFP) chose CWD arthropods, (along with three other functional groups of arthropods), for further study and analysis within the southern portion of the northern spotted owl range. This study will focus on CWD arthropod response to wildfire and prescribed burning in the Siskiyou mountains of southwestern Oregon. A thorough survey of this functional group and how they respond to and recover from fire will be helpful in determining if current fire management practices threaten the abundance, diversity, and function of CWD arthropods and if more action needs to be taken to protect them.

Sarah Bates, a graduate student in the Centre for Pest Management at Simon Fraser University, presented a talk on continuing research to determine the effect of western conifer seed bug, *Leptoglossus occidentalis*, feeding on developing Douglas-fir cones. Co-authors of her paper were John Borden from the Centre for Pest Management and Allison Kermode and Cameron Lait from the Department of Biological Sciences, Simon Fraser University, and Robb Bennett from Seed Pest Management, B.C. Forest Service. The western conifer seed bug is a pest of conifer seed orchards throughout western North America. As part of an impact assessment of the seed bug in British Columbia, caging studies were conducted in 1997 on Douglas-fir to compare damage by different life stages of the bugs, as well as damage that occurred from feeding at different times during the growing season. Cones exposed for a 2 week period in August to females, males, or nymphs did not result in a greater number of empty seeds than unexposed cones. The number of partially fed-on seeds was significantly higher in the cones exposed to seed bugs, but did not differ between females, males, and nymphs. A significantly higher number of full seeds was produced in unexposed than cones exposed to females. In a second experiment, the number of empty seeds did not differ in cones exposed to early, mid- or late season feeding. Early season feeding caused a 3-fold increase in the number of fused seeds, an impact of *L. occidentalis* that may have been overlooked in the past. Current research includes the development of a biochemical marker to detect past feeding by the seed bug on empty seeds in order to more fully determine the impact of *L. occidentalis* on seed production in British Columbia.

Timothy Work, a graduate student in the Department of Entomology at Oregon State University, presented preliminary data from a study entitled, "A survey of arthropod predators across edge forest gradients: implications of community composition on mechanisms." Habitat fragmentation decreases habitat quantity as well as habitat quality. Edge effects are one reflection of the effects of fragmentation on habitat quality. During 1997, surveys were conducted of predatory ground arthropods along seven edge-forest gradients to determine the extent of any edge effects. A total of 49 predator taxa were collected. No differences in species richness or Shannon-Weiver diversity were detected across the gradients. However, species compositions did differ along the gradients. Edge effects may have altered species composition within 50 m of the edge.

Brett Schaerer, a graduate student in the Department of Entomology at Oregon State University, presented a research proposal to study diversity in regenerating stands and arthropod community structure. Plant community heterogeneity has been demonstrated to reduce insect pest populations in agroecosystems, but is a poorly understood concept in forests. This study will compare arthropod communities on different mixtures of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco and red alder, *Alnus rubra* Bong. on three replicate sites at the H. J. Andrews Experimental Forest. Each mixture has a control with identical Douglas-fir density but no alder, reducing diversity effects into host density and non-host presence components. Pitfall trapping, branch bagging, and sweep netting will produce complementary samples of the arthropod fauna. Individuals will be classified into functional groups whose abundance will be regressed on plant community variables. Tree damage, growth, and mortality will also be assessed to determine the influence of heterogeneity and whether this might be mediated by certain arthropod guilds.

3:30 - 5:00 pm **Significant Pest Incident Reports: Hot Topics on Big Bugs**
Moderator: Steve Burke, Phero Tech Inc., BC

Forest Insect Pest Incidence Report for 1997

Attendance: 18

Pest incidences of 1997 were reported. Some reports were more complete than others. This is not a reflection of the quality of pest incidence reporting conducted within each Region or Province and is due to an unfortunate cancellation by the original moderator of the topic "Hot Topics on Big Bugs". Or was it "Big Topics on Hot Bugs"?

The report consists of a table to give you a quick and dirty (Q&D for the uninitiated) overview of the 1997 situation. Pests are rated, by "X"s as to their relative level of concern, within each jurisdiction. There was no attempt to amalgamate these ratings. Were information was available infestations were assessed either as inclining, static or decreasing. This shows up as arrows in the table.

If additional comment of significance was reported, the letter "C" in the table "prompts" the reader to look at the comment section of the report.

Region 3 - Southwestern
Arizona, New Mexico
Presenter: Jill Wilson, USDA Forest Service

Mountain Pine Beetle: 10,000 acres affected on north rim of Grand Canyon, most within the park. Pine stands very susceptible to attack.

Pinyon Ips: 17,000 acres affected, is a primary tree killer, 40% mortality in affected areas and mortality is climbing. Is attacking trees as small as 1.7" diameter at root collar.

Pinyon Sawfly: 3,000 acres affected, primarily on old foliage. Affecting pinion nut production.

Spruce Aphid: 27,000 acres of defoliation with unknown mortality, five established spots, some near ski areas. Worst in higher elevations, eg. White Mountains. Affecting Engelmann spruce.
Western Spruce Budworm: 150,000 acres affected with moderate defoliation, mostly in Northern New Mexico.

Region 4 - Intermountain
South Idaho, Nevada, Utah, Western Wyoming, some California (Tahoe area)
Presenter: Phil Mocittni, USDA Forest Service

Douglas-fir Beetle: Mortality down from 62,700 trees (1996) to 21,700 trees (1997). Increases seen in Utah.

Fir Engraver Beetle: Mortality decrease from 46,400 trees (1996) to 22,600 trees (1997). Declines mainly in Toiyabe National Forest and Tahoe Basin Management area. Increase in Utah especially. Manti-La Sal National Forest.

Jeffery Pine Beetle: Significant decrease in Toiyabe National Forest and Tahoe Basin Management area from 4,100 trees (1996) to 300 trees (1997).

Mountain Pine Beetle: Mortality increased from 29,100 trees (1996) to 35,000 trees (1997). Largest outbreak in Payette National Forest particularly in areas burned by fires of 1994. Decrease in Utah. Mortality also seen on whitebark and limber pines.

Spruce Beetle: 1997 mortality comparable to 1996 at 69,900 trees. Heaviest mortality in Dixie, Fish Lake and Manti-LaSal National Forests.

Western Balsam Bark Beetle: Decline in mortality to133,000 trees. Nearly 50% of the problems are in south Utah and of that 40% is in Bridger Teton National Forest in Wyoming.

Western Pine Beetle: Mortality comparable to 1996 with 4,900 trees killed. Mostly in south Idaho.

Region 5 - Pacific Southwest
California and Pacific Islands
Presenter: Dave Schultz, USDA Forest Service

California Budworm (*Choristoneura carnana* var *califorinica*): 5,000 acres of Douglas-fir affected in the Trinity Lake area. Both federal and industrial land affected.

Region 2 - Rocky Mountain
Colorado, Kansas, Nebraska, South Dakota, East Wyoming
Presenter; Bill Schaupp, USDA Forest Service

Douglas-fir Beetle: 7,000 trees killed, induced by fire and tussock moth.

European Gypsy Moth: First time detected for two consecutive years in one location (Wyoming).

Mountain Pine Beetle: Significant problem in the Vail area. Third year of increase in Colorado; rising in Wyoming and South Dakota. 40,000 trees killed.

Western Balsam Bark Beetle: 98,000 acres of spotty infestation. This beetle is part of an infestation complex.

Region 6 - Pacific Northwest
Oregon, Washington
Presenter: Iral Ragenovich, USDA Forest Service

Balsam Woolly Adelgid: Activity observed on 9,400 acres, down from 13,700 acres (1996). Most activity in Olympic National Park

Douglas-fir Beetle: Activity on 8,600 acres at 1.0 tree/acre mortality. Increased activity in Colville, Mt. Baker-Snoqualmie and Umatilla National Forests..

European Gypsy Moth: 1997 traps caught 69 moths. One identified as Russian Far East strain and one as central Siberian strain

Fir Engraver Beetle: Activity decreased from 377,600 acres (1996 @ 2.15 trees/acre mortality) to 26,000 acres (1997 @ 0.82 trees/acre mortality). Increase in Umatilla, significant acres in Wallowa-Whitman and Wenatchee National Forests.

Mountain Pine Beetle: Decrease in acres affected from 170,252 acres (1996 @ 3.45 trees/acre mortality) to 157,089 acres (1997 @ 2.16 trees/acre mortality). Decreases in whitebark, western white and lodgepole; increase in ponderosa and sugar.

Spruce Beetle: Tree mortality down from 31,800 trees (1996) to 6,500 trees (1997). All Engelmann spruce, over 70% in Okanagan and Wenatchee National Forests.

Western Pine Beetle: Decrease in mortality from 13,600 large and 12,400 small ponderosa (1996) to 2,900 large and 4,300 small ponderosa (1997).

Western Spruce Budworm: Decrease in visible defoliation from 191,000 acres (1996) to 166,000 acres (1997). Most activity in Glenwood area and Yakima Indian Reserve. Some increase in overall damage.

Region 1 - Northern
Montana, Northern Idaho, North Dakota, N.W. South Dakota
Presenter: Ken Gibson, USDA Forest Service

Balsam Woolly Adelgid: Infested areas increased to 56,300 acres. Most mortality seen in subalpine fir in north central Idaho.

Douglas-fir Beetle: Increase in infested areas from 7,400 acres (1996) to 9,500 acres (1997), most in western Montana, northern Idaho and Yellowstone National Park.

Eastern Spruce Budworm: Endemic populations, 1,600 acres affected.

Fir Engraver Beetle: Increase in affected acres from 19,000 acres (1996) to 115,000 acres (1997). Roughly 71,000 trees killed. Most mortality in northern Idaho.

Mountain Pine Beetle: Increase in infested areas from 53,000 acres (1996) to 72,000 acres (1997). Over 347,000 trees killed, 5% lodgepole. Most activity in Idaho panhandle and Lolo National Forests. Some areas as high as 100 attacks per acre.

Western Balsam Bark Beetle: Decline in infested areas from 53,000 acres (1996) to 47,500 acres (1997). Over 101,000 subalpine fir infested. High activity in S.W. Montana.

British Columbia
Presenter: Russ Cozens, B.C. Ministry of Forests

Douglas-fir Beetle: Static at 8,600 hectares affected, central B.C.

Mountain Pine Beetle: Increase in Prince George, Chilcotin/Cariboo and Nelson Regions. Affected area not precisely known.

Spruce Beetle: Of particular concern in the Mackenzie area. Third year of continued increase.

Western Balsam Bark Beetle: Increasing concern; 300,000 hectares of spotty infestation in the Prince George area, 23,000 hectares in the Kamloops area.

Western Spruce Budworm: Static at 45,000 hectares affected in the Kamloops area, 14,000 hectares in the Cariboo.

Alberta
Presenter: Steve Burke, Phero Tech Inc. for Hideji Ono, Alberta Land and Forest Service

Eastern Spruce Budworm: 1997 saw 64% reduction in defoliated areas in the Northwest Boreal Region to 33,146 hectares from 1996, lowest in 10 years, in part due to aggressive control effort. Moderate to severe defoliation in Northeast Boreal Region. Increase in defoliation in Wood Buffalo National Park to 134,707 hectares.

European Elm Bark Beetle: 30 beetles caught in traps in Calgary area, fungus *Ceratocystis ulmi* not found.

Region 10 - Alaska

Presenter: Ed Holsten USDA Forest Service

Blackheaded Budworm: 1,200 acres of defoliation in southeast Alaska; 30,000 acres in Prince William Sound area.

Eastern Spruce Budworm: Continued decline to 38,414 acres, significant decline in the Yukon River drainage.

Spruce Beetle: Decline from 1,100,000 acres (1996) to 544,315 acres (1997), some areas 80-100% of susceptible spruce has been killed. Roughly half the affected area is on the Kenai Peninsula.

FOREST INSECT PEST INCIDENCE REPORT 1997

As Presented at WFIWC 1998

INSECT	US R3	US R4	US R5	US R2	US R6	US R1	BC	Alta	US R10
Alder Wooly Sawfly *Eriocampa ovata*									X
Asian Longhorn Beetle *Anaplaphora glabripennis*				X					
Aspen Leafroller *Pseudexentera oregonana*								X	
Balsam Woolly Adelgid *Adelges piceae*					X↘C	XX↗C			
Birch Aphid *Euceraphis betulae*									X
Birch Leafminer *Fenusa pusilla*									X
Black Headed Budworm *Acleris gloverana*									X→C
Black Pineleaf Scale *Nuculaspis californica*					X→				
Bracken Fern Sawfly *Strongylogaster* sp.		X							
California Budworm *Choristoneura carnana (Californica*			XC						
Cooley Spruce Gall Adelgid *Adelgis cooleyi*		X							
Douglas-fir Beetle *Dendroctonus pseudotsugae*		X↘C		XX↗C	XX→C	XX↗C	X→C		
Douglas-fir Tussock Moth *Orgyia pseudotsugata*			X→	X	X→	X→			
Eastern Spruce Budworm *Choristoneura fumiferana*						X→C		XX→C	X↘C
European Elm Bark Beetle *Scolytus multistriatus*								XX→C	
European Gypsy Moth *Lymantria dispar*		X		XC	XXC	X→	X→		
Fall Cankerworm *Alsophila pometaria*		X							
Fir Engraver Beetle *Scolytus ventralis*		X↘C	X→		XX↘C	XXX↗C			
Forest tent Caterpillar *Malacosoma disstria*								X↘	
Hemlock Sawfly *Neodiprion tsugae*									X↘
Ips pertrubatus									X
Jeffery Pine Beetle *Dendroctonus jeffreyi*		XC	X→						
Larch Casebearer *Coleophora laricella*		X			X→	X↗			
Larch Sawfly *Pristiphora erichsonii*									X↘
Large Aspen Tortrix *Choristoneura conflictana*								X	X
Lodgepole Pine Needleminer *Coleotechnites milleri*			XX						

(con.)

INSECT	US R3	US R4	US R5	US R2	US R6	US R1	BC	Alta	US R10
Mountain Pine Beetle *Dendroctonus ponderosae*	XX↗C	X↘C		XXXX ↗C	XXX ↘C	XXX ↗C	XXX ↗C	X→C	
Pandora Moth *Coloradia pandora*					X↘C				
Pine Engraver Beetle *Ips pini*		X↘			X↗	X→			
Pine Sawflies *Neodiprion* sp.	X↗C	X							
Pinyon Ips *Ips confusus*	XX→C								
Pinyon Pine Needle Scale *Matsucoccus acalyptus*	X								
Poplar/willow Borer *Chryptorhynchus lapathi*		X							
Round Headed Pine Beetle *Dendroctonus adjunctus*		X							
Rusty Tussock Moth *Orygia antiqua*									X
Sagebrush Leaf Beetle *Trirhabda* sp.		X							
Satin Moth *Leucoma salicis*								X↗	
Sequoia Pitch Moth *Synanthedon sequoiae*		X							
Sitka Spruce Weevil *Pissodes strobi*									X
Spruce Aphid *Elatobium abietinum*	XXX↗C								X
Spruce Beetle *Dendroctonus rufipennis*		XXC		XC	X↗C		XX↗C	X	XXXX↘C
Western Balsam Bark Beetle *Dryocoetes confusus*		XX↘C				X→C	XX↗C		
Western Hemlock Looper *Lambdina fiscellaria*					X				
Western Pine Beetle *Dendroctonus brevicomis*		X↘			X↘C	X→			
Western Spruce Budworm *Choristoneura occidentalis*	XXC			X	XXX↘C	X↗	XX→C		
Willow Leaf Blotch Miner *Micrurapteryx salifolliela*									X
Xyelid Sawfly *Xyella* sp.		X							

Code: X - Insect was mentioned either at the conference or within printed material submitted at or shortly after conference time
XX - insect was mentioned as above and is of moderate concern
XXX - insect was mentioned as above and is of high concern
XXX - insect was mentioned as above and is of extreme concern

↘ - infestation levels in decline compared with 1996
→ - infestation levels comparable to 1996
↗ - infestation levels increased compared with 1996

C - comments included in text portion of report

7:30 -9:00 pm	State Forest Entomologists Meeting

No report submitted.

WEDNESDAY

8:30 - 10:00 am

Panel: Changing Human Perception of Forest Values: Implications for Forest Entomology

Moderator: Jesse Logan, Forest Service Research, Logan, UT
Tim Paine, University of California, Riverside
Dave Iverson, Economist, Region 4, Forest Service, Ogden, UT

Beyond Forest Pest Management

Jesse A. Logan, Logan Forestry Sciences Laboratory, 860 N 1200 East, Logan, UT

Attempting to understand the role and process of disturbance in ecosystems is an essential element of ecosystem management—**Jack Ward Thomas, 1996**

Not only does the large and slow control the small and fast, the latter occasionally "revolt" to affect the former as a part of a natural process of renewal—**Holling and Meffe, 1996**

Forest entomology, as a distinct and separate discipline, is in a state of serious decline. While there has been a nation-wide decline in importance and support for Forest Entomology, in no other region of the country has this decline been as devastating as in the West (particularly the interior West). In the recent past (25 yrs ago, for example), forest entomology was a viable, even premiere, subdiscipline of the entomological profession. This golden era was characterized by active forest entomology programs at most Land Grant Universities, abundant funding for research (i.e. the so called "big bug" programs), and optimistic employment opportunities for trained professionals in both the land management agencies (i.e. the USDA Forest Service) and the state universities. No characterization could be further from the current state of affairs. Many Western land grant universities no longer have any program in forest entomology, and those that do are likely to be vastly diminished from that of 25 yrs ago. Research funding is at an all-time low, and employment prospects for the few students that are being trained are less than optimistic. The reasons behind the eclipse of forest entomology are complex, however, the principle driving forces are the dramatic changes that are occurring in society and culture in the West and the subsequent, equally dramatic, shift that has accompanied these changes in the way forests and other natural resources are viewed by society. In the remainder of this essay, I will attempt to document that the perceived decline has in fact occurred, and discuss the changes that have occurred in western culture and society as they relate to forest entomology. Finally, I will provide one perspective on why it is important to reverse this trend and how we might go about doing so.

The allocation of monetary resources in a free market society is a reflection of the values of that society. Twenty-five years ago significant resources were being expended in forest entomology research. Much of this went directly to support Forest Service scientists, but significant resources also were made available to bolster university programs and to train graduate students. Since that time, the major funding from the Forest Service has shifted to other geographic regions of the country (gypsy moth in the East and mid-West, and southern pine beetle in the South). There has been an accompanying decline in Forest Service entomologists in general (over a 50% reduction in the past 25 yr) and there is no longer even a specific, identified research staff dealing with forest entomology (the Washington Office Staff, Forest Insect and Disease Research, was a casualty of recent government reorganization). The West has carried a disproportionate burden of the reduction in forest entomologists.

The university system in the interior West has also experienced a dramatic reduction in forest entomology programs. Although this decline is somewhat difficult to document, Colorado State

University, my Alma Mater, serves as an example. During the late 1960's, when I was a Masters degree student at CSU, there were 2 faculty working primarily in forest entomology, each supporting graduate students working on forest entomology projects. There was also a recently retired USDA Forest Service entomologist who held an active adjunct appointment and supported graduate students. Additionally, there was a forest insect project at the former Rocky Mountain Forest and Range Experiment Station that employed three forest entomologists, all active at some level in the affairs of the CSU Entomology Department. At the present time there are no forest entomologists on the Entomology faculty, no students are being trained in forest entomology, and there is no longer a Fort Collins based forest entomology research project in the Rocky Mountain Research Station. Forest entomology is clearly not a priority issue at Colorado State University. Other Universities have experienced similar declines in forest entomology. During the late 1960's, UC Berkeley had 4 forest entomologists on the faculty, there was a major Forest Service research project located on the Berkeley campus (6 forest entomology scientists), and most importantly, over 20 graduate students were being trained in forest entomology. At present, there is only one forest entomologist on the faculty (nearing retirement) who supports 6 graduate students. There are currently four USDA Forest Service entomologists in the entire Pacific Southwest Experiment Station.

Why has this decline occurred? I certainly make no claim to be a spokesman for forest entomology, but as Project Leader for one of the few remaining western forest entomology research projects in the USDA Forest Service, I have given considerable thought to this issue, often in response to direct questions regarding the legitimacy for continued funding. In this presentation I wiil present one person's view of the current status of forest entomology in the West, particularly the interior West east of the Cascade/Sierra crest and West of the 100th meridian.

The Evolving Concept of "Multiple Use"

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

The concept of multiple-use forestry has a long history as a management strategy for much of the forested public lands in North America. This concept assumes that many forests can be simultaneously managed for rangeland, watershed, wildlife, mineral, recreation, and timber production. However successful this strategy has, or has not, been implemented, the public has frequently perceived forest use as dominated by an emphasis on timber production. The extraction of resources has been perceived by many as the primary organizational/ administrative use of forests.

The concepts of forest use or forest values have changed in recent years. The view of insects and pathogens in forests has also changed. Managers have changed their approach to these elements from pest management of insects and diseases to forest health protection to ecosystem management. A cursory survey of sites on the Internet suggests that the value of forests as wild open space and ecological habitats maintained for biodiversity has surfaced as an increasingly important element in public perception of these areas. Ecosystem integrity is perceived as a highest priority. Simultaneously, the public has increased the demand for forest protection to allow greater direct access to forest sites. This can be viewed as part of a changing lifestyle in which forests are perceived as either refuges or buffers to an urban existence. Ironically, the increased demand for access has also increased demand for services, and has contributed to the urbanization of forested areas. This has led to predictable conflicts between competing perceptions of forest values and restrictions on use. Finally, the value of forests as a source of employment and maintenance of a timber-based lifestyle has surfaced in the Pacific Northwest. This lifestyle-based value is gathering strength in many regions that have been severely affected by reduced timber harvests resulting from emphasis on other forest values.

The changes in forest management objectives away from a timber-based focus has been influenced by a large number of factors. Changes in public perception of value of the forest are critical components in the development of new policies for use of public lands. However, changes in perception may be partly based on the increased urbanization of North America, and the increasing unfamiliarity of the public with basic concepts related to wood and fiber production. The agricultural production industries have faced similar problems in maintaining the resource base required to meet the rising demands for produce. The lack of information of knowledge on the part of an urban population about basic requirements for production of high quality, inexpensive food and fiber creates significant perception issues.

Forests have many values that can, at the same time, include aesthetic, spiritual, and economic elements. However, it may be time to reevaluate the multiple-use concept as an expression of those values. Not all forests may be appropriate for all uses. It becomes a question of stewardship to maintain the balance between needs. It seems to be increasingly difficult to find that balance with the same lands. It is ironic that with increasing growth and demand for use, there is also an increasing demand for protection of what appears to be wild space. The challenge is to find the balance when the issues are becoming increasingly polarized. It may be possible to accommodate the values of the forest resources by developing a public distinction between agroforestry/ plantation forestry and ecoforestry. The public needs to become more directly involved in the process of setting management or stewardship goals and objectives. The result of this process will mean setting the highest values for particular lands recognizing that those values are not the same for all lands.

The Transformational Nature of Cultural Values

Dave Iverson, Region 4, Forest Service, Ogden, UT

When Jesse Logan asked me to be part of this panel I asked myself, "Why would 'bugs and crud' practitioners be interested in Changing Perceptions of Forest Values?" I suspect that part of the answer lies in the fact that we are all a part of the rapid spread of humans across the face of the West, transforming values both in rural and urban environments throughout. And we are all wondering just what these new values might be. But part of the answer lies, I suspect, within a phenomena I know well: your own professional survival and respect. That is, "Why are there so few of you in the Forest Service and other government agencies State and Federal if 'restoration ecology' and 'forest health' are the big-deals everyone says they are?" Furthermore, "Why is it that you don't sit at any (or at minimum very few) tables where important natural resource decisions are made?"

Social scientists in government feel similarly dismissed. "Human dimensions of ecosystem management" are supposed to be as important as "biological" and "biophysical" dimensions of ecosystem management, and "collaborative stewardship" is talked up as the new order of the day in the U.S. Forest Service and other government agencies. Still, we social scientists note that our presence is declining in federal government agencies and has been since the mid-1980s. Like you, we social scientists sit at no tables where important decisions are made.

This morning I hope to give you a glimpse of my world as a social scientist and offer you a bit of hope that the time may yet come—may indeed be close at hand—when both social scientists and forest health specialists will be integral parts of big-deal decisions for federal and state land and resource management agencies. To begin to understand why, we need to address two inter-related themes. First, we need to talk about three great cultural transformations that have in essence changed everything for we humans. Second, we need to focus on a recent change in mindset—a focus on sustainability—that may guide this latest cultural transformation. I stress the word may because there are many paths to the future that have little to do with "sustaining quality of life for humans and others far into the future," my definition of sustainability. It will be up to us, individually and collectively, to decide which path to follow into the future.

Three Great Transformations

The first wave of cultural transformation is commonly called the Agricultural Revolution. The second wave is called the Industrial Revolution, and the third wave is called the Communications or the Information-Age Revolution. What we need to pay attention not so much to what happened—is happening—as to how it happened. Think about a fire spread model or an insect outbreak model. The cultural transformations must be viewed, or modelled in the same way.

Throughout the so-called first wave of civilization, the agrarians overran the nomadic herders and hunter gathers, replacing old with new as they went—new customs, new institutions, even new concepts of God. The industrialists did the same a few centuries later. In both cases, they left mosaics of older cultural forms in their path. But like forest replacement fires there was little doubt that the wave had passed through. The whole cultural landscape was transformed.

In each case the transformation wave began slowly, then gained force as it moved along—systems dynamics at work. To gain perspective, think back just one hundred years, not even enough time to sneeze at when measured in geological time. What was life like a hundred years ago? The agricultural revolution was well along, and the industrial revolution was building steam—literally and figuratively. We had no automobiles, only a handful of primitive telephones, no TVs, computers, and no global information networks.

In the course of one human lifetime our perception of reality changed as the Industrial revolution transformed our culture. And just as we were beginning to grasp the magnitude of that transformation, it was itself overrun by the Information-Age wave. Right now we have a culture that is struggling to reconcile functions, structures, even values that are a mismatch of forms from all three eras. Alvin and Heidi Toffler (1995) argue that we have a legislative government system that is a hold-over from the agriculture era, business and administrative government systems that were largely patterned after industrial era models and vectors of change challenging all our institutions forcing their way into the system from Information-Age startup organizations and institutions that are growing rapidly in strength. These transformations obviously have great impact on our thinking and our values.

Three fundamental features define "modern" cultures left in the wake of the Agricultural and Industrial Revolutions. These features are: belief in human domination of nature, belief in the primacy of method (technologically oriented science), and the belief in the sovereignty of the individual (Borgmann 1992). Postmodern critics stress the point that "modern era" values of "individualism," "domination of nature," and on the "primacy of method," forced from our field of vision earlier notions of "community," "living in nature," and the fundamental importance of knowing what "ends" are important and why they are important to us. We could argue that Information-Age cultures will need to champion community and individualism, living in nature and living apart from nature, and focusing on both means and ends. But we can find underpinnings of this agenda in some of the stated goals of the modern era. Problem was it just didn't turn out that way. A looming question is, "Will we find a way to make it happen? "

Sustainability as a New Watchword

One hundred years ago we were busying ourselves opening up new frontiers, literally across the landscape and in our thoughts and values. Manifest destiny was a watchword, and progressive scientific management was a governmental imperative. Families were big and growth desirable. Natural resources were abundant, although problematic which set the stage for federal and state natural resource management agencies. (note: When I say "we" I'm talking about those of us riding on the cultural wave of transformation, not those plundered by it. Those plundered by our transformational waves must be kept in the forefront of our thoughts lest we become even more violent and less caring than we already are.)

Today, things are much different. Frontiers are mostly in cyberspace. We killed both manifest destiny and traditional notions of God along the path. Progressive scientific management is now considered suspect, along with all the so-called professions including engineering, medicine, law, and so on. Families are smaller and everywhere—even in gathering like this one—people talk about the implications of adding yet another billion people to the planet in the next decade.

Again there are mosaics in this pattern. And the idea of God isn't really dead, just transformed once again to better reflect dominant cultural mores. Certainly during the course of the agricultural and industrial revolutions we self-fulfilled ancient prophecy: we multiplied and filled the world with our species. We dominated nature to a point that has begun to make us afraid. Is it any wonder that some of us are at least talking about "sustainability," and wondering whether or not we can make sustainability a new watchword to rally around?

Let's pause for a moment. What does this have to do with those of us gathered together today? How can this help us gain support for forest entomology, for forest health initiatives, for social science initiatives? In order to begin to form answers to these questions, we need to think deeply about what this moment in history is really about. It is about people, about people beginning to be afraid—afraid that the old order of things doesn't work anymore. About people is where we social scientists come in. About people being afraid is where you come in. Think about the all the recent fuss over the Earth Summit, the Santiago Declaration on Sustainable Forestry that Ann Bartuska talked about yesterday, the Global Warming Summit "Kyoto Protocol," and so on. Think about the fact that the bio-evolutionary model for life is now center stage in thinking ranging from medicine, to management, to economics and cultural anthropology, even physics (Capra 1982, Gould 1996, Smolin 1997). The bio-evolutionary model is your model, and it is beginning to have wide-ranging applicability. The books are already written and the messages are beginning to find their way into popular press, media, and other cultural mainstreams. Now we have only to apply that thinking to all aspects of our existence. I do not want to leave the impression that there is no dissent. I just want to stress the point that the dissenters are increasingly marginalized as the latest cultural transformation wave gathers momentum. I also do not want to leave the impression that I am an overly optimistic about our prospects for making it through this transformation without much suffering, indeed about our prospects for maintaining any semblance of order during the transformation. Like E.O. Wilson (1998), I only hope that we will not throw everything away at this moment of cultural chaos and crisis.

Certainly people distrust science and scientists right now, but many distrust a lack of science more. At least those seeking sustainability are likely to distrust a lack of science more. But it is clear that those seeking sustainability also seek a transformation of science, toward a more encompassing view that centers on life rather than on abstract notions of physical law. With the many fears that grip our world, at least there is a chance that prudent ecosystem managers will see out your advice and champion your worldviews and models—to the extent that your models are found compatible with sustainability thinking.

Finally we get to the heart of the issue before us: prudence and prudent ecosystem managers. Will sustainability be a rallying cry for humanity as ecosystem managers? Will we pull together to protect and maintain those systems that create and maintain quality of life for humans and others on Earth? Will we do it in the United States, where we are addicted to conspicuous consumption and a fixation on "growth"? If we find the will to do it both here at home and abroad, we will have to transform many (perhaps all) of our institutions. Consider this short list: Government of, by, and for special interests will have to recognize overriding "public interest" while protecting "private interest" in the context of public interest. Religious institutions will have to make sustainability a keystone. "Stewardship" will have to replace "domination." Educational institutions will have to abandon the multi-versity tradition, trading it for a university tradition centered on sustainability. The press will have to radically alter its focus away from sensationalism and feeding-frenzies on whatever sells. We as individuals will have to become much less self-centered and much more community-centered and service oriented in thought and action.

Will we make it, or will be disintegrate into warring tribes armed with ever-more-destructive weaponry? You decide. As for me I stumbled onto a principle from complexity theory some years ago that gives me a modicum of hope. It is called "the butterfly effect" and says, in essence, that small changes in initial conditions can effect dramatic changes in final outcomes. There are small changes at work in all the institutional arenas I've mentioned and in many more. But the seeds planted may or may not take root. We will choose a path (individually and collectively) toward sustainability or we will not. The jury is still out and will be out for some time for both culture at large and for the subcultures of what we used to call "natural resource management." As Kevin Ryan mentioned yesterday, our challenge is to move away from our older behavior of managing timber, range, etc. for fun and profit, putting out fires with wild abandon, and chasing bugs. We have to learn much more about the bio-evolutionary dance called life and our cultural connections to the whole of it. Your part is very important. All of our parts are very important.

Remember that your models underlie the best explanations of the mileposts of our cultural journey—as augmented by individual and cultural learning opportunities that are unique to human endeavors (Gould, 1996). And remember that your models served to launch statements like, "It is not business or the environment, it is always both." If you are to take your place in important councils it will be up to you to show your connections to the broader workings of nature and culture. None of us can afford to sit and wait for the powers that be to come to us. If we are to do our part in making sustainability a rallying cry for humanity we have to reach into extant councils and deliver important wake-up calls. And then we have to be ready to help make those councils much more effective in plotting a course into the future following a path of sustainability.

Related Reading

Karen Armstrong. 1994. A History of God: The 4000-Year Quest of Judaism, Christianity, and Islam. Alfred A. Knopf.

Albert Borgmann. 1992. Crossing the Postmodern Divide. University of Chicago Press.

Fritjof Capra. 1982. The Turning Point: Science, Society, and the Rising Culture. Bantam Books.

Fritjof Capra and David Steindel-Rast with Thomas Matus. 1991. Belonging to the Universe: Explorations on the Frontiers of Science and Spirituality. HarperSanFrancisco.

Riane Eisler. 1987. The Chalice and the Blade: Our History, Our Future. HarperCollins.

Neil Everden. 1992. The Social Creation of Nature. John Hopkins University Press.

Stephen Jay Gould. 1996. Full House: The Spread of Excellence from Plato to Darwin. Three Rivers Press.

Kevin Kelly. 1994. Out of Control: The New Biology of Machines, Social Systems, and the Economic World. Addison Wesley Publishing Co.

Jerry Mander. 1991. In the Absence of the Sacred: The Failure of Technology & the Survival of the Indian Nations. Sierra Club Books.

Daniel Quinn. 1993. Ishmael. Bantum Books.

Daniel Quinn. 1995. Providence: The Story of a Fifty-Year Vision Quest. Bantum Books.

Daniel Quinn. 1997. My Ishmael. Bantum Books.

Lee Smolin. 1997. The Life of the Cosmos. Oxford University Press.

Alvin Toffler. 1980. The Third Wave. William Morrow and Co.

Alvin and Heidi Toffler. 1995. War and Anti-War: Making Sense of Today's Global Chaos. WarnerBooks, Inc.

Alvin and Heidi Toffler. 1995. Creating A New Civilization: The Politics of the Third Wave. Turner Publishing, Inc.

Edward O. Wilson. 1988. Consilience. Alfred A. Knopf.

10:00 - 10:30 am	Break
10:30 am - 12:00 pm	*Concurrent Workshops* **Landscape Strategies to Mitigate Insect Impacts** Moderator: Darrell Ross, Oregon State University

Landscape Strategies to Mitigate Insect Impacts

Moderator: Darrell Ross, Oregon State University, Corvallis, OR

About 20 participants attended this workshop. The first half of the workshop was a presentation by Jack Amundson, Regional Silviculturist for the USDA Forest Service Intermountain Region. Jack's presentation was entitled "Rapid Assessment Process Using Properly Functioning Conditions." The second half of the workshop was filled with discussion among the speaker and participants of the properly functioning condition process in the context of approaches used by other groups to meet the same objective.

The concept of properly functioning conditions (PFC) has been used by the Intermountain Region for analysis and planning at a variety of scales. PFC is a rapid assessment process and is part of a greater whole. This greater whole is termed "Taking an Ecological Approach" or less precisely "Ecosystem Management". Ecosystems at any temporal or spatial scale are in a properly functioning condition when they are dynamic and resilient to perturbations to structure, composition, and processes of their biological or physical components.

All PFC assessments should use an ecological approach. An ecological approach requires consideration of three spheres, biophysical, social, and economic. Although PFC works mainly within the biophysical sphere there is significant relevance to the social and economic spheres. This is a coarse filter approach. The assumption is that if vegetative communities and their processes are similar today to those occurring historically; then conditions approximate those under which species evolved. Presumably, therefore, the full complement of species will persist. The most basic concept inherent in an ecological approach and in PFC is sustainability.

The design of this process includes three scales; regional, sub-regional, and landscape. Planning and analysis scales were used instead of Forest Service National Hierarchical Framework of Ecological Units scales for simplicity and because PFC is a planning assessment.

Basic characteristics of ecosystems include structure, composition, processes, and patterns. A matrix with these four characteristics as criteria and at three scales was developed to assess PFC. The matrix is used to describe each individual subject area to be assessed. At the scale of the Intermountain Region the subject areas include 16 vegetation types, a hydrologic regime, a soil quality description, and an aquatic and terrestrial animal description. Indicators of a properly functioning condition were developed for each subject area, by criteria, and at each scale.

Ecosystems vary in time and space. Changes may be rapid or gradual but change occurs. The term "historical range of variation" refers to ecosystem compositions, structures, processes and patterns for a specified time and for a specific area. The potential for survival of native species is reduced if their environment is pushed outside the range of natural variation. Ecosystems have the capacity to change drastically over short or long periods of time and from place to place. As a result, ecosystem components and processes are adapted to a range of conditions. It is believed that native species adapted to and, in part, evolved with the disturbance events of the preceding several thousand years. This provided patterns of landscape and ecosystem variation that were apparently self-sustaining.

Successive generations of the same biota under the same conditions give the best indication of sustainability. In the western states, the conditions present prior to European settlement is often used to indicate the historical range of variability. Threshold areas are identified to establish acceptable ranges of PFC to provide for ecosystem sustainability and resiliency. Thresholds are developed using the concept of the historical range of variation.

The PFC assessment process is as follows:

1. Define scale of assessment (temporal and spatial).
2. Assemble team of technical experts for scale(s) being considered.
3. Utilize the appropriate matrices by subject area to determine kind of resource information needed and available.
4. Select the appropriate subject areas and assess whether they are or are not in PFC.
5. If subject area(s) are not in PFC estimate the degree of departure from the PFC.
6. Summarize the results for the selected geographical and temporal scale and estimate a relative risk in terms of subject area or combinations of subject areas.

Biological Control: Risks and Benefits
Moderator: Don Dahlsten, University of California, Berkeley

Biological Control: Risks and Benefits

Moderator: Donald L. Dahlsten, University of California, Berkeley
Recorder: Diana L. Six, University of Montana, Missoula

Participants: Approximately 27 people were in attendance.

This workshop was an informal, general discussion of several topics in biological control. The workshop was introduced with a definition of biological control: The importation, augmentation, conservation of natural enemies to control pests. It was agreed that this definition does not include genetically altered organisms or bio-pesticides.

The topic of the resources (both monetary and personnel) available in biological control (BC) was raised. While monetary resources have never been very high for BC, many researchers are concerned with a continued decline in funds available. The loss of university personnel was also a concern. The number of BC positions in the west has declined dramatically as have positions training new BC people and the taxonomists that are so critical for this type of work. The University of California, Riverside, however, has in recent years placed a priority on BC taxonomists and has recently hired the first BC extension person in California as well as having built a new insectary and quarantine facility. The University of California, Berkeley, also has a new quarantine facility at the Oxford tract.

It was suggested that we, as scientists, need more than ever to collaborate and pool our resources in order to get the job done. Insecticide use has gone up at the same time that funding for BC has gone down. This is occurring at the same time that habitat restoration and environmental quality is being stressed.

One area where funding and effort is increasing is in BC of weeds in the forest. This may be an effect of a shift in forestry away from timber production to the management of the forest for other resources including recreation and wildlife habitat.

It was mentioned that we need some good economic information on our BC projects and their benefits to really sell our work and to maintain funding. Part of selling the value of BC will need to involve stringent risk assessments. It was suggested that we need to start screening insects introduced against insect pests as stringently as we screen insects to be released against noxious weeds. Concerns are being raised by scientists and the public on the impact of introduced natural enemies on non-targets. We need to deal with these concerns now before we are forced to by negative public opinion. However, it was acknowledged that it is difficult and expensive to do such risk assessments and even after many tests we can not always predict what a particular natural enemy will do when introduced into a new environment. Time is also a problem. By the time extensive testing is completed, the pest may have spread and be difficult to control.

A call for developing a standardized protocol for the introduction of all biological control agents was made by several participants. It was suggested that a protocol is needed now to show that we are concerned and serious about reducing non-target risks. By developing a protocol voluntarily, researchers would have a chance to develop this protocol before we are required to do it by law and thus allow science to dictate the protocol, not politics.

The topic of releases of exotics to control native pests was raised. Such releases were unanimously condemned by workshop participants. Several concerns were voiced. These included (1) that such releases might cause dissention and conflict with environmentalists, (2) that such releases may impact the roles of native pests in maintaining forest health and ecosystem function, (3) that hybridization and dilution of genotypes may occur with some predators, and (4) that we don't yet fully understand the roles of many of our extant natural enemies and we should learn more about them before we introduce potential antagonists.

Pheromone Implementation:
Why it Works & Why it Doesn't
Moderator: Steven Seybold, University of Nevada, Reno

Pheromone Implementation: Why it Works and Why it Doesn't

Moderator: Steve Seybold, University of Nevada, Reno

Attendees

John Anhold, Dayle Bennett, Ron Billings, John Borden, Cindy Broberg, Jenifer Burby, Steve Burke, Roger Burnside, Bob Cain, Valerie DeBlander, Ken Gibson, Jane Hayes, Ed Holsten, Dezene Huber, Mike Hulme, Nicole Jeans, Kier Klepzig, Steve Kohler, Susanne Kühnholz, Ladd Livingston, Rory McIntosh, Roy Mask, Vic Mastro, Laura Merrill, Tiffany Neal, Robert Peck, Robin Petersen, Nancy Rappaport, Richard Reardon, Karen Ripley, Terry Rogers, Darrell Ross, Guillermo Sanchez, Dave Schultz, Lia Spiegel, Sheri Smith, Jack Stein, Brian Strom, Jaime Villa-Castillo, Mike Wagner, Kimberly Wallin

Introduction

At this well-attended workshop, the moderator began by encouraging the participants to keep the workshop informal, and he provided a series of discussion topics to act as a guide for the session. The topics included a review of recent workshops dealing with the application of pheromones to forest insect management, technological issues associated with pheromones, the concept of blending or integration of different strategies that appears to be going on with the application of semiochemicals, the role of biological variation in the success of pheromone implementation, and finally technology transfer (i.e. extension) and intangibles associated with the application of pheromones. Darrell Ross suggested that the registration of pheromones for forest insect management might also be included in the discussion. Most of these topics had been identified as important issues at previous workshops/discussion groups on the implementation of pheromones in forest entomology held in Denver (NAFIWC, 1991), Kailua-Kona (Special Symposium on Development of Western Bark Beetle Pheromones, 1992), Sacramento (WFIWC, 1993), Indianapolis (ESA Nat. Meeting, 1993), Albuquerque (WFIWC, 1994), Rapid City (WFIWC, 1995), and San Antonio (NAFIWC, 1996). Although the application of pheromones to forest insect management has been a frequent topic of discussion, it is a rapidly changing area of great promise that merits frequent attention of the forest entomological community.

Technological Issues

Two major areas of technology were discussed: the chemical fidelity of pheromones (i.e. do we have the correct compounds and are they stable in the field?) and new developments in trap design/release devices. Newly isolated compounds from the Douglas-fir tussock moth and the vagaries of the response of the spruce beetle to its currently formulated attractants suggest that we might have to revisit many of our forest insect pheromone systems using the GC-EAD technique (John Borden). Steve Burke reviewed Phero Tech's plans for slight design modifications in their bark beetle funnel trap. The basic design of the trap will be the same, but it will be easier to repair with a snap-together construction, have a better fitting collection cup, and have greater availability of replacement parts. Darrell Ross described a bark beetle trap being developed in Oregon by IPM Technologies that would aim to be more portable, less expensive, and easier to store. Steve also described some release rate devices involving new polymer technology and construction. These devices promise to provide more controlled release of pheromones, but cost may be a factor in their further development. In the future we may even see release devices that are based on "puffers" with solar-driven timing mechanisms or modified fuel injectors from auto engines (also costly).

Registration of Pheromones

Nancy Rappaport and Jack Stein described their work as liaisons between the Forest Service and EPA for pheromone registration issues. They felt that a fairly complex process is becoming more streamlined and that the key is providing relevant information quickly to EPA. As liaisons they felt that they were given good access to the EPA process and were optimistic about the future registration of pheromones for forest insect management. Darrell Ross disagreed and a vigorous discussion ensued.

An Integrative Approach to the Application of Pheromones

Pheromones are not really the magic bullets that the public and practitioners might perceive them to be. In reality, to be used effectively in pest management, pheromones might need to be integrated with other behavioral odor stimuli (host/non-host odors, insect interspecific odors), other behavioral stimuli (e.g. visual, gustatory), and other IPM strategies (e.g. silviculture, timing of logging operations and log storage, timing of cargo inspections, etc.). Brian Strom described his studies of the responses of the southern pine beetle (SPB) and associated insects to pheromones combined with various visual stimuli. These stimuli included trees and traps painted with white or black paint. Apparently *Ips* spp. associated with the SPB are not as sensitive to visual cues (particularly white paint) as the SPB. Thus, SPB might be a visual specialist, while *Ips* might be a visual generalist. The issue of whether altering the visual silhouette of trees could be integrated as an application with pheromones was discussed and one unresolved question is how differences in light quality in an urban setting (e.g. a golf course) and a forest setting might affect this application. What is clear is that a deeper understanding of all stimuli that impact on host selection of forest insects and an integration of other techniques with pheromones might ultimately provide us with more efficacious treatments for insect management.

The Impact of Variation on the Application of Pheromones

The natural variability in the production and response to pheromones by insects has in some cases constituted a barrier to their operational use in insect management. This variation can include individual variation, geographic variation, variation in population type (e.g. outbreak vs. non-outbreak), or perhaps seasonal differences. For example, inconsistent results with the anti-aggregation pheromone verbenone and the mountain pine beetle have been attributed to differences in year-to-year responses by the beetles, differences in forest type, or geographic or regional differences in the populations. It is possible that within a population verbenone might inhibit most individuals, but attract certain others. Once the olfactory shield of an interruptant compound like verbenone is breached and the natural aggregation pheromone system of the insect engages, the operational treatment is doomed to failure. In the workshop we discussed two cases where geographic or individual variability was apparently impacting the operational use of pheromones. One case was the use of (-)-verbenone and racemic ipsenol as interruptants to protect broadcast slash from attack by *Ips pini*, while the other system was the attractive response of spruce beetle. Although verbenone and ipsenol were effective in preventing colonization of ponderosa pine slash by *I. pini* and *I. paraconfusus* in northern California (work by Pat Shea), Ken Gibson reported that he and Ladd Livingston have had variable results with several formulations of these interruptants and *I. pini* in small piles of ponderosa pine slash in northern Idaho and western Montana. Their best results (i.e. most interruption) were in a 1996 study when the release devices were placed on stakes (one- and three-feet above ground level) surrounding the slash piles. However, this treatment was ineffective in a 1997 study with slash that was broadcast rather than piled and the stakes were either surrounding the plots or were distributed evenly within the plots. John Borden suggested the possibility of incorporating other interruptive semiochemicals (e.g. non-host volatiles) into the operational treatment. The pharmaceutical industry is pursuing "combinatorial testing" of banks of potential drugs, and perhaps we might need to emulate that industry when we attempt to develop semiochemical treatments.

A second case of geographic variation discussed in the workshop involved several populations of spruce beetle on Lutz, white, and Sitka spruce in Alaska and a population on Engelmann spruce in the Dixie National Forest in Utah. Ed Holsten described various studies in California, Oregon, Washington, and Alaska that have been geared toward understanding possible regional variation in pheromone plumes in forested canopies and elution rates of spruce beetle semiochemicals (MCH and verbenone) from release devices like beads and bubble caps. Since temperature dictates the release, elution rates of verbenone in California can exceed those in Alaska by 15x. Thus, there is an element of physical or weather-dependent variability when considering the application of semiochemicals over wide geographic areas. Ed also showed how a bead formulation tested in California and Alaska only released MCH during a narrow two-week interval thereby decreasing the chances of successful interruption if treatment with the beads did not coincide with the flight of the spruce beetle. Ed commented that MCH, despite being listed for spruce beetle during registration, might not be a very effective interruptant for spruce beetle in Alaska. John Anhold briefly described the use of MCH to protect Engelmann spruce from attack by spruce beetle in environmentally sensitive campgrounds in Utah. This work has been ongoing since 1994. Ed suggested that successful use of spruce beetle semiochemicals in certain regions might reflect the underlying geographic variability in the species. This species is actually the result of multiple taxonomic synonymies, and Ed reported differences in spruce beetle responses to semiochemicals within south-central Alaska, let alone in British Columbia and Utah. The discussion concluded with the recognition we might need to move toward regionally-specific attractants and interruptants (as Phero Tech has done for the *Ips pini* pheromone) for species with extreme geographic variability.

	Advances in Risk Rating Systems Moderator: Tom Eager, Forest Health Protection, Gunnison, CO
12:00 - 12:30 pm	***Photo Session***
12:00 - 1:30 pm	**Lunch**
1:30 - 7:00 pm	**Poster Displays**

Association of Pitch-Eating and Pales Weevils with *Leptographium* spp. in Loblolly and Longleaf Pine

Kier D. Klepzig, Southern Research Station, USDA Forest Service, Pineville, LA

Root feeding insects are frequently associated with one or more species of stain fungi (*Leptographium* spp.). These insect-fungal complexes have been associated with declines and diseases of conifers, and hypothesized to act as predisposing agents to attack by tree-killing bark beetles.

We monitored abundance of root feeding insects in thinned and unthinned loblolly pine (*Pinus taeda*), as well as in longleaf pine (*P. palustris*) stands before and after prescription burns. We captured insects in pitfall and multiple funnel traps baited with ethanol and turpentine, and then plated them on medium selective for the isolation of stain fungi. We also artificially inoculated Two isolates of *L. procerum* recovered from captured insects into loblolly and longleaf pines to quantify their virulence.

Five insects were abundant in traps: Pitch eating weevil - *Pachylobius picivorus*, Pales weevil - *Hylobius pales*, Black turpentine beetles (*Dendroctonus terebrans*) and two root feeding bark beetles (*Hylastes salebrosus* and *H. tenuis*). All were more common in thinned than in unthinned loblolly pine stands. Patterns of insect abundance in longleaf pine stands before and after burns were unclear. *Leptographium procerum* and *L. terebrantis* were most commonly isolated from root insects. Pitch-eating weevils carried *L. procerum* more frequently in thinned than in unthinned loblolly pine stands ($p<0.01$). Pitch-eating and pales weevils both carried *L. procerum* more frequently in loblolly pine than in longleaf pine stands ($p<0.0001$, 0.10). *L. procerum* induced resinous lesions in loblolly and longleaf pines were larger than mechanical wounds, but did not differ significantly by host tree species.

Thinning activity in loblolly pine is associated with increased abundance of root insects which vector *L. procerum* capable of causing stain symptoms. The same insects are present in longleaf pine stands at lower numbers. The role of prescribed burning in affecting their abundance needs further study.

Augmentative Biological Control of Southern Pine Beetle

John D. Reeve, Southern Research Station, USDA Forest Service, Pineville, LA; M. Guadalupe Rojas, Subtropical Agricultural Research Center, USDA ARS, Weslaco, TX

The southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae), is a major pest of pine forests in the southern USA. Although a number of control methods have been developed to treat *D. frontalis* infestations, in many cases the beetles are able to reproduce and disperse to other infestations before or even after treatment. This problem could be alleviated by combining these methods with augmentative biological control using native natural enemies. One potential candidate for augmentation is the predator *Thanasimus dubius* (Coleoptera: Cleridae). If this predator could be reared in sufficient numbers, then its larvae could be released onto infested trees to destroy the brood inside, or adults released into an infestation to prey on adult *D. frontalis*. We present preliminary results for an artificial diet for *T. dubius* larvae that could be used to implement a mass-rearing scheme. The diet was derived from one developed for *Catolaccus grandis* (Hymenoptera: Pteromalidae), a parasitoid that attacks boll weevil. The nutritional content of *Ips grandicollis* larvae (a prey species that is easily cultured) was determined using HPLC, and the *C. grandis* diet modified to match it using inexpensive components. The diet was then presented to the predator larvae sandwiched between strips of stretched Parafilm®. The longevity and fecundity of the adults reared on the diet were similar or better than adults reared using *I. grandicollis*, and survival from egg to adult was higher (Table 1). The results further indicate that the factitious prey *C. maculatus* could be substituted for natural prey in feeding adult *T. dubius*. We also present a laboratory test of augmentation using *T. dubius* eggs with *I. grandicollis* as the prey. Loblolly pine logs were infested with three different initial densities of adult *I. grandicollis*, and 0, 25, 50, 100, or 200 *T. dubius* eggs then added. The number of *I. grandicollis* adults that emerged decreased significantly as egg density increased (Fig. 1), suggesting augmentation would also be effective for *D. frontalis*.

Estimating Extent of Mortality Associated with the Douglas-fir Beetle in Central and Northern Rockies

Jose Negron, Rocky Mountain Research Station, USDA Forest Service

A Cooperative project among Forest Health Protection units in Region 1, 2, and 4 and the Rocky Mountain Research Station was started in 1994. The project was funded by Forest Health Protection, WO, through the Technology Development Project Program. The objective was to quantify mortality caused by the Douglas-fir beetle using stand and site data in various parts of the range of the insect. Study areas were established in various parts of the Shoshone NF in Wyoming, parts of Utah, Idaho, and Montana. Data collected from the various study sites was analyzed using linear regression, the Regression module of Classification and Regression Tree analysis, and Loess Regression as a visual technique. Significant simple linear regressions to predict Douglas-fir basal area using Douglas-fir basal area as predictor variable were built for all study sites. Correlation coefficients ranged from 0.26 to 0.65. Regression tree models with R2 values ranging from 0.23 to 0.69 were also built for all study sites. These regression tree models predict average Douglas-fir basal area killed based on Douglas-fir basal area or stand density index or both. Loess regressions provided a visual analysis of how the regression trees were splitting the data and supported the splits closely. Using results from the regression tree analysis, potential damage classes were built using Douglas-fir basal area as a predictor variable. Since the regression trees produce terminal nodes with reduced variances they represent natural clusters of expected mortality, which is an alternative to arbitrarily splitting the data into damage classes. Data from the Utah study area was presented as an example of the results.

Stand Hazard Rating for Central Idaho Forests

Julie Weatherby, Forest Health Management, Boise Field Office

Robert Steele, Ralph Williams, Elizabeth Reinhardt, James Hoffman, Ralph Thier and I developed an approach for assessing relative vulnerability of forest stands to the major change agents as an indicator of forest health (Steele et al. 1996). Primary change agents addressed in the hazard rating system include Douglas-fir beetle, mountain pine beetle, spruce beetle, western pine beetle, Douglas-fir tussock moth, western spruce budworm, dwarf mistletoe, annosus root disease, armillaria root disease, Schweinitzii root/butt rot and wildfire. We used existing hazard ratings whenever possible. Hazard ratings developed by Amman (1977) for mountain pine beetle and lodgepole pine, Schmid and Frye (1976) for spruce beetle, and Weatherby et al. (1993) for Douglas-fir tussock moth were used. The western spruce budworm hazard rating was a modification of a hazard rating developed by Wulf and Carlson (1985). The dwarf mistletoe hazard rating is based on ratings developed by Hessburg (1993) and Schwandt (1981), The wildfire hazard rating is based on a probability of mortality equation developed by Reinhardt and Ryan (1989). If a hazard rating for a specific change agent was lacking we developed a rating from published relationships between agent activity and stand conditions. No formally published hazard ratings were available for Douglas-fir beetle and western pine beetle/mountain pine beetle in second growth ponderosa pine stands. Hazard ratings for root disease agents were developed based upon professional judgement and published information. Most ratings were based on stand conditions and stand attributes which are easily measured in the field. Individual ratings are adjusted to a common scale, 0 to 10. "Maximum individual ratings are based on maximum potential effects (mortality or growth reduction) given the occurrence of the agent in pure stands of vulnerable hosts within the next 10 years (Steele et al. 1996). A rating of 10 is reserved for change agents which are capable of destroying most of the stand (i.e. wildfire, mountain pine beetle, spruce beetle). Agents which are capable of causing lesser amounts of damage have maximum ratings between 4 and 9. "The system also makes some adjustments for the interacting effects of certain agents such as toot rots with bark beetles" (Steele et al. 1996). A composite stand hazard rating is calculated by summing the individual hazard ratings. These composite ratings indicate the relative hazard between stands.

The initial stand hazard rating system was designed to be used in the field. Most of the stand conditions and attributes are easily measured. "A computerized, menu-driven version of the hazard rating system called HAZARD has been developed" on the Data General platform (Roberts 1994). The computerized version uses stored data from the Rocky Mountain Resource Information System (RMRIS) and a small amount of non-routine stand information. In the future the system will be adapted for use on the IBM platform.

This hazard rating system "was developed to help land managers design stand treatments and set priorities for treatment.... The higher the rating, the greater the potential effects of change agents on the stand" (Steele et al. 1996)

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Advances in Risk Rating for Spruce Beetle

Edward Holsten, USDA Forest Service, Anchorage, AK

SBexpert Vers. 2.0 is a knowledge-based decision support system for management of spruce beetle (Reynolds and Holsten 1997). Four programs constitute SBexpert: SBhelp; SBtext; SBlit; and SBexpert which is an advisory system for spruce beetle management that provides recommendations for reducing spruce beetle hazard and risk to spruce stands. Thus, the SBexpert program consists of two main subsections that describe the Hazards and Risk topics.

Our definition of Hazard and Risk: Hazard is the amount of stand damage expected to occur as the result of a spruce beetle outbreak and is typically measured in units of basal area, volume, or numbers of affected trees. Hazard can also be thought of as a measure of stand susceptibility to attack. In SBexpert, hazard is expressed as % of spruce basal area killed by spruce beetles 5 to 10 years after the start of an outbreak and is predicted in terms of various site and stand factors (Reynolds & Holsten 1996).

Risk is a measure of the likelihood, or probability, that an outbreak will occur, and is usually expressed as a proportion. In our model, risk is predicted in terms of hazard as well as the size of the available spruce beetle population. This, reliable predictions of risk can be made for only 2-3 years (Reynolds & Holsten 1994). Nine potential risk factors were evaluated by spruce beetle experts. Risk factors were organized into a hierarchial model of spruce beetle risk. The relative importance of factors for determining risk was analyzed with the analytic hierarchy process that derives subjective estimates of factor priorities through a process of pair-wise comparisons.

How is this all integrated into the SBexpert program? The first step in the SBexpert program is to hazard rate your stand. This is an "interview" process which results in a pictorial view of your stand before and after a beetle outbreak as well as rating, such as low, low-medium, high, etc. which represents the amount of spruce basal area you can expect to lose in 5-10 years. Once your stand has been hazard rated, the program allows you to take a look at the effects of various management practices (thinning, etc.) on reducing your hazard.

Once the Hazard rating has been completed, the SBexpert program allows you to Risk rate your stand. Again this is an interview process. You are queried as to amount of blowdown, and other disturbances in yours and the neighboring stands as well as the presence or absence and extent of ongoing spruce beetle infestations in nearby stands. A default weather factor is also part of the risk rating, but the user is able to "fine-tune" this if more specific climatological data is available. Once this is done, the user is presented with a probability of an outbreak occurring in their stand in the next 2-3 years. The user is then able to determine the effect of reducing risk by mitigating some of the risk factors that were previously determined. For example, if the user "stated" that there is an active infestation of spruce beetles within a 1/4 mile of their stand; the user can evaluate the effect of sanitation/salvage logging of this infested stand on the risk of an outbreak in their stand. That is, how much will the probability of an outbreak be lowered.

Thus, the SBexpert program allows you to Hazard and Risk rate as many stands as you want. It also allows you to play "what if" scenarios and depicts the results of these scenarios in terms of Hazard and Risk reductions. As the user is Hazard-and Risk-rating stands, SBexpert generates a complete report of each rating for each stand. This report is a word processing document and can easily be edited and filed.

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Rating Risk of Mountain Pine Beetle Attack in Ponderosa Pine

David C. Chojnacky, Rocky Mountain Research Station, Logan, UT

The USDA Forest Service's Rocky Mountain Research Station and Forest Health Protection staffs are cooperating to study bark beetles in ponderosa pine (*Pinus ponderosa*) forests. The objective is to develop a risk rating system applicable to ponderosa pine in the Colorado Plateau. Risk rating tools have been developed for other host species and for ponderosa pine in other geographic areas (Stevens and others 1980; Bentz and other 1993) but none seem applicable to the clumpy ponderosa stand structures of the Colorado Plateau.

Data have been collected at 45 sites, representing endemic and epidemic bark beetle populations in Arizona, Colorado, and Utah. These field surveys sampled stands by using two parallel transects, each of 10 contiguous 0.1-acre plots. Thirty-eight sites showed signs or symptoms of bark beetle attack, but attacks were confined to 21 percent of the plots with transects. Generally, attacks occurred among consecutive plots within transects.

More than 19,000 trees were measured. Of these, 57 percent were ponderosa pine, and 7 percent of the pine were beetle attacked. Mountain pine beetle (*Dendroctonus ponderosae*) accounted for 79 percent of the attacks; 15 percent were round-headed pine beetle (*D. adjunctus*), and the rest were either western pine beetle (*D. brevicomis*), Mexican pine beetle (*D. approximatus*), red turpentine beetle (*D. valens*), or *Ips* species.

Average diameter of beetle-attacked trees was 13.2 inches, which was significantly larger than the 10.1-inch average diameter of nonattacked trees (according to paired t-test at 0.05 probability level). Generally, stand structure variables showed greater tree density for beetle-attacked plots than for non-attacked plots within sites.

For an initial analysis, the data were modeled by using logistic regression to estimate the probability of attack on individual trees from tree and stand variables. This "rating" was then compared to two empirical methods that have been used for rating risk of mountain pine beetle attack (Chojnacky, in preparation). The two empirical methods, Munson and Anhold (1995) and Stevens and others (1980), classify stands as low, moderate, or high susceptibility from measurements of stand characteristics. Results showed the Munson/Anhold method compared most favorably to the logistic-model rating.

Comparison of the logistic model to the empirical methods was a first step in the analysis. Additional interpretation of the raw data in relation to risk rating concepts is planned. Spatial relationships and endemic/epidemic host conditions will also be explored. Additional modeling will be done to improve upon the logistic-model rating.

Continued monitoring of the 45 sites is also planned. In 1998, about one-third of the sites were revisited and all ponderosa pine on plots were tagged. This will allow continued observation of bark beetle population dynamics over time.

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Chojnacky, D. C. [in preparation]. Rating risk of mountain pine beetle attack in ponderosa pine: comparison of two empirical methods. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Logan, UT.

Munson, S. Anhold. J. 1995. Site risk rating for mountain pine beetle in ponderosa pine. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Intermountain Region, State and Private Forestry, Forest Health Protection, Ogden, UT. 1p.

Stevens, R. E.; McCambridge, W. F.; Edminster, C. E. 1980. Risk rating for mountain pine beetle in Black Hills ponderosa pine. Res. Note RM-385. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, 2 p.

Posters

Title: Development and Evaluation of Host-Compound Use in Disruption of Southern Pine Beetle Infestation Growth

Authors: Jane Leslie Hayes, USDA, Forest Service, Southern Research Station and Stephen Clarke, USDA, Forest Service, Forest Health Protection

This project was designed to evaluate integrated behavioral chemical techniques, using 4-allylanisole (a host-produced deterrent) alone or with verbenone (an insect-produced inhibitor), for the suppression of southern pine beetle (SPB) infestations, reducing loss of uninfested trees. The specific objectives were to: 1. Develop and evaluate an effective, long-lasting elution device for 4-allylanisole (4-AA). 2. Evaluate operational techniques for using 4-AA and verbenone together, or 4-AA alone, to disrupt SPB infestation growth.

Gravimetric evaluations were carried out on numerous elution devices to determine 4-AA release rates, duration, and consistency. Field trials were conducted on selected devices using attractant-baited funnel traps to assess the efficacy of the device, dose response, and response of beetles to the simultaneous release of 4-AA and verbenone. A release device developed in cooperation with Phero Tech, Inc. provided a constant release rate of ca 80-100 mg/day for over 45 days. Two Phero Tech devices proved effective in significantly reducing SPB trap catches. The combination of 4-AA and verbenone did not differ significantly from verbenone alone in reductions of SPB capture, suggesting that these compounds would not produce a synergistic or additive response applied to the same tree.

Disruption treatments (4-AA only or 4-AA and verbenone) were evaluated in 16 small SPB infestations. All infestations were monitored for at least one week before treatment. Behavioral chemicals were placed on uninfested trees around the active head of the infestation. Eight elution devices of 4-AA were attached per tree, two devices each at 0, 1.3, 2.6, and 4 m. Verbenone was applied using established procedures. All infestations were monitored weekly for at least six weeks. Treatments were considered effective if infestation growth does not advance beyond the treated buffer.

In 1995, three of the infestations treated with 4-AA alone were completely suppressed, while the fourth treatment was ineffective. Six infestations were treated with a combination of 4-AA and verbenone. Three of these treatments were ineffective, as the infestation continued through the treated buffer. However, the rate of infestation growth was reduced in each infestation. Three infestations were completely suppressed. Due to low SPB populations in 1996, only six infestations were treated. None of the 4-aa alone treatments were effective. One of three 4-AA plus verbenone treatments successfully suppressed infestations. The direction of infestation growth was changed in two of the infestations treated with 4-AA alone and one infestation treated with the 4-AA plus verbenone. These data suggest we need to evaluate the deployment of the elution devices to prevent breakouts.

Based on the two years of infestation suppression data, it appears that spots with less than 40 currently infested trees and growing at a rate of less than one new infested tree per day can be successfully suppressed by the treatments. More data is needed to validate or revise these upper limits and to determine which parameters are important in deciding which treatment to use.

Title: Western Spruce Budworm as a Regulator of Resources, Physiology, and Growth of Douglas-fir Seedlings

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Thomas E. Kolb, Northern Arizona University, Box 15018, Flagstaff, AZ
Karen M. Clancy, Rocky Mountain Research Station, 2500 S. Pine Knoll Dr., Flagstaff, AZ

The objective of this study was to describe the role of the western spruce budworm (*Choristoneura occidentalis*) in regulating growth of host trees and in recycling nutrients to host trees. A greenhouse experiment was used to test the hypothesis that defoliation by western spruce budworm larvae regulates and influences the growth of Douglas-fir (*Pseudotsuga menziesii*) seedlings through effects on soil and foliar resources and plant physiology. We used three defoliation treatments (no defoliation, and approximately 30% and 60% loss of current-year foliage from feeding by budworm larvae) and two forest soil types (basalt-derived and limestone-derived soils). The defoliation treatments were repeated for two consecutive years. We evaluated both direct (damage from defoliation) and indirect (effects from inputs of frass and litter fall) affects of budworm herbivory on the seedlings. The plant responses we measured were levels of nutrients in foliage and soil, net photosynthesis, biomass allocation to roots and shoots, and growth (including root growth).

The Douglas-fir seedlings defoliated by budworm larvae had higher rates of photosynthesis than the undefoliated seedlings, showing that the plants responded to defoliation with compensatory photosynthesis. Soil type also affected net photosynthetic rates; seedlings grown in limestone-derived soil had higher foliar gas exchange than those grown in basalt-derived soil. As expected, the undefoliated plants had greater height growth compared with the defoliated seedlings. However, we did not find any detectable effects from the addition or deletion of the frass and green-litter (i.e., needles damaged but not consumed) generated by budworm feeding.

We concluded that the western spruce budworm can regulate growth of host trees; budworm defoliation had both positive and negative direct effects on plant growth and physiology. We failed to find any evidence that the budworm recycles nutrients to host trees via increasing soil fertility through inputs of frass and litter, at least in the short-term.

Title: Resistance of Western Larch to Douglas-fir Beetle

Tiffany A. Neal and Darrell W. Ross, Department of Forest Science, Oregon State University, Corvallis, OR

The Douglas-fir beetle has been observed to occassionally attack western larch in addition to it's primary host, Douglas-fir. However, successful brood production has only been observed in recently downed western larch. Live western larch are apparently resistant to Douglas-fir beetle attacks. A previous study found that 3-carene was the only monoterpene that was present in higher concentrations in larch compared to Douglas-fir. We have begun to study the possible role that 3-carene may play in the observed resistance of western larch to Douglas-fir beetle attacks. In a laboratory study, 3-carene was significantly more toxic to adult Douglas-fir beetles than myrcene, alpha-pinene, or water. In a field test using multiple funnel traps baited with frontalin, traps containing 3-carene alone or in combination with alpha-pinene caught significantly less beetles than traps containing only alpha-pinene. These results suggest that the high concentration of 3-carene in larch may prolong the attack process providing a better chance for live trees to survive. Studies are continuing to test this hypothesis.

Title: A New Bark Beetle Pheromone Trap

Darrell W. Ross, Department of Forest Science, Oregon State University, Corvallis, OR
Philipp A. Kirsch, IPM Technologies, 4134 N. Vancouver Ave., Suite 305, Portland, OR
Gary E. Daterman, USDA Forest Service, PNW Research Station, Corvallis, OR

The multiple-funnel trap has become the standard in North America for collecting bark beetles. Although the trap is adequate for many research and operational uses, it has a number of shortcomings. In particular, the size and weight of the trap create problems with storage and transportation.

The relatively high cost of the traps may also limit their use in some situations. In 1997, we began testing a prototype of an alternative trap design. The new design is lighter, more compact, and less expensive than the multiple-funnel trap. The collecting surface of the new trap is constructed from light-weight, corrugated, black plastic formed into a cylinder. The cylinder will snap into a plastic top and funnel-shaped base which directs intercepted beetles into a collecting cup. When fully developed, the new trap will increase potential management applications of bark beetle aggregation pheromones.

The new prototype trap was tested against the 16-unit multiple-funnel traps using a paired plot design. At 4 different sites, 3 or 4 pairs of traps were baited for a single bark beetle species. Sites for *Dendroctonus ponderosae, Dendroctonus brevicomis,* and *Ips pini* were located in central Oregon and the site for *Dendroctonus pseudotsugae* was located in central Washington.

The multiple-funnel trap caught significantly more *D. ponderosae* and *D. brevicomis* than the prototype cylinder trap. The funnel trap also caught over 4 times as many *I. pini* as the cylinder trap, but the difference was not statistically significant. Both trap types caught similar numbers of *D. pseudotsugae*. There were no differences in the sex ratio of bark beetles collected by the two trap types for any species. Although the funnel traps tended to catch higher numbers of predators than the cylinder traps, none of the differences were statistically significant.

There are several possible reasons for the higher catches of bark beetles in the multiple-funnel traps compared with the prototype cylinder trap. First, we know that some beetles caught by the cylinder traps escaped from the bottom of the collection cups based on observations at the time the samples were collected. The design of the collection cup allowed insects to crawl between the wall of the cup and the drainage screen that was installed. This hypothesis is supported by the lack of any difference in numbers of beetles caught between the 2 trap types for the largest beetle we studied, *D. pseudotsugae*. This beetle would presumably have had the greatest difficulty fitting through the narrow space that allowed some beetles to escape. Second, the collecting funnel at the base of the cylinder trap probably did not extend far enough outward to catch all of the beetles that fell after encountering the trap. Finally, the trapping surface of the cylinder trap (3,125 cm^2) was less than half that of the multiple-funnel trap (6,615 cm^2).

We were encouraged by this first test of a new bark beetle pheromone trap design. We feel that with several modifications this trap will collect similar numbers of beetles as the standard multiple-funnel trap.

Title: Variation of Piperidine Alkaloids in Ponderosa and Lodgepole Pine Foliage from Central Oregon.

E.A. Gerson and R.G. Kelsey, USDA Forest Service, PNW Research Station, 3200 SW Jefferson Way, Corvallis OR

We quantified piperidine alkaloids in *Pinus ponderosa* Dougl. ex Laws. and *P. contorta* Dougl. ex. Loud. needles from three forest sites in April, June, August, and December. Pinidine was the major alkaloid constituent of ponderosa pine, while euphococcinine was the predominant compound in lodgepole pine. These alkaloids were detected on at least one date in 71% of the ponderosa pine and in 29% of the lodgepole pine trees sampled. For ponderosa pine, total alkaloid concentrations were very low at two sites on all dates. At the third site, concentrations were variable but significantly higher on all dates. Total alkaloid concentrations in previous-year foliage from this site were highest in April, then significantly lower from June through December. Current-year foliage collected in August and December had significantly higher alkaloid concentrations than previous-year foliage on the same dates. Variation in foliar nitrogen concentrations accounted for some of the alkaloid variation in current-year foliage sampled in August.

Title: Ethanol in Douglas-fir and Ponderosa Pine with Black-Stain Root Disease

R.G. Kelsey, USDA Forest Service, PNW Research Station, 3200 SW Jefferson Way, Corvallis OR G. Joseph, Department of Forest Science, Oregon State University, Corvallis, OR

Diseased and healthy Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, trees were identified at two black-stain root disease, *Leptographium wageneri* var. *pseudotsugae* Harrington & Cobb, centers in the Oregon Coast Range near Coos Bay. The phloem and sapwood near the root collar were sampled monthly for one year, whereas the roots were sampled in October and November. Ethanol concentrations in the sapwood of diseased trees near the root collar were significantly higher than in healthy trees for all months during the year, except January and June. Roots from diseased trees in October had significantly higher ethanol concentrations in the phloem and sapwood than the corresponding tissues from healthy trees. Stem sapwood above the root collar of ponderosa pine, *Pinus ponderosa* Dougl. ex Laws., was sampled in June near Burns, Oregon. Trees infected with *L. wageneri* var. *ponderosum* (Harrington & Cobb) Harrington & Cobb, and annosum root disease, *Heterobasidion annosum* (Fr.) Bref., had 30 times more ethanol than the sapwood of healthy trees. Ethanol concentrations in tissues from around the root collar of both species and the roots of Douglas-fir varied substantially among positions on a tree. Ethanol may play an important role in the biology of *L. wageneri* root disease and beetle-pathogen interactions in conifers.

1:30 - 3:00 pm	**Panel: Assessing Risk for Introduced Insects: Political Imperative or Biological Reality?** Moderator: Dawn Hansen, Forest Health Protection, Ogden, UT Vic Mastro, Methods Development Center, APHIS, Otis, MA Bill Wallner, Forest Service Research, Hamden, CT Borys Tkacz, Forest Health Protection, Flagstaff, AZ Lee Humble, Forestry Canada, BC

Assessing Risk for Introduced Insects: Political Imperative or Biological Reality?

Moderator: Dawn Hansen, Forest Health Protection, Ogden, UT

Introductions

Panel Members and a brief background of each:

William E. Wallner, Senior Research Forest Entomologist, USDA Forest Service, Northeastern Center for Forest Health Research, Hamden, CT. William Wallner has had a varied background including a B.S. degree from University of Connecticut in 1959 and a Ph.D. in Entomology from Cornell University in 1965. He was a professor of Entomology at Michigan State University, teaching for 13 years, before starting his Forest Service career in 1976. William currently has a joint appointment between the Forest Service and Yale University. William has conducted research on forest insects in Europe and Asia and is a gypsy moth specialist. He has made scientific trips to the former Soviet Union on 13 different occasions and spent 6 months there in 1989 as a US Academy of Sciences Scholar. William has published over 125 scientific articles and was recognized for his contributions with USDA's highest award for superior service in 1993. He has served on numerous academic and scientific review committees including pest risk analyses for russian larch and recently pest risk assessment for conifer pests on unprocessed logs from Mexico.

Vic Mastro, USDA APHIS, PPQ, Otis ANGB, MA. Vic works for the Animal Plant Health Inspection Service, Plant Protection and Quantine at the Otis Center for Point of Origin Risk Mitigation Survey and Detection Pathways.

Borys Tkacz, Team Leader for the Wood Import Pest Risk Assessment Team, USDA Forest Service, Forest Health Protection, Arizona Zone Office, Flagstaff, AZ. Borys recieved a B.A. in Botany from Rutgers University in 1976 and an M.S. in Plant Pathology and Forest Management from Oregon State University in 1980. Other post-graduate studies included silviculture and forest ecology at Northern Arizona University, Utah State University, and Colorado State University. From 1981 to 1987 Borys was a Plant Pathologist with Forest Pest Management in the Intermountain Region in Ogden, UT. Since June of 1988 Borys has been the Arizona Zone Leader for Entomology and Pathology in Flagstaff, AZ.

During 1991, Borys served as Team Leader for the joint USDA FS and APHIS Core Team conducting a pest risk assessment of the importation of logs from Siberia and the Russian Far East. The pest risk assessment involved over 70 experts in the fields of pathology, entomology, forestry, and economics in the US and Canada and paved the way for subsequent assessments for New Zealand and Chile. Since September 1995, Borys has led the Wood Import Pest Risk Assessment Team of the Forest Service. This team has recently completed a pest risk assessment of the importation of pine and fir logs from Mexico into the US.

Lee Humble, Entomologist, Forest Biodiversty Network, Canadian Forestry Service, Victoria, B.C. Lee joined the Canadian Forestry Service in 1982 as a Diagnostic Research Scientist in the Forest Insect and Disease Survey. Lee has a long standing interest in adventives, also known as hitchhikers. At present, Lee is involved with two research projects: 1) Canopy diversity study in coastal montane forests, 2) Non-indigenous bark and woodborer study.

Invasive Pests: Threats to Forest Biodiversity, Management and Commerce

William E. Wallner, Forest Service Research, Hamden, CT

Introduced pests constitute a continuing threat to forests around the world. This presentation will use specific organisms as examples to illustrate the economic and ecological impacts of invasive species on forest and urban forest ecosystems. The permanency of exotic insects, diseases, or plant pests should be considered in designing and adopting mutual trade agreement protocols and pest risk assessment procedures. It is particularly critical to countries in transition who should be cautioned against ignoring long term effects of such pests in expanding their economies. Suggestions are made to address these impending needs in view of expanding global trade in wood products and the urgency of protecting global forest resources.

Pest Priorities or Top Ten Pests

V.C. Mastro, Methods Development Center, APHIS, Otis, MA

The Animal and Plant Health Inspection Service (APHIS) and its state cooperators annually conducts surveys for introduced exotic pests. Target for these surveys are chosen using a variety of techniques. Perhaps the most systematic and successful has been the use of a simplified risk assessment process to rate various exotic pests and their possible entry pathways. This process has successfully targeted a number of pest populations of which have been found through surveys. Only five criteria are used for ranking pests 1)entry potential 2)climatic requirements 3) host requirements 4) miscellaneous establishment factors and 5) the potential economic and environmental impacts.

A primary source of information used to assess entry potential is APHIS pest interception data base (PIN). Although this data base is useful for estimating entry potential of easily identified pests of known significancy, it has limitations. Other sources of information often can be used to complement this information. Perhaps most importantly this system recognizes that a risk assessment is not a static document but should be a continuing process which is adjusted as new information becomes available.

Assessing Pest Risk from Importation of Wood Products into the United States

Borys M. Tkacz, Forest Health Protection, Flagstaff, AZ

ABSTRACT: Increasing world trade in unmanufactured wood articles has amplified the risks of inadvertent introduction of pests into new environments. Previous introductions of exotic pest organisms into the United States have resulted in severe outbreaks with economic and ecological disruption in forests. The United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) and the USDA Forest Service (FS) have developed a pest risk assessment process that attempts to identify the risks associated with importation of unmanufactured wood articles. Assessments have been completed for importation into the United states of logs from Russia, New Zealand, Chile, and Mexico. The results of these assessments are reviewed and the implications for trade in wood articles are discussed.

Case Histories of Pest Introduction

The associations between pests and their hosts have developed over millions of years. When trees from one region are exposed to insects or pathogens from another similar region, the evolved defenses of the tree may not be effective against the new organisms. Other ecological constraints on population growth, such as antagonists, predators, or pathogens, may not be effective in limiting populations of exotic organisms. The results of introductions of exotic organisms may be expressed as severe pest outbreaks with economic and ecological disruption in forests (Liebhold et al. 1995, USDA Forest Service 1991, U.S. Congress, Office of Technology Assessment 1993).

While it is impossible to say how many exotic organisms are imported across national boundaries without becoming established in their new environment, there are sufficient examples of exotics becoming major pests to conclude that introduction of exotic organisms carries considerable risk. Six case histories were reviewed during the Russian pest risk assessment (USDA Forest Service 1991). Five of the pests were introduced into North America: the European gypsy moth (*Lymantria dispar*), chestnut blight fungus (*Cryphonectria parasitica*), Dutch elm disease fungus (*Ophiostoma ulmi*), Port-Orford-Cedar root disease fungus (*Phytophthora lateralis*), and white pine blister rust fungus (*Cronartium ribicola*). Moreover, all but the gypsy moth were unknown pests in their native habitats. The sixth case described the pine wilt disease, which resulted from the introduction to Japan of a North American species, the pinewood nematode (*Bursaphelenchus xylophilus*). These case histories provided a framework for the assessment of the potential impacts from new introductions.

The gypsy moth, *Lymantria dispar*, was introduced into eastern North America in the 1869 by a French entomologist seeking a silk moth that could survive in North America. It has since spread throughout 200,000 sq. mi. of the Northeast forests and now threatens trees in the Southeast, Midsouth and Midwest regions of the United States. The gypsy moth is considered the most destructive insect that attacks hardwood forest and shade trees in the United States. Trees that are repeatedly defoliated can be killed, often by secondary insects or pathogens. In 1980 alone it defoliated more than 12 million acres (the largest area since 1978) and caused an estimated $764 million loss (U.S.

Congress, Office of Technology Assessment 1993). The introduction of the Asian strain of gypsy moth into the Pacific Northwest on grain ships from Russia in 1991 resulted in a $25 million eradication program (USDA Forest Service 1995).

Chestnut blight, caused by the fungus, *Cryphonectria parasitica*, was first discovered in New York in 1904. Within 50 years it had spread to the extremes of the natural range of American chestnut (200 million acres) and had killed approximately 8 million trees. The blight has resulted in the near total decimation of the American chestnut, one of the most valuable eastern hardwoods, from its natural range. The disease also led to wholesale species conversions, primarily to oaks, on sites where chestnut was predominant; deforestation of many ridge tops in the Appalachian Mountains; and a reduction in biodiversity as an important food source for wildlife was eliminated.

The dutch elm disease fungus, *Ophiostoma ulmi,* was introduced to North America, along with its insect vector, *Scolytus multistriatus*, on unpeeled veneer logs from France. It was first reported in the United States in 1930 and by 1968 had spread throughout the eastern half of the continent. More than $11 million was spent over a 5 year period in the 1930's by Federal and State agencies in attempts to eradicate the disease. By 1977, sixty percent of the 77 million planted elms had been killed by the disease. New, more aggressive forms of the fungus have been developed in North America and reintroduced into Europe where they cause increased mortality.

A root disease of Port-Orford-cedar was first reported on nursery stock near Seattle, WA in 1923. The causal fungus, *Phytophthora lateralis*, was isolated and described in 1942 from dying ornamentals in the Willamette Valley of Oregon. It appeared in the native range of Port-Orford-cedar in 1952 and has spread throughout the range in southwestern Oregon and northern California. Mortality losses in old-growth Port- Orford-cedar peaked at about 10 million board feet per year in the 1970's. Port-Orford-cedar is highly valued by the Japanese as a replacement for the hinoki cypress and export logs have been priced at five times the price of prime Douglas-fir.

Cronartium ribicola, the cause of white pine blister rust, was introduced into Eastern and Western North America on diseased planting stock from Europe around the turn of the century. It has subsequently spread virtually throughout the range of hosts (five needle pines) in the United States and Canada. The rapid spread in the United States resulted from the combination of numerous highly susceptible hosts, the close proximity of primary and alternate hosts, and favorable environmental conditions. Eighty to ninety-five percent of eastern and western white pine and sugar pine have been killed or damaged over 9 million acres. The disease has recently been discovered in southern New Mexico. Ecological impacts of white pine blister rust include species conversions, increased susceptibility of residual stands to native insects and pathogens, degraded wildlife habitat, and reduction in biodiversity.

Bursaphelenchus xylophilus, the nematode which causes pine wilt disease was probably introduced into Japan on pine logs from North America around the turn of the century. It was effectively vectored by a native insect, *Monochamus alternatus*, and spread at a rate of 20 miles per year through the pine forests of Japan, solely because of beetle movement. By, 1979, 2.4 million cubic meters of standing timber were killed, and by 1983 it was estimated that 25 percent of all Japanese pine forests had been infested.

Pest Risk Assessment Process

The purpose of pest risk assessments for wood commodities is to: identify the pest organisms that may be introduced with imported wood; assess their potential for introduction and establishment in the United States; and estimate the potential economic and environmental impacts these pests may have on forest resources if established in the United States. Pest risk assessments should be comprehensive, logically sound, practical, conducive to learning, and open to evaluation. Pest risk assessments for wood imports conform to the standards for plant pest risk assessments as described in Title

7 of the Code of Federal Regulations, Subsection 319.40-11. The first step is to collect commodity information. Permit applications and other sources for information describing the origin, processing, treatment, and handling of the commodity proposed for importation are evaluated for pertinent information. The assessors also collect data from agencies in the United States and foreign countries on the history of past plant pest interceptions or introductions associated with the commodity proposed for importation. The next step in the process is to catalog potential pests of concern. This is done by determining which plant pests or potential plant pests are associated with the commodity. A plant pest that meets one of the following criteria is a pest of concern and is further evaluated:

1. Nonindigenous plant pest not present in the United States;
2. Nonindigenous plant pest present in the United States but has not reached probable limits of its ecological range and is capable of further dissemination in the United States;
3. Nonindigenous plant pest that is present in the United States and has reached probable limits of its ecological range, but differs genetically in a way that demonstrates a potential for greater damage;
4. Native species of the United States that has reached the probable limits of its ecological range, but differs genetically in a way that demonstrates a potential for greater damage;
5. Native or nonindigenous organism capable of vectoring a plant pest that meets one of the above criteria.

In addition to these criteria (specified in Title 7, CFR 319.40-11), the most recent pest risk assessment (Tkacz et al. 1998) expanded two of the five criteria for identifying potential pests of concern. Criterion 2 was expanded to include pests that are native in limited regions of the United States and may be further disseminated through the proposed importation. The definition of Criterion 4 was expanded to include native species that may differ in their capacity for causing damage, based on genetic variation exhibited by the species.

Individual pest risk assessments are completed for a subset of the potential pests of concern. The following steps help determine which pests of concern will be assessed in detail:

1. Divide the potential plant pests identified in previous paragraph into one of the following groups by associated taxa:
   a. Plant pests found on the bark;
   b. Plant pests found in or under the bark; and
   c. Plant pests found in the wood.
2. Evaluate the plant pests in each of the above groups according to pest risk, based on the available biological information and demonstrated or potential plant pest importance.
3. Conduct individual pest risk assessments (IPRA) for the pests of concern.

The number of IPRAs is based on biological similarities as they relate to susceptibility to mitigation measures. The lack of biological information on any given insect or pathogen should not be equated with low risk (USDA Forest Service 1993). By necessity, pest risk assessments focus on those organisms for which biological information is available. By developing detailed assessments for known pests that inhabit a variety of different locations on imported logs (i.e. on the surface of the bark, within the bark, and deep within the wood) effective mitigation measures can subsequently be developed to eliminate the known organisms and any similar unknown ones that inhabit the same niches.

The risk associated with introduction of exotic forest pests is a function of the probability of pest establishment and the consequences of establishment. These factors are evaluated by assigning a risk value (high, moderate, or low) for each of the following elements based on available biological information and the subjective judgement of the assessment team:

1. Probability of Pest Establishment. Estimate the probability that the pest will become established in the United States. Exotic organisms are considered established once they have formed a self-sustaining, free-living population at a given location (U.S. Congress, Office of Technology Assessment 1993).
   a. Pest with host at origin. Probability of the plant pest being on, with, or in the commodity at the time of export.
   b. Entry potential. Probability of the plant pest surviving in transit and entering the United States undetected.
   c. Colonization potential. Probability that the plant pest will successfully colonize once it has entered the United States.
   d. Spread potential. Probability of the plant pest spreading beyond any colonized area. Factors to consider include the pest's ability for natural dispersal, ability to use human activity for dispersal, ability to readily develop races or strains, the distribution and abundance of suitable hosts, and the estimated range of probable spread (USDA Forest Service 1993).
2. Consequences of Establishment. Estimate the potential consequences if the pest were to become established in the United States.
   a. Economic damage potential. Estimate of the potential economic impact if the pest were to become established. Factors to consider include: economic importance of hosts, crop loss, effects on subsidiary industries, costs and efficacy of eradication or control.
   b. Environmental damage potential. Estimate of the potential environmental impact if the pest were to become established in the United States. Factors to consider include: potential for ecosystem destabilization, reduction in biodiversity, reduction or elimination of keystone species, reduction or elimination of endangered/threatened species, and non-target effects of control measures.
   c. Perceived damage potential (social and political influences). Estimate of the impact from social and/or political influences, including the potential for aesthetic damage, consumer concerns, political repercussions, and implications for international trade.

Results Of Previous Pest Risk Assessments

At the request of APHIS the FS has completed pest risk assessments on the importation of larch (*Larix* spp.) from Siberia and the Russian Far East (USDA Forest Service 1991), plantation grown Monterey pine (*Pinus radiata*) and Douglas-fir (*Pseudotsuga menziesii*) from New Zealand (USDA Forest Service 1992), plantation grown Monterey pine and native species (*Nothofagus dombeyi* and *Laurelia philippiana*) from Chile (USDA Forest Service 1993) and *Pinus* and *Abies* logs from Mexico (Tkacz et al. 1998). Each of these risk assessments identified potential forest pests that could be introduced into the United States on logs. Some of these organisms were judged to pose significant risks to timber resources and forest ecosystems in the United States.

The Russian organisms evaluated in detail included: the Asian gypsy moth (*Lymantria dispar*), nun moth (*Lymantria monacha*), spruce bark beetle (*Ips typographus*), pine wood nematodes (*Bursaphelenchus* spp.), larch canker (*Lachnellula willkommii*), and annosus root rot (*Heterobasidion annosum*). The potential economic costs associated with the introduction of these forest pests from Russia are high (Table 1.). These costs would result from potentially reduced yields caused by growth loss, increased mortality, defects in the host species, and increased management costs. The introduction of these exotic pest organisms from Russia and their subsequent establishment in North American forests could result in significant changes in forest ecosystems, such as: tree species conversion, deforestation, wildlife habitat destruction, degradation of riparian communities, increased fuel loading, and loss of biodiversity.

Table 1—Summary of Potential Economic Costs to the Timber Resources of the Western US from the Introduction of Selected Russian Forest Pests (unreserved timber for all ownerships).

Pest	Economic Cost (Millions 1990 $) Best Case	Worst Case
Defoliators	35,049	58,410
Nematodes	33	1,670
Spruce beetle	210	1,500
Annosus	84	344
Larch canker	25	240

The primary pests of concern identified during the pest risk assessment of New Zealand logs included: the wood wasp (*Sirex noctilio*) and its associated fungus (*Amylostereum areolatum*), a root disease fungus (*Leptographium truncatum*), a drywood termite (*Kalotermes brouni*), pinhole borers (*Platypus apicalis* and *P. gracilis*) and the huhu beetle (*Prionoplus reticularis*). The potential economic costs associated with the introduction of these organisms from New Zealand are not as high as those estimated for the Russian pests of concern, but are still substantial (Table 2.).

The major pests of concern identified on Monterey pine from Chile included: pine bark beetles (*Hylurgus ligniperda, Hylastes ater*, and *Orthomicus erosus*), siricid wood wasp (*Urocerus gigas)*, stain and wilt fungi (*Ophiostoma* spp.) and shoot blight *(Sphaeropsis sapinea*). The pine bark beetles from Chile could potentially be effective vectors of the native black stain root disease (*Leptographium wageneri*) and could lead to a ten percent increase in losses caused by this disease (present value of $31 million) in the western United States.

The pest risk assessment for Mexican pine and fir logs (Tkacz et al. 1998) identified numerous potential pest organisms. Some of these organisms are attracted to recently harvested logs while others are affiliated with logs in a peripheral fashion. A few of the organisms of concern would only be associated with pine logs as hitchhikers, most likely confined to the bark surface. These include *Pineus* spp., *Pterophylla beltrani, Lophocampa alternata*, and *Hylesia frigida*. Since there is little information on what species of *Pineus* are present in Mexico, assessment of risk is difficult. However, past introductions of this insect group have had devastating consequences to coniferous ecosystems throughout the United States and hence a moderate pest risk potential was assigned. The tettigoniid,

Table 2—Summary of Potential Economic Costs to the Timber Resources of the Western US from the Introduction of Selected New Zealand Forest Pests (unreserved timber for all ownerships).

Pest	Economic Cost (Millions 1990 $) Best Case	Worst Case
Wood Wasp	24	131
Root disease	7	69
Drywood termite	1	5
Pinehole borers	12	119
Huhu beetle	8	40

Pterophylla beltrani, is representative of organisms which feed on trees other than pines, but lays eggs in pine bark. This insect, colloquially known as the "Queen of Crickets" attacks a broad range of hosts in oak and mixed oak forests of Nuevo Leon and Tamaulipas and has caused economic losses in high value forests in populated areas, fruit orchards and even agricultural crops (Cibrian Tovar et al. 1995). The mexican tiger moth, *Lophocampa alternata*, feeds on foliage of *Pinus, Abies* and *Pseudotsuga.* The egg masses are laid under bark scales and would be readily transported on logs.

Insects that inhabit the inner bark and wood have a higher probability of being imported with logs than the hitchhikers. *Dendroctonus mexicanus* is a concern because of its broad host range and economic importance in Mexico. The host range includes 21 pine species in most of the subgenera of *Pinus.* Another bark beetle of concern is *Ips bonansei.* Although this insect is found in southern portions of Arizona and New Mexico, it could be introduced into new regions in the United States through the importation of raw logs. The knowledge of fir bark beetles is limited, but several species, including *Scolytus mundus*, have the potential to be transported on logs and cause significant damage if introduced into forests in the United States.

Mexican insects of concern that can be found deeper in the wood include termites, such as *Coptotermes crassus,* pitch moth, *Synanthedon cardinalis*, and round-headed wood borers, such as *Monochamus clamator rubigineus.* Because of their location deep in the wood, these insects may be more difficult to eliminate from logs.

Wood Import Regulations

On May 25, 1995, APHIS promulgated a Final Rule on Importation of Logs, Lumber, and Other Unmanufactured Wood Articles (Title 7, Code of Federal Regulations, Parts 300 and 319) with the intention of eliminating "any significant plant pest risks presented by the importation of logs, lumber, and other unmanufactured wood articles". These regulations establish general prohibitions and restrictions, general permits, procedures for permit applications, importation and entry requirements for specific articles, universal importation options, standards for treatments and safeguards, and pest risk assessment standards. In developing these regulations, APHIS utilized all available sources of information on the biology and risk of exotic forest pests, including the previous pest risk assessments completed by the FS. To assist APHIS in future pest risk assessments, the FS has chartered a Wood Import Pest Risk Assessment Team that includes forest pathologists and entomologists from Forest Health Protection and Forest Insect and Disease Research. The role of this team is to cooperate with APHIS by ensuring that the balance between protection of North American forest resources and free trade is sustained through sound, science-based decision processes.

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Assessing Risk for Introduced Insects: Political Imperative or Biological Reality? Interceptions and Establishments of Non-indigenous Bark- and Wood-boring Beetles in British Columbia

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The low grade wood and wood products used to support, brace or package commodities during shipment provide a pathway for the global movement of bark and wood-boring beetles. Immature stages of bark and wood-boring insects present within the wood used in such packaging can complete their development and emerge later as adults after the commodity has arrived at its destination. A wide range of commodities including raw and finished stone products, varied steel products, industrial castings and heavy machinery are packaged with low grade wood. The diverse businesses importing high risk commodities are situated in industrial or commercial parks dispersed throughout urban areas, often in close proximity or adjacent to forested lands or trees retained in urban landscaping. Storage of commodities packaged or shipped with low grade wood products near forested lands, or the disposal of wood packaging in or near treed sites, provides an avenue for the introduction and establishment of non-indigenous bark- and wood- boring insects.

Evidence from recent regulatory interceptions and ongoing biological diversity studies in British Columbia demonstrates that non-indigenous species continue to establish and accumulate in western North American forests. The data presented is derived from research studies conducted by the Canadian Forest Service (CFS) and regulatory interceptions and surveys by the Canadian Food Inspection Agency (CFIA). Results of ongoing trap based detection programs, surveys of Coleopteran diversity in urban forest reserves and an audit of selected high risk wood packaging are discussed.

Trapping Program

A study of the composition of the bark- and wood-boring beetle community and the relative abundance of its non-indigenous component in an urban forest in greater Vancouver was started in 1995 by the CFS Forest Biodiversity Network. The study site, Richmond Nature Park (RNP) is located on Lulu Island in the Fraser River delta south of Vancouver. The 80 ha preserved in the park contains the last remnant of an extensive sphagnum bog which once covered much the island. Wetter areas of the park are dominated by shore pine (*Pinus contorta* Dougl. ex. Loud. var. *contorta*), while white birch (*Betula papyrifera* Marsh.) predominates on better drained sites. Lindgren traps, baited with one of the following commercially prepared lures (Exotic Bark Beetle Lure, Pine Shoot Beetle Lure, or Wood Borer Lure; Pherotech Inc., 7572 Progress Way, Delta, BC) were operated from the end of March through September.

At the same time a survey for the detection of accidental introductions of non-indigenous Scolytidae in and around the ports and other high risk sites around Vancouver was established by the CFIA (then Plant Protection, Agriculture and Agri-Food Canada). Lindgren traps baited with the aforementioned lures were used in the port survey. Species targeted in this survey included the pine shoot beetle, *Tomicus piniperda* (L.), recently discovered to be established in eastern Canada, and the United States and European spruce bark beetle, *Ips typographus* (L.). The regulatory survey collections from 12 locations (36 traps) were screened for the presence of non-indigenous species by the CFS.

In 1996, a second research location, the 300 ha Alaksen National Wildlife Area (ANWA), was included in the CFS study. Trapping was conducted in the coniferous and deciduous hedgerows and forest surrounding old field habitat and farm fields on Reifel and Westham Islands at the mouth of the Fraser River. Regulatory detection trapping was continued at 5 locations by the CFIA and 8 additional locations were trapped by other collaborators.

The trapping program was expanded in 1997 by increasing trap numbers at ANWA and RNP (n=20 and 12 respectively), and by the addition of nine sites trapped by the CFS-Forest Health Network (FHN). The additional 24 FHN traps were placed within or near selected warehouses or locations where dunnage and wood packaging associated with commodities such as wire rope, architectural stone and tile and pipe and steel shipments was present. In total, 92 Lindgren funnel traps were deployed across 24 locations in the lower Mainland and southern Vancouver Island.

Nineteen species of Scolytidae (n=937), eight species of Cerambycidae (n=30) and one species of Buprestidae (n=1) were captured in the 1995 trapping program. The first non-indigenous beetle discovered, *Xylosandrus germanus* (Blandford), is an Asian ambrosia beetle not previously known to occur in western North America. It was abundant at the RNP study site and was also captured at one regulatory site. While *X. germanus* was not recovered at any of the additional locations trapped, two individuals of a second exotic ambrosia beetle, *Xyleborus perforans* (Wollaston), were recovered from the ANWA at the mouth of the Fraser River. Re-examination of voucher material from the 1995 trapping program following a report of the discovery of *Xyleborinus alni* (Niisima) in traps in Washington State (E. Lagasa, M. Furniss, pers. comm.) subsequently led to the confirmation of *X. alni* in British Columbia. It was found recovered at RNP and one of the delimitation trap locations.

Fifteen species of Scolytidae (n=1024) and seven species of Cerambycidae (n=10) were recovered during the 1996 trapping program. No new non-indigenous taxa were found, however, the establishment of all three exotic taxa discovered in 1995 was confirmed by their recapture in 1996. During 1997, 41 species of Scolytidae (n=4439), nine species of Buprestidae (n=57) and 22 species of Cerambycidae (n=103) were recovered during more than 14000 days of trap operation. Five additional species of non-indigenous Scolytidae were detected in the trapping program. The presence of *Xyloterinus politus* (Say) and *Trypodendron domesticum* (Linnaeus) in rearings of native deciduous trees has confirmed that both species are established in BC. The remaining three species *Euwallacea validus* (Eichhoff), *Xylosandrus crassiusculus* (Motschulsky) and *Cyrtogenius brevior* (Eggers) were recovered at warehouse locations and may only represent interceptions of adults emerging from wood packaging. As well, two species of non-indigenous Cerambycidae, *Trichoferus* sp. prob. *campestris* (Falderman) and *Phymatodes testaceus* (Linnaeus) were recovered in the trapping program. The former species was captured within a warehouse while the latter species was recovered at RNP and a nearby second trap location.

The distribution of trap locations and the number of non-indigenous species captured at each location during 1997 provides an overview of the distribution of the non-indigenous species recovered in the greater Vancouver area (Fig. 1). Two of the recently discovered introductions known to be established were found at 7 and 10 locations respectively across the area surveyed during 1995-97. An additional three of the species confirmed to be established were captured at only two locations and one species has been recovered from a single location only. Species recovered from within warehouses (*Trichoferus* sp., *E. validus*) or recovered as single individuals from traps placed near imported wire rope spools (*X. crassiusculus*, *C. brevior*) are currently thought to represent interceptions.

The abundance of non-indigenous species of Scolytidae, relative to native taxa responding to the lures employed in this program, at the two intensive research locations are illustrated in Figure 2. At both locations, non-indigenous taxa (both the recently discovered species and previously established species) comprise the bulk of the individuals recovered in the traps. When captures in only the ethanol baited traps are considered, 8% or fewer of the individuals recovered were native species. Similar patterns were evident in the 1995 and 1996 data from the same locations.

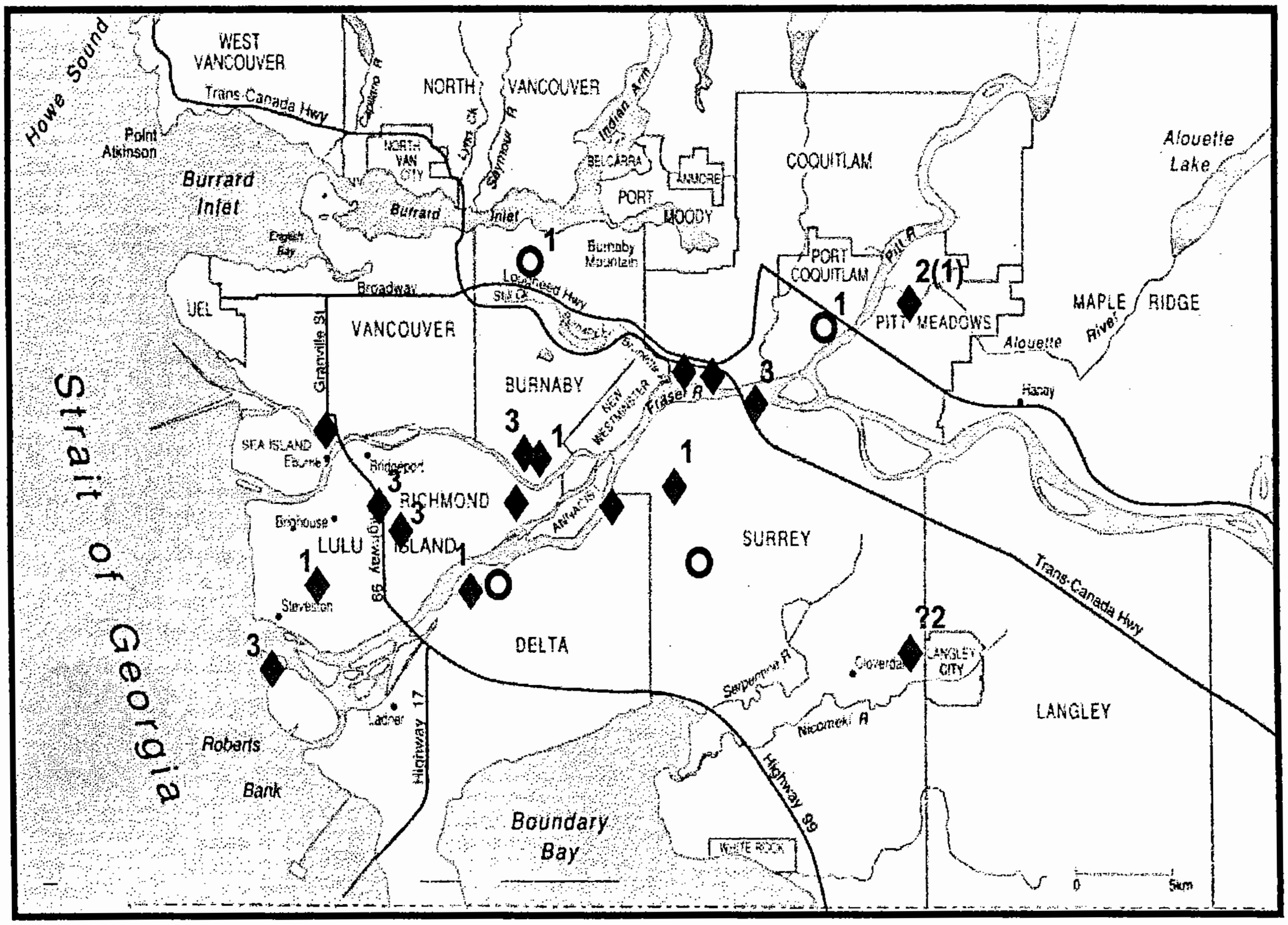

Figure 1—Distribution of Lindgren funnel traps operated by all agencies in greater Vancouver during 1997. Sites at which traps were placed outdoors are designated by diamonds; those at which traps were placed indoors are designated by circles. Numbers beside each symbol indicate the number of non-indigeous species recovered from each site.

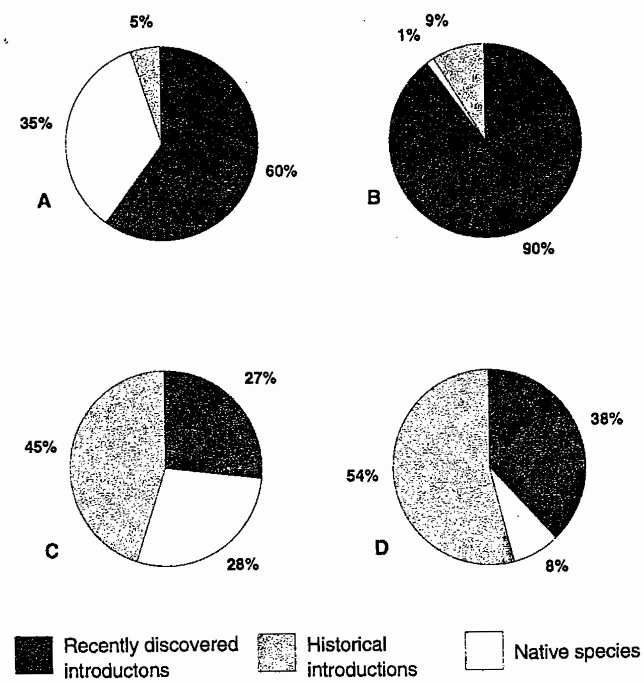

Figure 2—Relative abundance of native species, recently discovered introductions and historically introduced species of Scolytidae recovered at Richmond Nature Park (A, n = 749; B, n = 2581) and Alaksen National Wildlife Area (C, n = 56; D, n = 524) responding to selected lures during 1997. A and C present relative abundance of species responding to single traps baited with each of the three lures; B and D are relative abundance of species responding to ethanol baited traps.

Rearing Program

In 1997, bolts were cut from recently dead standing or fallen trees of three deciduous species, bigleaf maple, (*Acer macrophyllum* Pursh), red alder (*Alnus rubra* Bong.) and bitter cherry (*Prunus emarginata* Dougl.) exhibiting evidence of attack by Scolytidae. The samples were reared during the latter part of 1997 to determine the species attacking the various species. All beetles emerging from the bolts were collected and identified.

The relative abundance of native and non-indigenous species of Scolytidae reared from the three deciduous hosts are shown in Fig. 3. Non-indigenous Scolytidae predominate in all of the rearings conducted to date from a single location. It is not known if this pattern is reflected at other locations or in other deciduous or coniferous hosts. The rearing program also confirmed the establishment of all five of the recently introduced species of Scolytidae at a single location. Only three of the non-indigenous taxa had been detected in the trapping program conducted at that location for three years.

Wood Packaging Audit

In 1997, Dr. Eric Allen and the staff of the CFS-Forest Health Network in collaboration with the CFIA, undertook an audit of the wood used to construct the spools bearing imported steel cable or wire rope following interceptions made by the CFIA of live wood-borer larvae from imported spools. A considerable volume of wood is used in the construction of each spool. On average, each contained 0.11 m^3 or 46 board feet of wood. Empty spools originating from China, Korea and Malaysia were disassembled and examined for the presence of wood-borers. Live larvae were reared under quarantine to determine species associated with the spools.

The audit demonstrates that cable spools pose a significant risk for the introduction of non-indigenous wood-borers. Eighty-two percent of all spools examined (n=92) contained galleries in the wood and 14% of the spools contained live larvae. Multiple individuals of five species of Cerambycidae, *Monochamus alternatus* Hope, *Trichoferus campestris* (Falderman), *Ceresium flavipes* (F.) *Psacothea hilaris* (Pascoe) and *Megopis* sp. prob. *sinica* White and one species of Anobiidae, *Ptilineurus* sp. were recovered as living larvae or adults from the spools examined. Numerous live adults of *Anoplophora glabripennis* (Motschulsky) were recovered from a warehouse

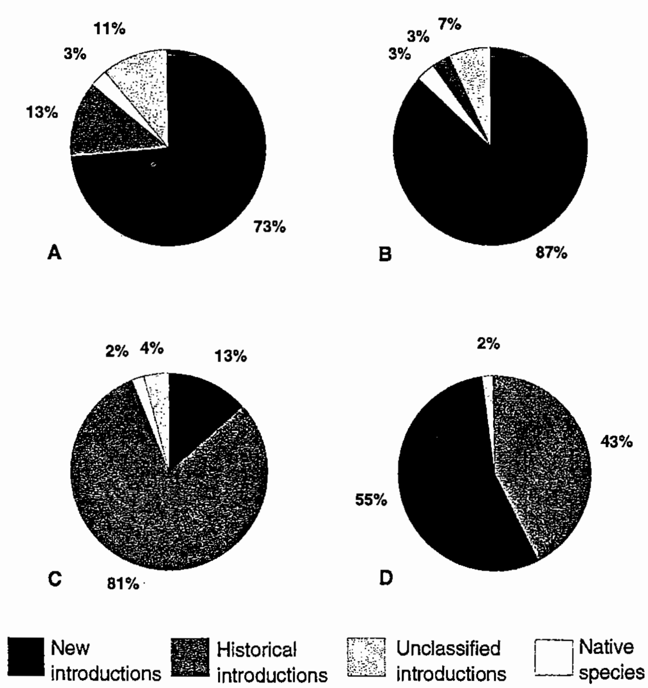

Figure 3—Abundance of native and non-indigenous bark and ambrosia beetles reared from deciduous hosts in 1997. A. Red alder collected September 1997, n = 203 adults; B. Bitter cherry collected September 1997, n = 136 adults; C. Bigleaf maple collected July 1997, n = 927 adults; and D. Bigleaf maple collected September 1997, n = 368 adults.

storing wire rope reels and one dead adult of *Batocera lineolata* Chevrolat was recovered from a gallery within a spool, however, neither species of Cerambycidae was reared during the audit.

Discussion

The limited surveys discussed above clearly demonstrate that the introduction and establishment of non-indigenous species developing in wood still continue in spite of regulatory controls. Numerous species of Scolytidae and Cerambycidae were intercepted in quarantine trapping programs and wood packaging audits. Field trapping programs have shown that various species of bark- or wood-boring beetles have successfully established in southwestern BC. These recent establishments originate from almost all regions of the world. Two of the species of Scolytidae originate from temperate Asia, while each of the remaining species originates from a different region including: subtropical and tropical Asia and Africa; eastern North America; or Europe. The single species of non-indigenous Cerambycidae discovered is also native to Europe.

This study also shows that current knowledge of the extent to which non-indigenous taxa have established in western North America is incomplete at best. The scolytid establishments discovered between 1995 and 1997 increase the percentage of known introductions in British Columbia from four to seven percent (n=140 spp.). As well, the non-indigenous species established in the urban forested areas studied now comprise the majority of the total scolytid fauna recovered (Fig. 2). A similar pattern of dominance is evident when the scolytid fauna breeding in dead and dying native deciduous hosts is examined (Fig. 3). Additional research is needed to provide baseline information on the composition of the introduced faunas regionally as well as to determine the economic and ecological impacts of the non-indigenous species.

The increasing globalization of trade and the increased efficiency of transport will continue to increase the risk of new introductions. Many of the introductions of concern to the forest community are not associated with the commodity being traded, but rather are hitchhikers on or in the packaging. Effective international standards or regulations are urgently needed to prevent the further globalization of the insect fauna associated with wood and wood products.

Acknowledgments

Significant contributions to this interagency research were made by: Jane Seed (trapping and collection processing) and Bob Duncan (diagnostics, exotic screening), CFS-Forest Biodiversity Network; Nick Humphreys and Dr. Eric Allen, CFS-Forest Health Network (quarantine trapping and audit data) and Jon Bell, Sue Grant and April Ingram (quarantine trapping); CFIA Regional Staff; Dr. Bruce Gill (identifications of non-indigenous Coleoptera), CFIA-Ottawa; and Dr. Don Bright, Res. Branch, Agriculture Canada (identification of non-indigenous Scolytidae). The provision of early research results by Dr. Eric Lagasa, Washington State Dept. of Agriculture and Dr. Mal Furniss aided in the identification an exotic ambrosia beetle. The cooperation of the Municipality of Richmond and the staff of the Richmond Nature Park and the Canadian Wildlife Service made long term trapping at the research sites possible.

3:00 - 3:30 pm	Break
3:30 - 5:00 pm	*Concurrent Workshops* **Forest Pest Management** **and the Urban/Forest Interface** Moderator: Dave Schultz, Forest Health Protection, CA

Forest Pest Management and the Urban-Forest Interface

Moderator: David E. Schultz, USDA- Forest Service, Shasta-Trinity NFs

Approximately 55 people attended the workshop. There was time for two presentations of case studies, a short video tape, and some questions. Don Owen gave a presentation on Pitch Canker in California. Roy Mask from the USDA-Forest Service Gunnison Service Center gave a presentation on a mountain pine beetle outbreak in the Vail Valley. Abstracts of these case studies are presented below. Dave Schultz showed a short video showing mechanical harvesting equipment being used to thin and alter the fuel profile in older ponderosa pine plantations adjacent to residential areas in Mt. Shasta, California. Homeowner reaction to the program has been mixed, and not all homeowners seem to appreciate the risk posed by wildfire. Bill Schaupp from the USDA-Forest Service Lakewood Service Center had maps prepared to talk about a proposed project to reduce mortality due to mountain pine beetle, and also reduce the risk of wildfire by thinning ponderosa pine in the Front Range in Colorado. One of the points Bill hoped to make was that similar problems and projects had occurred in the same area 20 years previously.

Common themes among these case studies was a wide divergence of expectations and values placed on trees on their property by different types of landowners. Some of the private landowners have an emotional attachment to their trees. The corporate memory of previous forest health disturbances is short. Politics is often a large factor in forest health projects, with money flowing to the most current emergency. The use of some tools , such as prescribed fire, is limited by concerns over air quality, liability, and public discord. The slow reaction time of some public land-managing agencies may cause some opportunities too be foregone. Although it appears to be a process which has to be endlessly repeated, public education appears to be the best prospect to foster realistic expectations and logical forest management actions from the greatest number of landowners.

The Pitch Canker Task Force

Donald R. Owen, California Department of Forestry and Fire Protection, and Chairman, Pitch Canker Task Force

Pitch canker, an introduced disease first discovered in California in 1986, is a serious threat to Monterey pine. By 1994, the disease had spread to 14 counties, including all three native Monterey pine stands, and infected numerous pine species as well as Douglas-fir. In response to the continued spread of pitch canker and the threat to native Monterey pine stands, the California Forest Pest Council passed a resolution calling for the formation of a Pitch Canker Task Force (TF) composed of public, private, and non-profit sector members.

The TF held its first meeting in December 1994 and has continued to meet on a regular basis since then. Meetings are open and all groups involved with pitch canker are encouraged to participate. By being inclusive, the TF hopefully can address the needs and inputs of a broad "constituency." A diverse membership also helps to insure that information outputs from the TF get wide distribution. This is important because of the large number of people currently and potentially impacted by the problem. Infested areas include some of the most densely populated areas of the state. Two main emphases of the TF are slowing disease spread and addressing the threat to native Monterey pine forests.

Without regulatory authority to impose restrictions on the movement of diseased material, the TF has conducted an educational campaign promoting the slow-the-spread message. On June 4, 1997 the State Board of Forestry helped boost the TF's efforts by establishing the Coastal Pitch Canker Zone of Infestation (ZOI). The Zone designation is mainly a publicity tool for educating and encouraging appropriate action from affected governments, businesses, organizations, and individuals. The California Department of Forestry and Fire Protection, with grant support from the USDA Forest Service, is providing funds for management and research programs to slow the spread of pitch canker within and out of the ZOI.

Pitch Canker is one of many threats that face California's native Monterey pine forests, including predominance of over-mature trees, competition, high levels of native pests, poor regeneration, urbanization, fuel buildup and exclusion of fire. The TF came to the conclusion that addressing the impact of pitch canker would be of limited value if these other issues were not also addressed. The TF has therefore taken the lead in initiating a Natural Community Conservation Plan (NCCP) for the native forests. Authorized by the California Natural Community Conservation Planning Act, a NCCP is a science-based conservation plan that incorporates appropriate land use and resource management activities.

For more information on the TF and pitch canker in California, visit the website
http://frap.cdf.ca.gov/pitch_canker/

Mountain Pine Beetle in Colorado's Vail Valley: Lessons Learned in the Wildland-Urban Interface

Roy Mask, Supervisory Entomologist, USDA Forest Service, Rocky Mountain Region, Gunnison Service Center

Background. The Vail Valley in Eagle County Colorado, is undergoing change on several fronts. Demands on the area's natural resources are ever-increasing. Vail Valley is a popular multi-season haven for recreationists. Estimates of Recreation Visitor Days (RVDs) for the area are among the most numerous in the state. Vail Valley is home to Beaver Creek and Vail Ski areas, the latter being the host of the 1999 World Ski Championships. In addition, private properties in Vail Valley are among the most valuable in Colorado. The area is easily accessible, located along Interstate Highway 70, ninety miles west of Denver.

Large portions of the valley's landscape are dominated by mature stands of lodgepole pine, *Pinus contorta*. During the past four years, substantial increases in mountain pine beetle, *Dendroctonus ponderosae*, activity has occurred in these stands, impacting federal, state and private lands. In addition, a recent interagency fire protection assessment (Anonymous, 1997) identified significant fuel loading and wildfire potential within this cover type of Vail Valley.

In 1996, federal, state and local government agencies initiated a cooperative effort to a) assess current and future mountain pine beetle implact; and b) identify management options for areas of greatest concern. Cooperators include the USDA Forest Service (National Forest System and State and Private Forestry-Forest Health Protection), Colorado State Forest Service and the Town of Vail.

Methods. The Forest Health Technology Enterprise Team (USDA Forest Service, Forest Health Protection) flew CIR imagery missions of the assessment area. Imagery acquisition was co-funded by the USDA Forest Service and the Town of Vail. Region 2 Forest Health Management staff members analyzed the CIR imagery, recent aerial survey sketch maps and field maps (from the Colorado State Forest Service) to locate and quantify mountain pine beetle activity as of 1996. Stand susceptibility for inventoried stands was determined using Amman's model (Amman et al. 1977). Potential losses were also modeled for representative stands using the Forest Vegetation Simulator (FVS) model.

Results.

Reporting

An assessment report with general management recommendations was completed in May 1997 (Mask and Eager 1997).

Information has been shared with the public through presentations to the Vail Town Council, during two open house meetings, and with news releases and media interviews.

Area Affected (current, 1997)

Mountain pine beetle activity is evident on approximately 1900 acres. Most of this is in the Interstate 70 corridor, in and immediately above the communities of Vail and Minturn.

Ninety-eight percent of the inventoried stands (>7000 acres) were rated as moderate-high hazard of mountain pine beetle infestation.

Challenges.

Ownership is intermingled across the beetle-impacted wildland-urban interface and management goals and approaches differ. A related problem is that the USDA Forest Service is often unable to respond to developing situations as timely as are adjoining private property owners. Some property owners are strongly opposed to logging (sanitation/salvage) activities, yet the majority seems to support "doing something."

The inaccessibility of the steep terrain that rises above the Interstate 70 corridor.

The vast expanse of beetle-susceptible lodgepole pine forests.

Limits on the use of tools like prescribed fire (to enhance vegetation species and age diversity) due to air quality and related concerns.

The politically charged atmosphere often conflicts with natural resource realities.

Successes.

Interagency cooperation has enhanced everyone's understanding of the situation of what can or can't be done (= great educational opportunity).

A protion of the public has voiced strong support for implementing appropriate management actions.

Good opportunity to develop some "long-term memory" that should reflect positively on needed forest manaagement efforts in the future, especially in the wildland-urban interface.

A large-scale planning and management effort to address mountain pine beetle (and related) concerns has been funded and is ongoing.

References

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History Workshop: Glimpses of the Past—Remembering and Preserving Them

Moderators: Mal Furniss & Boyd Wickman

Participants: Gene Amman, Bruce Baker, Lynn Rassmussen, Roy Renkin; and attendees: Ron Billings, Phil Mocettini, Takuji Noma, Eric Smith, Jesse Logan, Matt Hansen, Evan Nebeker.

Themes involved insect outbreaks and control efforts in Yellowstone N.P. and environs from 1922 (pine sawfly, West Yellowstone) to ca 1972 (abandonment of direct control of mpb); and the need to catalog and preserve historical photos of the former Bureau of Entomology (1902-1953).

The session began with poster displays of historical photos and "grey cover" unpublished reports, relating to J.C. Evenden & T.T. Terrell of the Coeur d'Alene FIL (1919-1954), followed by self introductions. Furniss presented anecdotes, including the first aerial survey in the Rocky Mtns (1930) by Tom Terrell in an open cockpit biplane to map spruce budworm in YNP. A snowstorm engulfed them over the Absaroka Mtns and the engine suddenly stopped. Tom was about to bail out when he heard pounding behind him. Pilot just wanted to know "should we turn around?" Emphatic "**Yes**."

The first experimental control project against the western spruce budworm was in "Cody Canyon" near the east entrance to YNP. Prompted by public clamor, 205,000 gals. of lead arsenate spray were applied during 1929-1930. The spray didn't stick well; results were erratic. Crew chief Vernon Lopp writes to Jim Evenden: "Holm Lodge management finds it can't feed its cows on lead arsenate and make them thrive." And, "Found underwear plugging spray tank. Made a checkup on crew to learn who was missing."

Gene Amman, Lynn Rassmussen (INT, retired), and Bruce Baker (R-4, now natural resource consultant), recounted that the mpb had begun its rise in the Yellowstone region in the late 1950's. Three million trees were treated chemically on the Targhee and Teton NF, alone, between 1957-1969, at great cost. By then, direct control was contributing to local economy, and was accepted among high administrative levels. In spite of that, Gene & Bruce set out in 1969 to compare rates of mortality and residual stand composition, over time, on areas that varied in their infestation history and treatment.

Their findings, published in J. Forestry 70:204-209 (1972), demonstrated that, whether treated or not, the end result (residual stand) was the same. In consequence, direct control efforts were abandoned in favor of silvicutural treatment on the forests, while the parks adopted a "let it be" policy. (This has to rank among the greatest cost-benefit ratios in the history of western forest entomology... Furniss).

But this initiative did not find favor among all levels, and carried considerable professional risk, as recounted by Bruce, who happened to be in the W.O. when a retirement party was being held for Chief Cliff. Upon learning that Bruce had co-authored the article, the Chief shook his prominent jowels and pronounced: "I shudder at your conclusions."

Ron Renkin, Management Biologist, YNP, distributed and discussed a handout summarizing outbreaks and control of the sbw & mpb in YNP since 1925 (even included DDT in 1955). He has assembled a large volume of related records for preservation in the park archives now being constructed at Mammoth. Furniss provided him with a list of 50 unpublished "grey cover" reports of the Coeur d'Alene FIL, relating to YNP and environs.

Boyd Wickman described the former Bur. Entomology, Forest Insect Investigations (1902-1953), historical photo files located presently at Forestry Sciences Labs in Albany, CA & LaGrande, OR. The latter are suitably housed for now, but the former is in "dead storage," enclosed in plactic in a warehouse environment. He called for suggestions regarding cataloging and preserving them. Baker suggested a grant to inventory & evaluate the photos, including tracking-down missing ones sent to the W.O. or elsewhere. Development of an electronic, cross-referenced, numerical - subject catalog with facsimile images would then then allow transfer of this unique historical resource to a safe repository, yet allowing access to it. Some favored a University as that repository.

Biological Control of Exotic Forest Weeds

Moderator: George P. Markin, U. S. Forest Service, Rocky Mountain Research Station, Bozeman, Montana

Classical biological control of weeds, locating the natural enemies of a plant in its home country—their importation and release in the new area where the weed has become established—is an old, well proven, and effective method of controlling exotic species of plants that have invaded a new country or area. While the technique has been extensively used in agriculture, particularly on rangelands, it has generally been overlooked as a possible control method for exotic weeds that have invaded natural areas, and in particular in the forest environment of the West. However, with the recent realization of the extent, speed, and number of exotic weeds that are invading the forested environment of western North American forests, extensive weed management programs are being implemented; and vegetation managers are beginning to consider the use of biological control. Since most biological control agents are insects, the rapidly growing interest in using biological control creates a unique opportunity for forest entomologists here in the West. At the workshop, entomologists actively involved in biological control in agricultural systems presented an overview of how biological control functions, who is involved with it, what weeds are presently being targeted, and particularly the potential use of this management tool in the forest environment.

George P. Markin introduced the topic by outlining the basic steps involved in finding and testing new biological control agents in their country of origin. He described the U.S. Forest Service's Rocky Mountain Research Station's program, which is attempting to introduce biological control agents for four weeds in the Pacific Northwest, Rush skeletonweed (*Chondrilla juncea*), Scotch broom (*Cytisus scoparius*), gorse (*Ulex europaeus*), and tansy ragwort (*Senecio jacobaea*). His biological control program is also temporarily assisting the Forest Experiment Station in the southeast U.S. in developing its own new program for a very aggressive vine, kudzu (*Pueraria lobata*).

Robert Nowierski, Entomologist with Montana State University, described the on-going testing and releasing of new biological control agents being done by universities, the Agricultural Research Service, and by Ag-Canada in the Northwest. Many of the weeds they are targeting, such as spotted knapweed (*Centaurea maculosa*), leafy spurge (*Euphorbia esula*), Dalmation toadflax (*Linaria dalmatica*), yellow toadflax (*Linaria vulgaris*), houndstongue (*Cynoglossum officinale*), and hawkweeds (*Hieraciuim* spp.), are also major problems in the forest environment.

Richard Hansen, USDA Animal Plant Health Inspection Service (APHIS) Plant Protection Quarantine (PPQ), described the role of this agency in both maintaining quarantines to prevent introduction of new exotic pests and the control of existing introduced pests that have large, i.e. multi-state, distributions. Biological control is the management method of choice for USDA-APHIS-PPQ for well established weeds that cover multi-state areas. At present, USDA-APHIS-PPQ is participating in biological control programs for leafy spurge (*Euphorbia esula*), diffuse and spotted knapweed (*Centaurea diffusa* and *Centaurea maculosa*), purple loosestrife (*Lythrum salicaria*), dalmation toadflax (*Linaria dalmatica*), and saltcedar (*Tamarix ramosissima*), and it is also the lead agency implementing a new program for Russian knapweed (*Centaurea repens*). During its weed biological control programs, USDA-APHIS-PPQ first releases a comparatively small number of each new agent at a few field insectories in each state. When these populations have established and grown large enough, they are harvested and used to initiate additional field insectories. When adequate populations are available from these insectories, large numbers of insects are then made available to other federal, state, and private organizations for further redistribution. This approach recognizes a decreasing involvement by PPQ personnel and an increasing involvement by local personnel as new agents become more available.

Richard C. Reardon of the U.S. Forest Service Forest Health Technology Enterprise Team reviewed the new policy approved at the Washington Office level allowing Forest Service entomologists in Forest Health Protection (FHP) to become involved in weed biological control. While Forest Health Protection's core focus will continue to be on forest insects and disease management and pesticide use management and coordination, Forest Health personnel are now allowed and are actively being encouraged to provide technical assistance to National Forest personnel by (1) designing operating guidelines for release and monitoring of biological control agents, (2) designing integrated weed management programs, and (3) providing economic analysis of programs. While present Forest Health Protection management funds cannot normally be used for noxious weed control, funding for technical assistance by FHP staff for biological control of invasive weeds is available through the special technology development program grants and from the Forest Health Technology Enterprise Team located in Morgantown, West Virginia. At the Washington Office level of the U.S. Forest Service, Dave Thomas is the vegetation management specialist for Forest Health Protection and has the lead for the Forest Service noxious weed program. At each U.S. Forest Service region in the U.S., a designated FHP noxious weed contact has been assigned who will coordinate the efforts between Forest Health Pest Management and the forest vegetation management staff for implementation of biological control of invasive plants.

In the Pacific Northwest, the most aggressive and widespread weed is probably spotted knapweed. Nancy Campbell of the Forest Health Protection office in Missoula, Montana, described a program to evaluate the release of a complex of biological control agents against this weed to determine what habitats they are most likely to become established in and their impact on the target weed. Her study is aimed at developing guidelines that vegetation management personnel can use in releasing these agents and monitoring their impacts.

3:30 - 5:30 pm **Increasing Public Awareness for the Need of a Scientific Based Management**
Moderator: Steve Burke, Phero Tech Inc., BC

Increasing Public Awareness and Support of Forest Entomology

Moderator: Steve Burke

Attendance: 7

It is generally recognized that, for the past decade or more, forest entomology funding for both research and extension purposes, in North America, has declined. The severe depletion of research personnel at the US Pacific Northwest Station in the late 1980's and the recent elimination of the Canadian Forest Service's Forest Insect and Disease Survey (FIDS) are two notable examples. In the foreseeable future the optimistic perspective is that financial support will, at best, not decline. Few would predict a significant increase. This concern has surfaced before at Western Forest Insect Work Conference 1988, Southern FIWC1988 and National FIWC1996.

Flying in the face of this is society's increased need for the products forest entomology researchers and extension personnel deliver. The public, through advocacy groups, are demanding action and accountability on issues as apposed as preserving biodiversity to maximizing our financial return on the forest resource. The following news brief serves to exemplify this point:

> "TIMBER POLICY: The House Agricultural Committee approved a bill aimed at reducing fire risk. But it is apposed by environmental activists who say it would accelerate logging under the guise of improving forest health. Chairman Bob Smith, R-Ore., said 40 million acres are at extreme risk of wildfire. Among the remedies would be salvage logging, which is cutting down stands of trees that are sick, bug infested or choked with underbrush. Agriculture Secretary Dan Glickman opposes the bill because it gives the Forest Service financial incentive to choose logging over other remedies."

USA Today, March 5, 1998

The problems are complex and so are the solutions. Balanced forest entomology solutions result from an accumulation of information gained through research and application. Support for both research and implementation requires a level of support that should match this inclining need, or better still, anticipate future increased needs. So where have things fallen off the rails? If there is an increased need for the products forest entomologists deliver why is this discipline faced with declines in financial support and long-term commitment? To some extent this field has, like many other scientific fields, fallen victim to government cutbacks. However, there maybe a reprieve, an opportunity to reflect and become proactive.

> " A BREAKTHROUGH FOR SCIENCE? A year ago, the science community was crying into its petri dishes. Federal spending for research was rising slower than inflation-with the prospect of crippling cuts ahead." Now the outlook for research is looking up. In the Senate, Phil Gramm (R-Tex.) and Joseph I. Lieberman (D-Conn.) want to nearly double the $35 billion non-defense research-and-development budget over the next decade, and colleagues in both parties are embracing their plan. ... Still that doesn't mean that Congress will start showering money on science. ... First they have to make a strong case. Otherwise, proposals to boost spending could just "get the science community salivating-and then get thrown in the wastebasket"

Excerpts from an article in Business Week, February 9, 1998

Much of the problem for forest entomology and part of the solution may well lie in the lack of visibility and understanding the public has for the science. Simply stated, the beneficiaries don't understand how forest entomology impacts them and how an increased and stable support can be in their best interest. If the benefitting public aren't gaining an appreciation for forest entomology and what it means to them they can hardly be expected to sympathize with those that would seek increases in funding. Improving public awareness is seen as a long-term, grass roots effort that can pay off.

Three areas where activities seem to be paying off are:

- Stewardship
- Public speaking
- Publications in popular magazines

Karen Ripley, Washington State DNR forester described the multifaceted approach to increasing public awareness of forest management and entomology in Washington State. Current political will is helping to advance these programs. Interest in fire prevention provided an opportunity to increase the awareness of forest insects and their impact. Many "teachable moments" became available because of an impending tragedy, declining salmon habitats and dramatic reductions in stocks of certain species and runs.

Environmental education programs include a series of one and two-day teacher workshops focusing on creative classroom activities which integrate science with social issues. Entomology workshops are popular because teachers recognize that kids like "bugs". They also recognize that forest entomology can provide opportunities to integrate complex issues of natural history and human choices. Another DNR program involves high school students to conduct environmental monitoring. These students go on to teach fourth graders.

DNR's landowner assistance program has three major thrusts:

a) informing the public through regular columns in forest and landowner newsletters, press releases that capitalize on newsworthy events
b) public exposure through media outlets such as inexpensive advertising on cable TV and radio and press releases, in local newspapers, that capitalize on newsy events such as forest fires (and anniversaries of forest fires), windstorms and endangered species. Often local reporters are desperate for newsy items.
c) creation of readily available "Backyard Forest Stewardship Kits" (with lots of illustrations). The focus is on fire prevention but information on urban forestry, wildlife, forest health, forest entomology and forest practice regulations completes the forest stewardship package. A mailing list is maintained and those on the list receive update and are encouraged to participate in educational programs.
d) person to person contacts. A broad range of partners are enlisted including relators and utility and insurance companies. These partners fund publications, disseminate literature, pay for advertising and participate in educational programs.

Forest entomology research can help in this effort on a number of levels. Three key ones identified are a) allowing some natural disturbances to take place and carefully observing the outcome, b) more investigations regarding appropriate buffers around homes and c) designing better tools to protect high value trees.

In British Columbia Kornelia Lewis, Forestry Canada, pointed out some parallels to the Washington State program.. Through Forest Renewal B.C. funding a number of information videos have been created and made available (especially to schools) covering forest health issues. In addition, an Elder Hostel program is in place; seniors are even marking trees for thinning. Interestingly, in Jackson Hole an Elder Hostel program is now available at the Teton Science School.

What is really needed in the West is a clear understanding of the financial benefits that come from good forest management. The benefits must be substantial, unequivocal and understandable to the general public. More research in this area would be very beneficial. For example, if good stewardship was a proven way to reduce fire loads, the public will start to make the mental link and get on board.

Additional comments were made about the press and public speaking. It was reemphasized that local newspapers are keen on getting articles pertaining to forest insects. Some publications even have a recurring column focusing on forest health, including insects. Readers soon learn to expect the column in the next issue. Similarly, local horticultural, naturalist, garden and related clubs are very interested in receiving offers to speak on forest health issues. Quality speakers are hard to find. Slides and actual "touch and feel' samples work nicely.

A final comment from the moderator: "Get personally active in expanding the awareness and benefits of forest entomology, and don't be shy about it."

5:00 - 5:30 pm	***Photo Session***
6:00 - 7:00 pm	**No-Host Mixer and Poster Discussions**
	Poster Authors will be Present
7:00 - 9:00 pm	**Banquet Dinner and Guest Speaker** **"The Yellowstone Wolves"** *Doug Smith, Naturalist, Yellowstone National Park*
THURSDAY	
8:30 - 10:00 am	**Final Business Meeting**
10:00 - 10:30 am	Break
10:30 am - 12:00 pm	*Concurrent Workshops* **Re-Evaluation of Techniques and Policies** Moderator, Sheri Smith, Forest Health Protection, CA

Re-evaluation of Techniques and Policies

Sheri Smith, USDA Forest Service, Forest Pest Management, Region 5

The following topics were discussed in this workshop: 1) the Special Technology Development Program; 2) aerial surveys; 3) use of bark beetle pheromones in British Columbia; and 4) pine slash treatments and susceptibility to attack by *Ips paraconfusus*.

Special Technology Development Program

Ed Holsten

The Special Technology Development Program (STDP) is administered by Forest Health Protection (FHP) and the Forest Health Enterprise Team (FHTET), both being Washington Office staff units. STDP was established in 1990 and is a means of accelerating research findings into practical applications that contribute to fulfilling FHP program goals. The STDP program has been funded annually at about the $1.3 million level. STDP projects increase FHP's ability to: (1) provide forest health protection for all lands; (2) anticipate and respond to new/increasing forest health risks/threats; (3) prevent, detect, and manage non-indigenous pest infestations; and (4) manage native pest infestations (prevention and suppression).

Recently, the STDP process has been re-vamped. This was done as there were perceived problems with the overall program efficiency and a "burden" of sustaining ten committees and review teams. Some program managers, who were members of the evaluation team, were uncomfortable with rating projects on technical merit. Likewise, a few of the ten Steering Committees were perceived as ineffective. Instead of "fixing what was broken" it was decided to come up with a re-vamped process for selecting, evaluating and awarding STDP proposals. FY 98 is the first year for this "new" process.

The new process consists of a single FHP STDP Steering Committee, which will set direction for the program and identify the strategic goals, and five Technical Committees (Survey/Evaluation/Monitoring; Planning & Public Information; Disease Management; Insect Management; and Vegetation Management) which will provide information for the STDP review process and FHP-technology programs, examine the needs from a field perspective, and identify priorities for the Steering Committee. Proposals will now be reviewed by both the STDP evaluation panel as well as external reviewers. This was done to "reduce the burden" of the review process on the directors of FHP programs. The STDP Steering Committee will meet once a year, after the proposals have been awarded to determine if the process is "working or in need of a fix" as well as provide direction for future funding areas to the Director of FHP/WO.

Concerns regarding the old process include: the timeliness of selection of proposals and transfer of funds; the expense of maintaining 10 Steering Committees and an Evaluation/Steering Committee Panel; and technical merit (proposals were discussed and ranked by various Steering Committees and each Region reviewed proposals before submitting to Evaluation Panel for consideration). Concerns regarding the new process include: timeliness of selection of proposals and transfer of funds; expense of maintaining five Technical Committees, an evaluation panel, a STDP Steering Committee Meeting; the cost associated with external reviews; the cost ($30,000+ out of STDP funds) for FHTET administration of the program; and technical merit (will the external review panel be able to adequately address technical merit of proposals which are more of a "pilot study" in nature vs. research).

Ed concluded by asking several questions: "Are we really gaining anything? Is this going to be more cumbersome & costly? Should we have just fixed the old process instead of re-inventing the wheel?" The STDP Steering Committee is charged to answer these questions. The STDP Program is extremely valuable to the "field." The Steering Committee and the WO need to demonstrate credibility to all field units, or the Program will fail!

Aerial Surveys

Dave Schultz

Dave discussed the advantages and disadvantages of using human observers in aircraft for aerial surveys. In general, humans are good at picking out one faded tree in many acres of green trees, airplanes can quickly cover large areas, there can be a rapid turn around time with instant results and flights are relatively inexpensive. Some of the disadvantages include: there is often low to moderate precision in estimating numbers of trees and/or acres; relatively low precision on locations; typically there is a high rate of variability if multiple observers are used; and inspection/quality control is difficult and expensive. In addition, adding technology such as the use of GPS and video increases cost and slows turn around time.

Dave also discussed the differences between detection flights and aerial surveys.

Detection flights:
- -search large areas to determine occurrence of symptom (s)
- -location and magnitude of damage is unknown in advance
- -generally fly high and fast
- -may require several flights to detect different types of damage
- -relatively low level of precision may be completely adequate
- -low cost per unit area usually anticipated

Aerial Survey:
- -determine the amount or location of previously detected damage
- -search area is relatively discrete
- -generally fly low and slow
- -usually flown at optimum season to measure signature
- -relatively high degree of precision expected
- -adding technology may improve precision
- -moderately high cost per unit area usually anticipated

Discussion among the group involved the need to prioritize areas for detection surveys in the future as dollars decrease and we will not be able to afford flying every acre every year and there likely is not a real need to do this. Some Regions and Forests find the detection maps very useful, others are going through the exercise to provide information to the Washington office. There was a general concern over the inappropriate use of the information and trying to generate very specific numbers out of a process that is not set up to obtain that type of information.

Use of Bark Beetle Pheromones in British Columbia

Russ Cozens

To set the scene, about 95% of the land in British Columbia is owned by the Crown and managed for the benefit of its citizens. About 45 million hectares of forest on that land are either managed by the Forest Service or managed by a licensee (company) under the terms of an agreement with the Forest Service. Each year, about 70 million cubic meters of timber are harvested from about 220 thousand hectares of managed forest land. The Forest Act defines the type of agreement and its general terms. The Forest Practice Code of British Columbia Act, and its regulations, prescribes management methodologies to protect, conserve, and utilize the resources. It applies not only to licensees, but to the Forest Service as well. Forest development plans are required of licensees and of the Forest Service and are approved for a five year period on an annual basis. Forest development plans must provide an assessment of forest health factors and must describe appropriate methods to mitigate any negative impacts of those factors.

Much of British Columbia's forest management is predicated by the presence or threat of bark beetles. Management of lodgepole pine forests includes a heavy reliance upon pheromones, to keep bark beetles where managers want them and can manage them. Depending on the year, between 30,000 to 50,000 baits are used. Baits are placed to contain beetles in an area where a cutting permit will be issued before the next flight. Baits are used to "mop up" the remaining beetles in patch removal or single tree treatment areas, with the attacked trees are being removed the following year. Their successes in mountain pine beetle management are largely attributable to the availability and wise use of pheromones. The costs average C$9 per bait and C$9 for bait placement. The combined C$540,000 to C$1,000,000 annual expenditure is considered an important investment in forest management.

Pine Slash Treatments and Susceptibility to Attack by *Ips Paraconfusus*

Sheri Smith for Pat Shea

Over the past several decades the threat of Ips paraconfusus (IPS) build-up in pine logging slash and subsequent tree mortality in the residual stand has been problematical. This situation may be the result of the diligent treatment of logging slash to prevent build-up of IPS populations or some other unknown factor(s). We have all experienced years when, as a result of excessive blowdown within pine plantations, IPS aggressively colonize this material. This is followed by several years of breeding and presumed population build-up yet no mortality occurs in the plantation. Nevertheless, there are standard, well accepted guidelines on how to treat downed material whether it results from blow-down or logging activity. Generally it is best to lop and scatter downed material up to 3 inches in diameter. The underlying reason for this recommendation is to dry out the phloem of the slash and thereby make it unsuitable for production of IPS brood. However, there is no research data to support the most efficient way to dry out slash.

In an effort to begin to provide some answers to these questions Pat conducted a preliminary experiment that included different mechanical treatments of pine slash. The treatments consisted of the following mechanical manipulations of the residual slash: (1) removal of all branches to a 1 inch diameter, buck bole to 4 ft. lengths; (2) removal of branches on upper side of main stem, leave main stem whole; (3) buck main stem to 4 ft. lengths, no branch removal; and (4) no bucking or branch removal. Each of the treatments were established in separate areas and consisted of three .1 acre plots.

Statistical analysis indicated there was no significant difference between the number of trees or diameter of stumps by treatment. The only slash material that was attacked by IPS was located in treatment 1. Virtually all of this slash was colonized and evaluations taken in October indicated that brood was produced. These findings are counter-intuitive in that: (1) treatment 1 is the recommended treatment of slash; and (2) even though this material was attacked it was reasonable to assume that brood would not have been produced. Since this was a preliminary experiment, Pat plans to follow-up with a much more extensive study during 1998. Plot size will be increased and a fully controlled randomized block design will be employed. If the results of further experimentation confirm those reported here then the current management recommendations concerning treatment of pine slash need to be revisited.

10:30 am - 12:00 pm	**Monocultures, Exotic Tree Species and Bio-engineering: Impacts on Insects** Moderator, Ron Billings, Texas Forest Service

Monocultures, Exotic Tree Species and Bioengineering: Impacts on Insects, the Environment, and Management Practices

Workshop Moderator: Ronald Billings, Texas Forest Service, Lufkin, TX

Participants: Approximately 25.

The moderator began with an introduction that explained recent developments in intensive forestry which involves increasing emphasis on monocultures, exotic tree species, and bioengineering as a means to meet future demand for forest products. These developments, in turn, may be setting the stage for increased activity and losses due to forest pests. Several speakers were invited to discuss different perspectives on this workshop theme.

Farming Poplar in the Oregon Desert

Jack Eaton, Potlatch Corporation, Boardman, OR

Potlatch Corporation is in the fourth year of converting 22,000 acres (9,000 hectares) of Northeast Oregon center-pivot irrigated farmland to hybrid poplar. Conversion of this acreage will take place over a six-year period with approximately 3,800 acres (1,500 hectares) of new plantations established annually. The farm will provide a sustainable annual production of fiber beginning in the year 2000 and furnish 20% of the chip fiber for Potlatch's Pulp and Paperboard operations located at Lewiston, Idaho.

The Columbia River provides a stable source of irrigation water that in combination with the area's long sunny days, sandy loam soils, and 185 day frost-free growing season, creates an ideal environment for intensive poplar culture. Drip irrigation allows efficient delivery of water, fertilizer, and some pesticides to individual trees. State-of-the-art filtration, pumping, and water delivery systems are used to run the 200,000 gallon per minute irrigation system.

Farming activities focus on field conversion to drip irrigation, planting stock and clonal propagation, and plantation establishment and development. Conversion and site preparation activities involve pivot removal, field leveling, soil ripping, and incorporation of pre-emergent herbicide. A rigorous clonal testing program from breeding new material to selections for operational deployment results in new clonal material that is mass propagated at contract stoolbeds. Post planting activities include herbicide and manual release, cultivation, and pest monitoring.

Currently, 12,500 acres (5,000 hectares) are under management and irrigation system construction is underway on the 3,800 acres (1,500 hectares) scheduled for planting in 1998. Mid-rotation tree performance is meeting expectations, and production levels of 40 bone dry tons of pulp chips per acre are realistic with a six year rotation. To date, pest problems have been minimal.

Fiber Farming and Pest Management Opportunities in the South

T. Evan Nebeker, Department of Entomology, Mississippi State University, Mississippi State, MS

To date, the most common pest of hardwood fiber farms in Mississippi has been the cottonwood leaf beetle (*Chrysomella scripta* F.). The study reported on was undertaken primarily to develop economic thresholds for cottonwood leaf beetle (CLB) on first year plantings of cottonwood (*Populus deltoides* Bartr. ex Marsh) in the lower Mississippi River Valley. The decision to apply insecticide to CLB infestations in first year plantings of cottonwood is somewhat arbitrary at this time. Hence, entire fields are often treated without prescription. Guidelines for treating nursery clonal banks are also lacking and the decision making process again becomes arbitrary. The purpose of this study was to determine what level of defoliation, expressed in numbers of CLB, is necessary to significantly reduce growth of first year plantings of *P. deltoides*. Sampling was also performed in an attempt to determine distribution of CLB in first year plantings through time.

Cottonwood can withstand a high level of defoliation during its first growing season. The impact, either as mortality or growth, is seasonally dependent. During the course of these observations, mortality was observed when adult populations arrived in the fields in early April with 100% defoliation. Those trees surviving this early season defoliation had a significant reduction in growth at seasons end in comparison to those not attacked during the early season. Significant differences in height were not detected in trees with less than 100% defoliation during the 3 years of this study. Predicting the time of adult mass feedings is of prime interest. In September of 1997, mass feeding of adults was observed in 2-yr old settings. Data collected in the area for purposes of following the dynamics of the CLB population failed to predict a mass population build up. It is concluded that the adults arrived from distant locations. Extremely high populations of adult CLB have been observed to exhibit behavior similar to swarmings. This is still in need of additional investigation. Gratitude is expressed to James River, Crown Vantage and the USDA Forest Service for supporting this study.

Bioengineering of Plant Defense Responses

Charles H. Michler, North Central Research Station, USDA Forest Service, Rhinelander, WI, and Leah S. Bauer, Michigan State University, East Lansing, MI

Our current biotechnology research efforts, located in Rhinelander, WI and St. Paul, MN, included micropropagation, selection, and genetic engineering of disease resistant eastern white pine and butternut genotypes. By far, white pine blister rust is the most serious disease of eastern white pine throughout its range, limiting the reestablishment of this important tree species both in natural and commercial forests. Our strategies include selection of white pine genotypes for resistance to blister rust, identifying resistance genes, and determining mechanisms of tree resistance to rust. Also, we are screening white pine blister rust strains for genetic variability in infectivity and virulence to determine suitability and durability of resistance genes among our rust-resistant white pines.

Butternut, a relatively uncommon, but highly valued northeastern hardwood species closely related to black walnut, is being decimated throughout its range by a non-indigenous fungal pathogen commonly known as butternut canker. We are developing propagation and screening techniques to clone and test remaining uninfected butternut trees for canker resistance from forests known to harbor the pathogen. Strains of butternut canker with different characteristics have been identified, and we have developed molecular techniques that allow us to differentiate between canker strains. Also, the potential role of insects as vectors of this pathogen is under investigation.

In our East Lansing, MI laboratory, our research efforts involve identifying potential toxins, primarily from *Bacillus thuringiensis* (Bt), for genetic engineering of insect resistance into poplars. Of particular interest is the cottonwood leaf beetle, a major defoliating pest of poplars which is especially damaging during the first three years of plantation establishment. We have identified several Bt toxins with activity against these leaf beetles, and researchers at Oregon State University successfully bioengineered hybrid poplar clones with one of these toxins known as Cry3A. We continue to collaborate with other research laboratories to screen promising transgenic poplar clones prior to field trials, and to develop strategies to delay rates of beetle resistance to these toxins.

Are Monocultures of Exotic Tree Species More Susceptible to Pest Outbreaks?

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

Forest entomologists often anticipate serious pest problems in plantations of fast-growing exotic tree species. This implies that plantations of native trees will have fewer insect problems than exotic tree species. A review of the literature revealed that in fact, many exotics, at least initially, have much lower species accumulation by indigenous insects, in both tropical and temperate zones. Some examples of exotic species which have not experienced serious colonization from indigenous insects include: *Cedrela odorata*, *Eucalyptus camaldulensis*, *Pinus radiata*, *Populus* spp., *Robinia pseudoacacia*, and *Tectona grandis*.

Pests Associated with Exotic Monocultures of Monterey Pine in Chile

Ronald Billings, Texas Forest Service, Lufkin, TX

More than 1.5 million hectares of Monterey pine (*Pinus radiata* D. Don) have been planted in Chile. This forest resource has become the source of raw material for an expanding forest products industry and national economy in this small South American country. Seemingly, the stage is set for a disastrous outbreak of insect or disease pests. Fortunately, Chile has escaped major losses, despite reliance on a single-species monoculture. The major insect problem to date has been the European pine shoot moth, *Rhyacionia buoliana*, introduced from Argentina in the early 1980s. The potential impact of this pest of young pine plantations has been maintained at low levels due to aggressive control and prevention programs involving a combination of biological, chemical, and mechanical methods.

More recently, three European scolytids have been introduced into Chile: *Hylurgus ligniperda* , *Hylastes ater*, and *Othotomicus erosus*. Populations of these bark-beetles have spread throughout the pine-growing region. To date, economic losses from these insects have been minimal. *Hylurgus ligniperda*, the most abundant scolytid found in recent surveys, only occasionally causes losses to newly-planted seedlings as adults emerge from pine stumps.

Needle diseases annually cause the largest impact to exotic pine plantations in Chile, requiring aerial sprays to prevent excessive growth losses. The paucity of insect and disease problems on exotic pine plantations in Chile is attributed to the fact that this country has no native pine and continues to be isolated from other countries by physical barriers. Strict quarantine laws also help to reduce the number of new pests being introduced from other sources.

10:30 am - 12:00 pm	**Insects Associated with Pinyon & Juniper** Moderator, Jill Wilson, Forest Health Protection, Flagstaff, AZ

Pinyon Insects Workshop

Moderator: Jill Wilson, US Forest Service, Southwestern Region

Attendees: Boyd Wickman, Tom Eager, Laura Merrill, Steve Seybold, Dave Chojnacky, Julie Weatherby, Debra Allen-Reid, Terry Rogers, Bob Cain, Jaime Villa-Castillo, Guillermo Sanchez, Matt Hansen, Lee Humble, Steve Koehler, Dave Leatherman, Roy Mask, Dave Johnson

Pinyon-Juniper woodlands are one of the major forest cover types in the Southwest as well as portions of the intermountain west. These forests are composed of several species of pinyon pine and juniper. Interest in these systems has increased over time as their importance for fuelwood production, recreation values, wildlife habitat etc has been realized. In this workshop we took a tour around three of the US Forest Service regions that contain pinyon-juniper woodlands and learned about some their more interesting and significant insects. We then focused on three research projects.

Attendees

Front: Jose Negron, Lee Humble, Mal Furniss, Julia Smith, Mike Hulme, Sarah Bates. **Rear:** Roger Burnside, Ronald Billings, Karen Clancy, Michael Wagner, Lea Spiegel, Jaime Villa-Castillo.

Front: Darrell Ross, Tiffany Neal, Marnie Duthie-Holt, Nicole Jeans, Cindy Broberg, Robin Petersen, Sheri Smith. **Rear:** Andrew Lawson, William Wallner, Boris Tkacz, Kier Klepzig, Jennifer Burleigh, Lorraine Maclauchlan, Russ Cozens.

Front: Guillermo Sanchez, Tom Eager, Iral Ragenovich, Jane Hayes, Timothy Paine, Don Owen, David Leatherman. **Rear:** Susanne Kuhnholz, Matthew Greenwood, Evan Nebeker, Ann Bartuska, Terry Rogers, Bob Cain.

Front: Laura Merrill, Phil Mocettini, Dezene Huber, Brian Strom, Julie Weatherby, Nancy Rappaport, Ladd Livingston. **Rear:** John Reeve, John Borden, Dave Johnson, Gene Amman, Bruce Baker, Mary Ellen Dix, Lynn Rasmussen.

Front: Steve Seybold, John Anhold, Beth Williams, Dave Chojnacky, Anne Lynch, Jill Wilson, Dawn Hansen. **Rear:** Barbara Bentz, Steve Munson, Bridget Kobe Clayton, Creed Clayton, Valarie Deblander, Roy Mask, Robert Peck, Maureen Duane.

Front: John Dale, Peter Lorio, Brett Schaerer, Nancy Sturdevent, Jack Stien, Tim Schowalter, Tim Work. **Rear:** Debra Allen-Reid, John Moser, Steve Kohler, Ken Gibson, Dayle Bennet, Dave Schultz, Jesse Logan.

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