Pacific
Climate
Impacts
Consortium

Summary Report

Forest Pests and Climate Change Symposium: 14-15 October 2007

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Forest Pest and Climate Change Symposium

Table of contents

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Executive Summary

The Pacific Climate Impacts Consortium hosted a meeting entitled *Forest Pest and Climate Change Symposium* as part of a Forest Science Program project. The purpose was to initiate a dialogue on the scientific requirements for research on forest pests and climate change. In light of considerable uncertainty about forest pests, accelerated or unanticipated changes in the forests, and a potentially short time span to react and adapt, we attempted to focus research resources across disciplines and organizations. A small number of experts were invited and asked to consider five topic areas, described below. This report summarizes the dialogue in each session.

In the first session economic modelling was discussed, emphasizing both monetary and non-monetary values. Carbon accounting and market diversification, including non-timber forest products, will increase the monetary value of future forests. However, key ecosystem services with no direct monetary value, such as water quantity and quality, are also essential for both a functioning ecosystem and for human benefit. Some tools were discussed that could be used or modified to incorporate these values into planning.

The second session topic focused on biological simulation models of pests and hosts in relation to climate. Process-based simulation models are based on the physiological response of the pest organism to weather events and climate patterns. Knowledge of pest phenology can be used to build simulation models that explore the effect of changes in temperature, precipitation and other climate variables on pest outbreaks. There are many areas related to simulation models which require further research, including: disturbance cycles, impact of climate on the host species, effects of extreme events, modelling pest drivers other than weather, modelling the effect of pests on non-host species, biology of new pest species including invasive species, and the range of current pests in relation to hosts.

Session three provided an overview of available forest and pest outbreak databases, and this led to a discussion of statistical methods. There are two major sources of pest outbreak data: tree ring records and aerial survey data. Tree ring data are collected in the field for specific research projects. Aerial survey data are available for many pest species in BC through an ongoing monitoring program at the BC Ministry of Forests and Range. Tree host species data are available as forest inventories or vegetation plots (collected for the biogeoclimatic ecosystem classification system). Major data gaps exist in areas not managed for timber, including federal and provincial parks. Statistical models can be used to explore the temporal and spatial relationships between pests, their host species, available site characteristics (e.g. drainage, soil), and climate. A simple approach develops independent climate envelopes for both the pest and the host species to forecast future ranges of pest outbreaks. Statistical models can also be used to appraise process-based models, quantify uncertainty, and for exploratory analysis during the initial stages of research. A statistical model is more useful if it directly incorporates biologically meaningful information based on scientific knowledge and understanding of the pest or host itself.

The fourth session concentrated on climate databases and methods for downscaling to a biologically meaningful scale. Climate databases are continually improving, including data on the probability of occurrences of extremes. There are three important issues: 1) distribution of the climate stations (90% of the stations are below 1000 m); 2) geographical variability in precipitation; and 3) incomplete snow depth data. Future projections from Global Climate Models (GCMs) are reasonable in their estimation of future climate. However, daily GCM output may not be used directly. This may present a difficulty for modelling where pest outbreaks are tied to sequences of weather events. Needs for climate data related to impacts of forest pests include improvements in: 1) climate triggers of pests and host stress, as well as 2) geographical resolution and data frequency.

The final session discussed ways to move forward, including filling gaps in knowledge and solutions to some of the problems brought up in other sessions. Participants created a list of top pests expected to impact BC forests in the future.

Acknowledgments

Introduction

The purpose of the symposium was to initiate a dialogue on the scientific requirements for research on forest pests and climate change in Canada and the United States. In light of considerable uncertainty about forest pests, accelerated or unanticipated changes in the forests, and a potentially short time span to react and adapt, we hoped to focus on identifying and producing information which can assist researchers and planners with short and long-term efforts to respond to forest pest outbreaks. In addition, we wanted to help build new collaborative relationships between scientists, learn about new data sources, discuss the application of modelling and statistical methods, and explore the integration of economic impacts into detailed research studies. The priority was to better understand pest dynamics in the non-pine forest and younger forests in order to: guide retention for non-timber values, direct current and future harvesting, and minimize potential threats to these forests.

The focus of this discussion was largely on forest pests in British Columbia and their potential future impacts. British Columbia's Chief Forester, Jim Snetsinger, opened with an overview of the problem from the perspective of the BC Ministry of Forests and Range. The main question facing foresters in BC is: what is sustainable forest management in the context of rapid climate change? Many knowledge gaps exist, including the rate and magnitude of climate change, which climate conditions are favourable to pest outbreaks, capacity of the plant community to adapt, how forest pest species will adapt, and which forest pests could cause the greatest impacts. As trees become stressed by changes in temperature and precipitation, pest populations and the existence and prevalence of non-native invasive pest species may increase. However, the rate or geographical scale of anticipated pest response is not known. Intermediate and fine scale disturbances are the least understood processes and new information is required to plan at this level. The focus of the symposium was on large scale disturbances which also requires further research.

The symposium discussion sessions were organized into five topics, as follows:

1. Models of economic impacts of forest pest outbreaks;

2. Biological models of pests and hosts in relation to climate;

3. Forest and pest outbreak databases and statistical methods;

4. Climate (historical and future) databases and methods for downscaling to a biologically meaningful scale; and

5. Input for a strategy for a comprehensive analysis of impacts of climate change on pests in western North America.

Session 1: Models of economic impacts of forest pest outbreaks

In order to integrate research on forest pests and climate change, future modelling must incorporate an economic component that addresses the impact of pests on future timber supply, especially in areas not currently infested by mountain pine beetle. Economic value must be incorporated into models as both monetary and non-monetary values. The "Triple Bottom Line" in this context is: 1) social values of the forests, significance to culture, recreation, and community, 2) biophysical values - functioning ecosystem processes and services, and 3) economic values. This is also illustrated by the concept of 'emergy', which is described by Odum and Odum as follows:

> *"Emergy…expresses all numbers in one kind of energy (for example, solar energy) required to produce designated goods and services. Thus, it measures the work of the environment and economy on a common basis."*[i]

Risk management and maintenance of resilient forest ecosystems will help to ensure all types of values are retained in BC's forests.

Economic values

In the future, carbon will be a key component of economic models. Retaining carbon in the system and limiting its release into the atmosphere will be essential. The way to keep the carbon in the system is to maintain healthy, vital and productive forests. Risk management will be essential since both pests and fire release carbon into the atmosphere.

Diversification of the species harvested and replanted for commercial use may be required for adaptation to climate change as well as changing market conditions. BC's current tenure system may require changes to enable adaptation. More research is needed into updating existing growth and yield curves to consider climate change. Models, including timber supply models, must incorporate uncertainty. Yet, model assumptions and boundary conditions could require updating to account for response to climate change (directional) and climate variability (cyclic).

There is also a need to include non-timber forest products into our market evaluations. This will require additional information on understory growth rates and productivity; most of these essential data are currently unavailable.

One challenge is that the rate of climate change is faster than changes to rate constants. Current discount rates do not adequately account for the low rate of technological change, the fast rate of climate change, the global aspects of impacts, and the socializing of losses. Management systems must be developed at a faster rate than the rate of discount. Consideration of who will bear the gains and losses in terms of distributional economics, and whether compensation is fair is important

Non-economic values

Key ecosystem services are also essential to consider. These include, but are not limited to, water quality and supply, air quality, and soil processes. Knowledge is weak in terms of understanding ecological processes, but forest management must aim to keep the forest growing, healthy and resilient in spite of a lack of information about the complexity of forest ecology. This is beyond the issue of pests since resiliency can be affected by other disturbances (including harvesting). Cultural, recreational and subsistence use of the forest and forest species are also essential considerations. Once the forest is healthy, community values can be centered on forest values. Non-timber values from the forest require additional information since very little is known about the forest understory.

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[i] Odum, Howard T. and Eugene P. Odum. 2000. The Energetic Basis for Valuation of Ecosystem Services. *Ecosystems* 3(1): 21-23.

Integrative approaches

Some suggestions were made as to how we can incorporate monetary and non-monetary values as well as uncertainty into our planning:

1. Create a value index. This can include primary productivity, adaptation, risk management, and a measure of diversity. The index could be tested and monitored to ensure it stays within a sustainable range.

2. Use scenario planning. Develop multiple future scenarios, including those that seem farfetched. This can also include sensitivity analysis of the models used to develop the scenarios.

Session 2: Models of pests and hosts in relation to climate

Process-based, simulation biological models (such as BioSim) have been developed which are based on the physiological response of the pest organism to weather events and climate patterns. Knowledge of pest phenology can be used to build simulation models that explore the effect of changes in temperature, precipitation and other climate variables on pest outbreaks. These models have not yet successfully or comprehensively included all of the other fundamental population processes (reproduction, dispersal, survival), and thus are limited in their ability to forecast insect numbers (outbreaks).

The best use for such models in a climate change context may be for approximating an insect species' fundamental niche (mapping where it could possibly complete its life cycle). Building simulation models is possible for pests for which we are knowledgeable, but more difficult for lesser-known or invasive pest species. There are no generic climate triggers for pest species that would allow us to build a generic pest simulation model. However, a tool could be built which incorporates a biological simulation model for important pest species (see list below). To go forward new tools must be welcomed while improvements to existing models and approaches must continue.

There are many areas related to biological models that require further research. These include:

- Disturbance cycles – what are the causes and correlations with other factors? We need to be able to map out the range of responses to these cycles. We also need to incorporate climate and disturbance cycles into our models.

- The impact of climate change on the host species – physiological stress and potential host migration scenarios. There may be an important link between host tree stress and pest outbreak that should be explored further.

- The effects of extreme events (tails of the distribution). The extremes are often more important than means/averages, although extremes are difficult to model.

- Modelling of non-climatic pest outbreak drivers will prevent placing too much emphasis on the importance of weather on pest behaviour.

- Modelling the (often indirect) effect of pests on species (e.g., understory) that are not the direct hosts is important for wildlife, biodiversity, and non-timber forest products.

- The biology of new pest species, including non-native invasive species. This information must be gathered quickly once a potential pest problem is noticed.

- The range of current pests in relation to their hosts. Do these distributions match? If not what factors constrain the distribution of the pest? What about in the past?

- Realistic incorporation of reproduction, dispersal, and survival, recognizing that these processes do not act independently of each other or phenological development.

Participants agreed that an anticipatory, detailed focus on exactly what research questions are being sought would save a lot of misplaced effort, especially when the required model outputs are more complex than simple harvesting levels.

Session 3: Forest and pest outbreak databases and spatial statistical methods

Databases

There are two major sources of pest outbreak data: tree ring records and aerial survey data. Tree ring data are collected in the field for specific research projects. Yearly aerial survey data are available for many pest species in BC through an ongoing monitoring program at the Ministry of Forests and Range[ii], which was previously conducted by the Forest Insect and Disease Survey Unit of the Canadian Forest Service. Historical pest data has been compiled into databases using such surveys by the Canadian Forest Service[iii]. For some pests, there are more than 50 years of data available within these historical databases, depending on the pest species.

Some issues to consider with these types of data include:

- They do not capture the troughs of population cycles, and thus miss any potential effect of climate on low density populations;

- Spatial and temporal resolution is limited;

- There are differences in methodology of data capture between different agencies;

- How the information is recorded/captured and what is being recorded varies. For example, due to poor weather, there can be difficulty in completing aerial surveys. These survey methods have not changed much since the 1960's although the reliability and quality has improved steadily since the late 1970's; and

- Tree ring analysis shows that the aerial surveys fail to detect outbreaks of some defoliator species due to subtle crown symptoms or for other reasons.

Opportunities must be created to integrate databases between institutions, including common data collection methods, and ensuring easy access to all information.

Tree distribution data were not discussed at this venue, but is an important issue. Forest inventory data, available for all of BC as a spatial coverage, are still inaccurate. Other data sources include vegetation plot data (which is collected for the biogeoclimatic ecosystem classification system) but these data are not a continuous spatial coverage.

In BC these data are incomplete because forest land is generally only inventoried regularly for pests or vegetation if it is managed for timber. Parks Canada has some limited inventory information, but BC Parks does not.

General areas of concern include:

- There is no funding available to fill data gaps, whether they are spatial or temporal gaps;
- Administrative and political borders create artificial boundaries and data gaps that must be overcome; and
- More data on endemic, not just epidemic, pest population dynamics is required.

Biological spatial statistical models

Biologically based statistical models can be used to explore the temporal and spatial relationships between pests, their host species, available site characteristics (e.g. drainage, soil) and climate. Such

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[ii] Available online at: http://www.for.gov.bc.ca/hfp/health/overview/overview.htm
[iii] Available online at: http://www.pfc.cfs.nrcan.gc.ca/entomology/pests/index_e.html

models typically focus directly on insect impacts (e.g. number of years of moderate-severe defoliation over space and time) and are thus relatively easily combined with economic models. A simple approach is to develop separate, independent climate envelopes for both the pest and the host species to forecast future ranges of pest outbreaks. More comprehensive approaches also consider interactions between pest impacts, host species, site factors, and climate to forecast outbreak intensity. Biologically based statistical models can also accept mapped output from phenological development models as input, thus producing a hybrid model.

Statistical models can be used to appraise process-based simulation models, quantify uncertainty, and be used in the initial stages of research for exploratory analysis. A statistical model is more useful if it incorporates biologically meaningful variables based on scientific knowledge and understanding of the pest or host itself. Quantifying uncertainties is essential if predictions are to be made of future responses of pest outbreaks as the climate changes. Biologically-based climate envelopes can highlight gaps in our knowledge about the pest or host species which can in turn be used to inform process based models. Statistical models have also been used to determine the scales at which different processes occur (e.g., climatic influences, contagious population processes), and in this sense, inform simulation modelers.

Statistical modelling of pest dynamics may be able to incorporate information from the abundant literature on human disease mapping. Many of the mapping and monitoring techniques from the medical field could be modified to address forest pest species. Breaking the problem into smaller components may be more effective than tackling the whole problem all at once.

Session 4: Climate databases and methods for downscaling to a biologically meaningful scale

Climate databases are continually improving, including data on the probability of occurrences and extremes. There is an issue with coverage of the climate stations since 90% of the stations are below 1000 metres in elevation. Also, precipitation varies considerably across the province. There are snow data available in the province, but some of the automated recorders do not record precipitation accurately.

Future projections from Global Climate Models (GCMs) are reasonable in their estimation of future climate. However, we cannot use daily output from the GCM directly. Cycles of climate variability (such as the Pacific Decadal Oscillation) are not necessarily simulated by a GCM. This may be a problem for pest modelling if pest outbreaks are tied to these cyclic patterns. Using GCM projections to drive a weather generator is one method to construct projections with observed statistics. This method has been used for process-based biological models.

Downscaling and empirical methods require a firm understanding of emerging methodologies. In BC, there is uncertainty around downscaling approaches, in particular with respect to precipitation. Generally, Regional Climate Models are expected to be an improvement over GCMs in BC partly because of better representation of BC's complex topography.

Climate data needs related to future pest/climate research:

- When does climate trigger an outbreak, affect outbreak periodicity, and affect outbreak amplitude? Are effects on periodicity and amplitude independent?

- At what scale is this information required for meaningful incorporation into biological models?

- Can a climate index be developed, much like the seasonal severity index for fire, which is applicable to pests? Can a drought index be related to host stress? A useful index could incorporate stress, growth efficiency and primary productivity. Can these indices be presented as probabilities?

It was suggested that insect pests could be divided into two groups (although the groups are not necessarily mutually exclusive):

- Eruptive species with known periodicities related to climate, dynamic outbreak patterns, perhaps occurring through unknown processes; and

- Species that respond primarily to host stresses.

A focus point could be on the need for complex models. However current understanding and predictability in individual components of the forest/pest/climate system should also be exploited in order to take steps forward. Continual monitoring of forest pests is important in addition to modelling because there may be unpredictable responses in the future as the climate changes.

Session 5: Input for a strategy for a comprehensive analysis of impacts of climate change on pests in western North America

List of future forest insect concerns

One of the outcomes of the meeting was a preliminary list of top insect pests that have the potential for significant impact on BC's forests in the future. This list can be used to focus research efforts on those insects that pose the greatest threat to many forest values. It was pointed out that pathologists were underrepresented at the meeting and thus the focus of this list is on insect pests, but pathogens should also be incorporated. Subsequently, input was provided from the BC Ministry of Forests and Range Regional and Branch Forest Health on insects, pathogens, and other disturbance agents (**Tables 1-3**).

The final list ordered by number of votes is:

1. Douglas-fir bark beetle (*Dendroctonus brevicomis*) (7 votes)
2. Western balsam bark beetle (*Dryocoetes confuses*) (6 votes)
3. Western spruce budworm (*Choristoneura occidentalis*) (5 votes)
4. Spruce bark beetle (*Dendroctonus rufipennis*) (5 votes)
5. Mountain pine beetle (*Dendroctonus ponderosae*) (4 votes)
6. Loopers, including Hemlock Looper (*Lambdina fiscellaria lugubrosa*) (3 votes)
7. Two-year cycle budworm (*Choristoneura biennis*) (3 votes)
8. Spruce terminal (or leader) weevil (*Pissodes strobi*) (3 votes)
9. Western blackheaded budworm (*Acleris variana*) (2 votes)
10. Gypsy moth (*Lymantria dispar*) (2 votes)
11. Douglas-fir tussock moth (*Orgyia pseudotsugata*) (2 votes)
12. Warren's root-collar weevil (*Hylobius warreni*) (2 votes)

Of these pests, western balsam bark beetle was identified by the entomologists and foresters attending the meeting as the pest that requires the most research. It was noted that there is little information on both host and pest dynamics for subalpine fir (*Abies lasiocarpa*) at this time because it is not a preferred commercial species.

The BC Ministry of Forests and Range Regional and Branch Forest Health specialists were later consulted after the meeting and were asked for a listing with regional breakdown of the top insects, pathogens and other disturbances that might be expected to respond to climate change (**Tables 1-3**). The approach was not to provide a specific species list but rather a list of pest groups that are expected to respond significantly to climate change.

Gaps in knowledge

- **Understory.** All plant species that are not commercial tree species tend to have had very little research conducted about them and are not included in economic modelling. Also, commercial tree species' dynamics in the understory needs more research.

- **Co-evolution.** The rate of co-evolution between pests and their hosts is not well studied in forestry, especially at the landscape scale.

- **Cumulative impacts.** Cumulative impacts of disturbance events are also not well studied.

- **Probabilities of extremes.** The probability of extreme climate events (extremes in temperature, precipitation, etc.) is difficult to project.

- **Pest biology.** Biologically-based simulation, statistical, and empirical models may assist in this research, as well as the study of thresholds beyond which outbreaks may occur.

- **Coordination.** All the above may be hindered by the absence of coherent strategy.

What can we do?

- **Implement facilitated migration.** Planting trees adapted to future climates is potentially the most effective method of reducing pest epidemic hazards. Testing of species in new habitats is essential; there is much to learn from ongoing BC Ministry of Forests and Range tree provenance trials. Other plants should also be considered.

- **Increase adaptive diversity.** We need to build in a buffering capacity by increasing diversity of species and seed lots at the cut block and landscape level.

- **Maintain forest resilience.** Attempt to avoid forest stress and increase understanding of forest stressors using process-based models. Increase species diversity in the forest. Consider management and resilience in the non-timber land base. Determine what acceptable levels of insect disturbance are before resilience is compromised, and whether or not it is possible to simultaneously manage for resilience and climate change induced stress.

Solutions?

- Use multiple GCMs and downscaling methods but use a consistent set in order to make comparisons between results where different methods are used.

- Expand outbreak database beyond administrative and political boundaries.

- Develop and share new statistical methods and tools to handle some of the complex analyses, e.g., incorporating measurement errors, identifying appropriate scales and investigating interactions amongst pests.

- Identify or build a common framework for biological modelling (such as BIOSIM).

- Expand the application and capability of economic models for these types of analyses.

- Collect and store seeds for all species, especially the non-commercial species, for seed propagation and assisted migration.

- Expand research efforts related to the insect species listed above.

Data

Issues with data currently are:
- Lack of integration and quality control of existing data,

- Missing data from areas not in the timber land base, such as parks and protected areas.

- Missing data from non-commercial species, including understory species,

- Gaps in planning at the watershed level: altitude, latitude, hydrology, weather,

- Difficulties modelling cycles and sequences of weather data for climate projections, and

- Uncertainties in the data.

Economics

Suggestions for future economic modelling:

- Incorporate uncertainty, include risk management;

- Implement adaptive environmental modelling;

- Create multiple scenarios;

- Consider scale and resilience in analysis;

- Look at forest health / regional economies and distributional economics;

- Further research on discounting and valuation of ecosystem goods and services.

Tables

1. Insects potentially influenced by climate change: regional breakdown
2. Pathogens potentially influenced by climate change: regional breakdown
3. Other disturbance agents potentially influenced by climate change: regional breakdown

Table 1 – Insects potentially influenced by climate change: regional breakdown

PEST GROUP	Northern Interior Forest Region		Southern Interior Forest Region			Coast Forest Region	PROVINCIAL
	West	East	Cariboo	Kamloops	Nelson		
Bark Beetles			Spruce beetle				Spruce Beetle
				Douglas-fir beetle			Douglas-fir Beetle
		Western balsam bark Beetle	Western balsam bark Beetle				Western Balsam Bark Beetle
		Ips pini and other 2nd beetles	Various Secondary Beetles			Fir engraver beetle	Secondary bark beetles
Defoliators		Eastern spruce budworm	Western Spruce Budworm				Western Spruce Budworm
		Western hemlock looper		Loopers			Loopers
			Two year cycle budworm				2 yr cycle budworm
				Sawflies			
		Forest tent caterpillar					
Weevils			Spruce leader weevil				Spruce Weevil
			Pine Terminal weevil				
		Warren's root collar weevil	Warren's root collar weevil				Warrens root collar weevil
	Poplar and Willow Borer						
Other	Balsam wooly adelgid					Balsam wooly adelgid	Balsam Woolly Adelgid
	Invasive species						

Data provided by Tim Ebata based on input from BC Ministry of Forests and Range Regional and Branch Forest Health.

Table 2 – Pathogens potentially influenced by climate change: regional breakdown

PEST GROUP	Northern Interior Forest Region – West	Northern Interior Forest Region – East	Southern Interior Forest Region – Cariboo	Southern Interior Forest Region – Kamloops	Southern Interior Forest Region – Nelson	Coast Forest Region	PROVINCIAL
Foliar Diseases		*Dothistroma septospora*				Dothistroma & others	Foliar diseases
		Lophodermella concolor					
		Elytroderma deformans					
		Phaeocryptopus gaeumannii (sp?)					
		Rhabdocline					
		Delpinella spp.					
Pine Stem Rusts		Western Gall Rust				All Rusts	Stem rusts
		Comandra Blister Rust					
		Stalactiform Blister Rust					
Root Disease			Armillaria root disease				Root diseases
			Phillinus root disease				
		Tomentosus Root Rot					
Decays						All Decays increase with moisture	Decays
Mistletoes			Lodgepole pine dwarf mistletoe				
			Douglas-fir dwarf mistletoe				

Data provided by Tim Ebata based on input from BC Ministry of Forests and Range Regional and Branch Forest Health.

Table 3 – Other disturbance agents potentially influenced by climate change: regional breakdown

PEST GROUP	Northern Interior Forest Region		Southern Interior Forest Region			Coast Forest Region	PROVINCIAL
	West	East	Cariboo	Kamloops	Nelson		
Wildlife		Rabbits/Squirrels/voles					Wildlife
Abiotics		Growing Season Drought					Abiotics (drought, fire, wind throw, snow press, frost)
		Cold Extreme Events on unsuited species and provenances					
		Extreme Snow Press Events					
Declines						Yellow cedar decline & others	Declines
Unknown Endemics						Unknown endemic pests	Unknown endemics becoming pests
Unknown Exotics						Unknown Exotic pests	Unknown exotics becoming pests

Data provided by Tim Ebata based on input from BC Ministry of Forests and Range Regional and Branch Forest Health.

Appendix I: Agenda

Forest Pest and Climate Change Symposium
Dunsmuir Lodge, Victoria, BC, October 14-15, 2007

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Sunday, October 14, 2007
5:30 – 6:00PM – Reception (Peninsula Lounge)

6:00 – 8:30PM – Informal Dinner (Dunsmuir Lodge, Room 353)
    Tour de Table- Personal Introductions

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Monday, October 15, 2007 (room 353)
8:30 – 8:45 AM: Purpose of the meeting / Setting the Context:
    Harry Swain, Executive Director, Pacific Climate Impacts Consortium

8:45– 9:00AM – Welcoming remarks
    Jim Snetsinger, BC Chief Forester - *Information requirements for policy and management*

9:00 – 10:00 AM: SESSION 1: *Models of economic impacts of forest pest outbreaks (chair: Vince Nealis)*

10:00-10:30 AM: Coffee Break (Peninsula Lounge)

10:30 – 11:30AM – SESSION 2: *Biological models of pests and hosts in relation to climate (chair: Jacques Régnière)*

11:30 – 12:30PM – SESSION 3: *Forest and pest outbreak databases and statistical methods (chair: Steve Taylor)*

12:30 - 1:30PM – Lunch (Main Dining room)

1:30 - 2:45PM – SESSION 4: *Climate (historical and future) databases and methods for downscaling to a biologically meaningful scale (chair: Dave Spittlehouse)*

2:45 – 3:00PM Coffee Break (Peninsula Lounge)

3:00 – 4:30PM Moving Forward: *Input for a strategy for a comprehensive analysis of impacts of climate change on pests in Pacific North America (chair: Harry Swain)*

Appendix II: Participant List

Forest Pest and Climate Change Symposium
Dunsmuir Lodge, Victoria, BC, October 14-15, 2007

Name	Title	Organization
Mr. Clint Abbott	Assistant Director/Business Consultant	Centre for Global Studies/Pacific Climate Impacts Consortium
Dr. Rene Alfaro	Research Scientist	Forest Entomology, CFS, Pacific Forestry Centre, Victoria
Dr. Rasmus Astrup	Senior Scientist, Bulkley Valley Research Centre	BV Research Centre, Vancouver & Smithers
Dr. Brian Aukema	Research Scientist & Assistant. Adj. Professor	CFS & University of Northern British Columbia, Prince George
Mr. Bryce Bancroft	Tree Species BC project manager	Symmetree Consulting Group Ltd., Victoria
Ms. Katrina Bennett	Hydrologist	Pacific Climate Impacts Consortium, Victoria
Ms. Jennifer Burleigh	Mountain Pine Beetle Research Specialist	BC Ministry of Forests & Range, Victoria
Dr. Kirstin Campbell	Post Doctoral Research Associate	TerraTree Forestry, Duncan
Dr. Allan Carroll	Research Scientist - Insect Ecology	Canadian Forest Service, Pacific Forestry Centre, Victoria
Ms. Wendy Cocksedge	Acting Director, Research and Extension	Centre for Non-Timber Resources, Royal Roads University, Victoria
Mr. Patrick Daigle		Ecosystems Branch, BC Ministry of Environment, Victoria
Dr. Charmaine Dean	Professor	Department of Statistics&Actuarial Science, Simon Fraser University
Mr. Tim Ebata	Forest Health Project Specialist	Forest Practices Branch, BC Ministry of Forests & Range
Dr. Richard Fleming	Research Scientist, Biological Systems Analyst	CFS, Great Lakes Forestry Centre, Sault Ste. Marie
Mr. Lyle Gawalko	Forest Ecosystem Officer	Parks and Protected Areas Branch, Victoria Ministry of Environment
Dr. Richard Hebda	Curator, Botany and Earth History	Royal BC Museum, Victoria
Dr. Kathy Lewis	Assoc. Professor, Ecosystem Science and Management	UNBC, Prince George
Dr. Jeremy Littell	Research Associate	Fire & Mountain Ecology Lab, University of Washington, Seattle
Dr. Lorraine MacLauchlan	Entomologist	Southern Interior Region, BC Ministry of Forest, Kamloops
Dr. Alan Mehlenbacher	Post Doctoral Research Associate	Dept. of Economics, UVic, Victoria
Dr. Alvaro Montenegro	Post Doctoral Research Associate	School of Earth and Ocean Sciences, UVic, Victoria
Mr. Trevor Murdock	Climate Scientist & Associate Director	Pacific Climate Impacts Consortium, Victoria
Mr. Vince Nealis	Insect Ecologist	Canadian Forest Service, Pacific Forestry Centre, Victoria
Dr. Greg O'Neill	Forest Geneticist	BC Ministry of Forest, Forest Genetics Section, Vernon
Dr. Marlow Pellatt	Coastal Ecologist	Parks Canada, Western and Northern Service Centre, Vancouver
Dr. Haiganoush Priesler	Research Statistician	USFS California
Dr. Jacques Régnière	Research Scientist, Insect Population Dynamics	Laurentian Forestry Centre, Natural Resources Canada, Quebec
Mr. Jim Snetsinger	Chief Forester	BC Ministry of Forests and Range , Prince George
Dr. Dave Spittlehouse	Research Climatologist	BC Ministry of Forest and Range, Victoria
Mr. Craig Sutherland	Deputy Chief Forester	BC Forest Service, Victoria
Dr. Harry Swain	Senior Advisor	Pacific Climate Impacts Consortium, Victoria
Mr. Steve Taylor	Forestry Officer	Canadian Forest Service, Pacific Forestry Centre, Victoria
Dr. Jan Volney	Research Scientist	Canadian Forest Service, Northern Forestry Centre, Edmonton