COMPLEX STANDS RESEARCH AND MANAGEMENT CONFERENCE

FEBRUARY 19-20, 2007
SMITHERS, B.C.

PROCEEDINGS

Bulkley Valley Centre for Natural Resources Research & Management
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INTRODUCTION

The **Bulkley Valley Research Centre** hosted a dynamic conference in February of 2007, attracting some of the province's top forestry professionals as well as prominent researchers from Alberta and the United States.

This conference was organized as a way for researchers, managers, silviculturists, and other practitioners to update themselves on current developments in the science of managing complex forest stands. In the past 5 years there have been substantial advances in our understanding of complex stand dynamics, in our knowledge of non-timber values, and in an array of simulation models and decision support tools to support decision-making around complex stands. Much of this is driven by the current mountain pine beetle epidemic. Such models continue to be modified and improved. The conference and proceedings are ways to distribute this information more broadly.

Our definition of 'complex stands' for this conference is fairly simple. 'Complex stands' have: multiple tree species, species of multiple ages, multiple layers, a variety of other organisms, and are managed for multiple values.

On the first day of this conference, speakers shared their **different perspectives on complex stand management**. Andrew George Jr. (Chief Skit'den) and David deWit of the Wet'suwet'en, spoke of their Wet'suwet'en Territorial Stewardship Plan. The Chief Forester of British Columbia, Jim Snetsinger, discussed the future of complex stands in BC and implications for timber supply analysis. One of the most significant obstacles to updating forest inventories, and to subsequent timber supply analyses, is a lack of trained people on the ground to carry out the inventories. Eugene Runtz presented a small-scale logger's perspective on partial cutting of visually sensitive landscapes in the Robson Valley. He emphasized the following points: keep your community informed, and attempt to apply different management schemes in various contexts (i.e., try different levels of harvest in different situations, including clear-cutting where appropriate). Carl vanderMark (Industry perspective) emphasized the need for greater flexibility and spoke to some of the forest policy issues that require retooling in order to make complex stand management affordable. This was followed by Steve Chatwin and Bryce Bancroft (the Hydrologists perspective) who concluded that salvage logging of mountain pine beetle-affected stands results in significant changes to streamflow peaks and discharge rates, over and above streamflow changes from grey-attack alone.

Dr. David Coates, Research Silviculturist with the Ministry of Forests and Range, spoke about the challenges facing traditional silviculture in embracing complexity. There is no longer one best treatment option to be implemented. There are choices to be made and trade-offs to be considered across a gradient of conditions. Growing healthy productive forests, with a diversity of structure in space and time, is going to be our best strategy over the long term to meet a range of objectives.

Dr. Charles Canham, Senior Scientist, Institute of Ecosystem Studies, Millbrook, New York spoke on the tension between embracing complexity and simplifying things enough to create a robust simulation model that we can work with and which can inform forest managers. He spoke about the evolution of the SORTIE model as a means of developing an understanding of the whole system based on local neighborhood interactions. A major concern of his is that we are developing models based on parameterization in our current world and yet that world is rapidly changing. Models are the best way to anticipate those changes. This is why long-term monitoring is so important. For adaptive management to work, we need to be able to compare the results of our models against long-term field data.

INTRODUCTION

The second day of the conference focused on active research projects addressing some of the questions and challenges that researchers have encountered over the past 5 years. The three main topic areas were:

1. **Research on complex stands and succession**. To understand and predict stand dynamics and growth of complex stands it is important to understand and quantify the relationship between light availability and tree performance. It appears that the light-growth relationship varies regionally, according to variations in macro-climate, and temporally, according to the age of the stand. Also, understorey tree development varies in aspen-dominated stands compared to conifer-dominated stands. For shade tolerant species such as subalpine fir productivity is strongly correlated with soil nitrogen regardless of light levels. Much has been learned in recent years, and there are still many unanswered questions in understanding complex forest dynamics.

2. **Management and research related to mountain pine beetle infected stands**. This section provided an update on some of the new research that has been undertaken over the past 5 years related to mountain pine beetle. In one study, the TADAM growth model was used to try to predict future productivity of 20 to 60 year old stands attacked by MPB. Another study uses modeling to predict wildlife habitat values following MPB attack and subsequent salvage logging. Emerging evidence suggests that beetle-killed forest, particularly containing residual live trees, continues to provide habitat for a number of species that do not use young clearcuts. In order to understand the cumulative impact of one disturbance process on another, dendroecological research is being used to elucidate the timing of the two-year cycle budworm, and subsequent spruce beetle and western balsam bark beetle outbreaks. Finally, a mountain pine beetle management decision support tool (MPB MDST) was presented in which cost/ benefit, net present value, and mean annual increment metrics can be modeled, according to a variety of stand treatment options grown in SORTIE. Many of these presentations were followed by insightful discussions of model assumptions and limitations that can be found in the question and answer section of the proceedings.

3. **Growth models and decision support tools for complex stand management.** The Prognosis model has been adapted for use in B.C. in order to obtain growth and yield estimates for complex stands. The model was first used to predict outcomes in partially cut complex stands in southeastern B.C. and is now being adapted to project stands following attack by mountain pine beetle. However, MPB-killed stands are more difficult to model because of the more complex mortality and ingrowth/regeneration dynamics. The Tree and Stand Simulator (TASS) model is a spatially explicit model that most often supports traditional silvicultural decisions and timber supply analysis, but is increasingly being used to design, project, and evaluate non-traditional silvicultural systems and stand management strategies, including estimates of wildlife habitat supply. In order to more precisely describe complex stands without the use of plots, a 17-class system of stand structure classification for even and uneven-aged stands has been developed in the Cariboo.

The conference was followed by a two day SORTIE-ND workshop which introduced foresters to the latest software that will offer an innovative approach to modeling complex stand structures. For more detailed information regarding SORTIE-ND, please visit http://www.sortie-nd.org/

SPEAKERS

Dr. Sybille Haeussler

Andrew George, Jr. & David deWit

Jim Snetsinger

Eugene Runtz

Carl vanderMark

Steve Chatwin & Bryce Bancroft

Dr. Dave Coates

Dr. Charles Canham

Marty Kranabetter

Dr. Phil Comeau

Dr. Rasmus Astrup

Cosmin N. Filipescu

Dr. Chris Hawkins

Doug Steventon

Doug Thompson

Dr. Kirstin Campbell

Dr. Valerie LeMay

James W. Goudie

Ian Moss

DR. SYBILLE HAEUSSLER

PRESIDENT, BULKLEY VALLEY RESEARCH CENTRE

Preamble:
The Science of Complexity

The study of complexity is an attempt to get beyond the traditional reductionist approach in science. Science has worked very well at taking systems apart and looking at their individual components and predicting how those components will be behave. Complexity is about looking at the interactions between those components, and that gets a lot more difficult. A second feature when we look at complexity is that while in traditional reductionist science there is usually background noise that you try to extract from so you can get at the true signal, in complexity science, variability is a really important aspect of the system being studied. One of the best ways to sum up the whole idea of complexity in science is the whole is more than the sum of its parts. So when the pieces come together what happens with the whole.

Some of the people who specifically define themselves as complex systems scientists define complexity as those properties in a real world system that can't be adequately understood or predicted by examining any or all of its component parts. So we are studying the phenomenon that occur because of the interactions.

Some of the features that occur in all types of complex systems:

- The relationships are non-linear because of positive and negative feedback loops;
- Open and non-equilibrium systems;
- Highly sensitive to the initial conditions;
- They have memory, or hysteresis, i.e., what happened before is important to what happens later;
- There are often many different scales of interactions, one nested inside the other;
- They have intermittency – big events, catastrophic or massive events seem to happen more often than what might be predicted based on random occurrence;
- There are either no boundaries or it is very difficult to establish where the boundaries are in complex systems; and,
- They have emergent behavior – when a phenomenon arises spontaneously because of the interactions.

Both forests and forestry are complex systems. Forests have many components, they operate at multiple scales. Single species and single age classes are insufficient ways to deal with the complex phenomena forests. In forests we do have emergent phenomena, a classic example being the mountain pine beetle outbreak, where it grew out of one point and became this huge phenomenon. It emerged in multiple centers and coalesced into what we now view as a giant outbreak. We wouldn't have been able to predict it. In hindsight we can say these are the factors that lead to it. But would we be able to predict when the next one is going to arrive? Will we have a spruce beetle outbreak on the same scale?

Forestry too is a complex system. It involves the interaction of ecological, social and economic systems. Technical solutions alone are insufficient for solving forestry problems.

Forestry is on the verge of adopting a complex systems approach. We are very aware that the current challenges we face are not solvable with traditional reductionist approaches. But, complex system science at this point can't provide workable solutions for managers. It's just an emerging science and we don't yet have the tools. The tools are more at the theoretical stage. We are at the

transition stage where I think we need to take a two-pronged approach. One is to use models that push the limits of our traditional reductionist approach by using advanced computing power, and perhaps by linking together various models at various levels that have been developed more traditionally and seeing what new knowledge emerges from those. Secondly, we can use complex systems, approaches, and models at a more conceptual level. If we haven't got the math and the science producing these very detail models yet, we can use the concepts, and adopts those to deal with some of the higher level social and ecological issues that we face. So, we should tackle our problems at an appropriate level of detail. To paraphrase something Einstein once said, "any problem that we approach should be approached as simply as possible, but not too simply". So we do have to deal with complexity but at this point we need to figure what's the appropriate level of detail. We need to find those interactions that are most important – which ones control system behavior; which ones we have the potential to affect in order to change the system.

A local example of emergent behavior: the moose have figured out that it is safer in the Town of Smithers than outside town.

DR. SYBILLE HAEUSSLER

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BIOGRAPHY:

Sybille Haeussler, PhD, RPF is president of the Bulkley Valley Research Centre. Sybille is a professional forester and research scientist whose work addresses the dynamics and diversity of plant communities and ecosystems — with a special interest in complex systems dynamics and the role of self-organizing processes in maintaining ecosystem diversity. Sybille has a BSF (Forest Biology) from the University of BC, an MSc (Forest Ecology) from Oregon State University, and a PhD (Environmental Sciences) from the Universite du Quebec a Montreal. Sybille currently works as a Killam (honorary) and NSERC post-doctoral research fellow for the Forest Sciences Department, University of BC, and before that was self-employed for more than 20 years as the proprietor of Skeena Forestry Consultants, based in Smithers, B.C.

Andrew George Jr.
David deWit

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Andrew George

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David deWit

A First Nations perspective on resource management: Forests for everyone

Undoubtedly, the sustainability of our forests and ecosystems are important to our entire population. This is particularly evident for the First Nations of BC, as these indigenous populations have a profound connectivity to their natural environments. Therefore, the sustainability of the natural environment, such as forests, is vital for First Nations cultural and physical continuity.

The Wet'suwet'en of north central BC exemplify the concept of spiritual, physical, mental and ideological connectivity to their traditional territories. The Wet'suwet'en epistemology (theory of knowledge) is dependent upon the continuous and regular use of the resources that the natural environment is able to provide for them. When Wet'suwet'en traditional use patterns change, it has a serious impact on their ideology and socio-political structure.

This presentation will describe some of the impacts of general forestry activities on the Wet'suwet'en culture. More specifically, it will address the importance of sustainability of forest ecosystems for the Wet'suwet'en, and their belief that forest resources are for everyone to utilize – past, present and future.

See next page for Biographies.

ANDREW GEORGE JR.
DAVID DEWIT

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Andrew George

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David deWit

BIOGRAPHIES:

Wet'suwet'en hereditary chief **Andrew George, Jr**. has extensive experience in forestry and Aboriginal lands and resources management. Andrew was the Lands and Resources Manager at the Office of the Wet'suwet'en for eight years before leaving to pursue his culinary interests. He has established countless relationships with government, industry and academic institutions throughout British Columbia.

As Wet'suwet'en Hereditary Wing Chief Skit'den, Andrew continues to be actively involved in the Wet'suwet'en traditional feast system and is deeply respected by the Wet'suwet'en hereditary chiefs, elders and clan members for his knowledge of the Wet'suwet'en territories, traditional system, lands and resources issues, and ability to build bridges with non-aboriginal agencies.

In addition to his resource management, traditional and life experience on the territories, Andrew is well-versed in the tourism sector, where he has participated in Aboriginal resource planning and product development missions to the United States and Europe.

Andrew George is a world-renowned chef and was a member of the Canadian Native Haute Cuisine gold-medal team at the World Culinary Olympics in 1992. He and his teammates were among 13,000 contestants from over fifty countries to enter the competition. They took first place and made history as the event's first native competitors. After winning seven gold, two silver and two bronze medals, George and his team are credited with establishing an Aboriginal presence in international cuisine.

In 1997, George published an aboriginal cuisine book entitled "FEAST". He will be catering the Complex Stands Conference.

David deWit studied integrated resource management in British Columbia and completed a biology degree at the University of Calgary. His background involves wildlife habitat surveys, sensitive ecosystem preservation and wildlife corridor design. He currently works at the Office of the Wet'suwet'en developing an ecosystem-based management tool that will enable the First Nation to manage cultural and natural resources effectively with community, industry and government parties.

JIM SNETSINGER

CHIEF FORESTER, MINISTRY OF FORESTS

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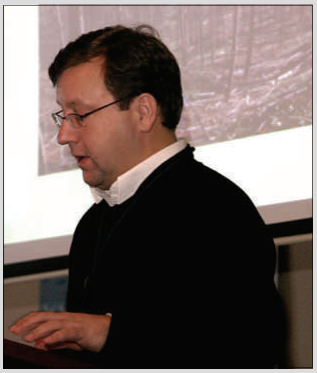
BIOGRAPHY:

In November, 2004, **Jim Snetsinger** was appointed as BC's chief forester.

As Chief Forester, Snetsinger is the senior professional forestry executive of the Ministry, responsible for developing plans and programs to manage provincial forest and range lands. He's the executive in charge of the Forest Science program and is responsible for determining timber harvest levels for each timber supply area and tree farm licence in the province. He also oversees the ongoing implementation of the new *Forest and Range Practices Act* and regulations.

Before becoming Chief Forester, Snetsinger was the regional executive director for the Northern Interior Forest Region. A professional forester since 1981, he's a graduate of the University of Toronto and worked as a forester for five years with BC Hydro before joining the Forest Service in 1986. Since then, he's worked in the former Prince Rupert Forest Region and also served as a regional director for Land and Water BC.



The future of complex stands in British Columbia, and implications for timber supply analysis

This talk comes from the perspective of the Chief Forester of British Columbia who is legally mandated with the responsibility for determining appropriate levels of annual allowable cut (AAC) in 137 forest management units every five years within the province. This determination depends on the best research, growth and yield, and inventory information available at the time of the decision.

Going back to the early 1970s, clearcutting was the dominant practice applied to forests that today would be largely described as old growth. During that time, the province deployed simple growth models, predicated on even-aged assumptions, and regulated harvests based on the Hanzlik formula. Harvest levels were also greater on the coast than in the interior. By 1985, the situation was starting to change; we had produced the first managed stand yield tables for second growth coastal Douglas-fir using the Tree and Stand Simulator (TASS).

Today there are greater public demands on all forest values, other than just timber. There has been a shift toward variable retention harvesting and ecosystem-based management, resulting in the retention of more complex stands following harvesting. The mountain pine beetle selectively removed lodgepole pine from the landscape, leaving a wide variety of secondary structures that are of potential significant to maintaining mid-term timber supplies. Climate change is expected to have dramatic effects on future forest and stand conditions.

It has never been as important as it is today to better describe how complex stands respond to management and how they are expected to grow over the longer term as a result. My next AAC determination is in the Morice Timber Supply Area immediately to the south of the Bulkley Valley, where this conference is being held. This is going to be a difficult task. Fifty-seven million cubic metres of lodgepole pine are at risk of being killed by the mountain pine beetle. As a result, secondary structures will be important to future wood supplies and to the protection of many forest values. Thank you for your interest in this conference and for your work on this topic. It is timely and important to fulfilling my responsibilities as Chief Forester.

JIM SNETSINGER

CHIEF FORESTER, MINISTRY OF FORESTS

The future of complex stands in British Columbia, and implications for timber supply analysis

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QUESTIONS & ANSWERS

Q: Are you planning to address the fact that our current inventory is out of date and in some cases in the province pretty poor by getting another inventory of the provincial forests going?

A: Good question. It was a little over a year and a half ago that the inventory came back to the Forest Service, which as the Chief Forester I was very pleased with. Since that time, we've done a review of our inventory program, which has led to the formation of the Vegetation Resource Inventory Advisory Committee to the Chief Forester and we're developing a strategic plan on what our priorities should be for inventory in the province. We have about a steady state inventory program of about $8 to $10 million a year over the course of the next number of years. The model's a little different now than the model that I grew up in where the Forest Service did all the inventory. We're now working collaboratively with industry. The advisory committee to the Chief Forester will be producing a strategic work plan over the course of the next five years and an annual work plan on which inventories need to be done first, or re-inventories need to be done first. So, we can't re-do the inventory all over the province at once, but we've got a plan in place to do it in the highest priority areas first, and to spend our FIA money as wisely as possible.

Q: Additional information on secondary structure?

A: There should be opportunities to do that through the Vegetation Inventory Advisory Committee.

Q: Do you know if, under the Forest and Range Practices Act (FRPA) it's clear that licensees, FF forest stewardship funders have to fully support all types of harvesting on the ground? For example, the licensee could be carrying out partial cutting and leaving a lot of retention behind, for reasons other than timber. Is it clear under FRPA that the Forest Steward Plan has to support or detail that type of harvesting? We're struggling with that right now.

FRPA standards are currently based on even-aged management. There really isn't any provincial standard that I'm aware of for retained trees, particularly on the coast. Licensees are starting to carry out partial cutting and leaving trees behind, for timber, and for other reasons. We're not clear whether or not under FRPA the licensees have the freedom to deviate from the forest stewardship plans.

A: Difficult question, but let me see what I can do with it. The licensees do have a lot more flexibility and freedom under FRPA. We have been monitoring partial-harvesting on the coast and I'll give you my impressions. The range of partial harvesting is all over the map depending on what ecosystem you're in and what the values are they're trying to manage for. I've seen partial-harvesting from helicopter logging that opens up a significant patch that

allows cedar and Douglas-fir to be planted with good regeneration. And then I've seen other harvesting practices, mostly outside the timber harvesting land base but nonetheless in the productive TSA, where we've had cedar, partially-harvested, leaving a stand of hemlock. Without a lot of light getting to the ground we're not likely to get a lot of cedar. So we're monitoring those kinds of practices and it's not clear under the Forests and Range Practices Act whether there's enough guidance that would require the licensees to specify what it is they're trying to achieve with some of this partial-harvesting activities. So the Coast Region Implementation Team is looking at it. I believe that if we're going to carry out partial-harvesting, and I think it's an appropriate tool in certain spots, we really have to know what the end game is. What's the desired future forest condition that you're actually striving to achieve and how will that management prescription actually get you there? That's a link that I'm not quite seeing yet, so at some point we might need to move to a practice requirement under FRPA that details, and requires that licensee to really think about future forest conditions before carrying out the practice.

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Q: As we're moving out of these pine areas we're going to be moving into the spruce and balsam areas. In terms of appraisals, there's lots of problems with getting proper decay, waste, and breakage factors especially in the spruce balsam stands, given the fact that those inventories were done in the early 1970s. Is this something that's been brought up?

A: It hasn't been brought up yet but I'm sure as we're going to be shifting operations at some point out of the pine-dominated stands into other areas, we'll probably have to have a much better handle on our decay, waste, and breakage. That will come up in the inventory, I'm sure, over time. It hasn't risen to the top of the pile yet, though.

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Q: Getting back to inventory, do you think it's a good model, considering inventory has is come back to forest service, that industry continues to coordinate specific inventories in specific places and the government coordinates the whole thing, or do you think that inventory itself should come back to the government.

A: It's the model we've got and I think it can work. This Cooperative Advisory Council that I've set up is meant to have the Forest Service and the industry look at those priorities across the landscape. It's my opportunity as the Chief Forester to give them where I think the priorities should be for them to chew it over and then for them to come back and produce a strategic plan that actually I endorse and approve. I think what's more critical for this model to work is actually getting the consultants to ramp up their expertise. We've had such a dearth of inventory work done in this province over the past five or 10 years, that the kind of classifiers we need and the kind of inventory people we need just aren't out there. What I want to do is create a stable inventory program of this $8 to $12, and then consultants around the province can count on that work and start to develop that expertise again.

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Q: With respect to seral constraints, what is the seral stage of a stand in which the overstorey has been killed by mountain pine beetle and when does it change?

A: That's a tough question. I'm not sure I quite understand it, but maybe Dave Coates could help me with this one. So, what are you driving at?

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Q: If the land base is being managed for seral, mid-seral, and old-seral, and you must maintain a certain amount of old-seral, then, if your considering your pine overstory and the age at which it is being killed then if the oldest trees are dead, then is the stand old then?

A: It depends on what kind of stand you are in. So that if you are in a stand that is heavily pine-dominated, then it doesn't have a lot of secondary structure in the overstorey, but it still has some understorey in terms of poles and saplings, it probably reverts back to early seral. If that stand is more mixed, with pine as leading but has some spruce and balsam in it and the pine drops out, it probably has more old-growth attributes and mature or old-seral characteristics.

There is no one answer. So foresters really have to take a look at each stand and what the stand conditions are and determine 1) whether or not a stand should be harvested; 2) if it's going to be harvested, how should it be harvested; and 3) if its going to be left, then what are you leaving it for and how will it grow, and will there be enough site occupancy to give you a mid-term timber supply. A whole host of questions.

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Q: You stressed several times in your presentation "other forest values" and I'm wondering if FRPA gives managers the flexibility to really manage for those other values given the language of the objectives in FRPA? I'm asking specifically about the phrase "without unduly reducing timber supply"?

A: I think it does and we've always been practicing with that unwritten objective in mind. And we've had land use plans in place which have zones in them (to protect other forest values), and land use decisions have been made, and trade-offs have been made. I think what that language shows is to take the decisions that society has made around those land use decisions and say yes we want to manage those within a context. The context is those higher level plans that have been established, plus the language that has been established in FRPA. So we still want to maintain a vibrant and healthy forest industry within the province and that's the context that we want to manage in.

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Q: Just thinking about policy. I'm a scientist, so might be a little naïve here. Generally partially cutting can be a little more expensive than clear-cutting. So people who do the partial cutting want some kind of break in stumpage to offset their extra costs. Yet, at the same time the Americans are quite suspicious when we give stumpage breaks to our industry, so there are trade issues involved here. Given this situation how tied are our hands in doing some kind of interesting forestry?

A: Our hands are probably a lot more tied than they used to be. Back about a year and half ago when I was out on a field trip with Dave Coates and others we looked at some of these understorey issues. Dave and Craig Delong said we have to do some research into that. So we did and that work continues. We got FERRIC involved in some partial- harvesting scenarios so we could get an idea of what the costs are in treating some of these stands differently. We are starting to get that information from FERRIC, and I hope I can bring that to the table with Bill Howard and the Director of Revenue Branch. So I don't know exactly how it will interface with the Softwood Lumber Agreement. I think as long as it didn't result in decreased costs, as long as there wasn't any subsidy to industry I think we'd be ok, but I might be a little naïve too. It's probably going to be a lot harder than that.

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Q: Given the changing state of the Interior forest, can you tell me what MoF, ILMB, any other agencies for that matter, are planning with respect to re-examining land use objectives in the light of a mid-term timber supply crunch?

A: The Forest Service is supporting ILMB in areas where there needs to be land use plans re-opened. ILMB has done an analysis on all land use plans to see what needs to be done in terms of opening up land use plans. Other folks like the Omineca Beetle Action Coalition and the Cariboo Chilcotin Beetle Action Coalition are also looking at their existing land use plans to see what changes should, could, or might be made. So there hasn't been a lot of action on that front yet. But I'll note it and see if I can get back to you with a better answer. So far there hasn't been any re-opening of land use plans that I'm aware of.

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Q: Due to the mountain pine beetle, timber supply has been going down for some districts. I'm wondering if you are looking into some redrawing of Timber Supply Area (TSA) boundaries?

A: There's no question when you have an insect like the mountain pine beetle affecting 80% of your mature pine, which in the province represents about 20% of our mature inventory in the timber harvesting land base (THL) there are going to be implications to timber supply. If your question is, have we looked at potentially modifying TSA boundaries as a result – we haven't started to do that yet but it is certainly not out of the question. What we are trying to do is extend the shelf life of this dead timber. One of the things we are trying to do is get other industries in place that can utilize that dead fiber. The milling industries are finding that in a lumber market that is about $260./1000 board feet the amount of decay, drying and checking really plays havoc on their lumber recovery and grade recovery. So what we are trying to do is see if there are other industries, like the pellet industry and oriented-strand-board (OSB), and, you'll see the province come out with a call for bio-energy. We'll see if we can get that dead pine being utilized by other non-lumber producing industries. So what we'd like to see is low grade fiber going to things like OSB and pellets and possibly electrical energy. And then when a stand is harvested that may have been dead a long time but still might have some solid saw logs – some of those logs could go to the lumber producers and the lower grade timber can go to another producer. We'll be looking at lots of ways to try to mitigate this fall-down on communities to reduce the economic impacts, including looking at TSA boundaries and movement of wood from non-impacted areas. There will be all kinds of strategies that emerge over time. But our first goal is to get as much of this timber utilized, so get the right log to the right processing facility at the right time.

EUGENE RUNTZ

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BIOGRAPHY:

Eugene Runtz graduated from Oregon State University with a Bachelor of Science in Forest Engineering. He is a professional forester who worked 10 years on the coast and 20 years in interior British Columbia in the layout of roads, blocks and logging systems. Until recently, he was president and CEO of McBride Forest Industries and is currently a partner with E.P. Runtz and Associates Ltd, in McBride.

Partial cutting of the visually sensitive landscapes in the Robson Valley near McBride, BC

This presentation is about my experience with development of 3,500 hectares of predominantly partial cutting in the Robson Valley east of McBride, British Columbia. Most of the valley is allocated to parks, particularly to the Mount Robson Provincial Park. The areas outside the parks were subjected to a logging moratorium until 2002, when the mountain pine beetle appeared on the scene. McBride Forest Industries was then directed by the Ministry of Forests to harvest in the valley with an emphasis placed on the removal of lodgepole pine. The beetle impacted only about five percent of any one stand at that time, but by 2006 most of the mature pine was dead. Many of the stands included significant representation of other species such as Douglas-fir, western hemlock, spruce and subalpine fir.

Partial cutting was the dominant harvesting system applied for the purpose of meeting Visual Quality Objectives (VQO's). The extent of tree removal was limited to ensure that full and partial retention standards were met.

There are many challenges that must be met to implement partial cuts in visible landscapes, not the least of which is to make them profitable from an industrial perspective. This meant many changes to forest practices. Advanced planning, supported by more intensive field sampling, was needed to really understand the options relating to the use of ground, cable and helicopter logging systems, and to the goal of protecting understorey regeneration. Road location and design specifications had to be carefully thought out. The choice of harvesting equipment and how, when and where it should be used were critical. Careful attention was paid to how these decisions interacted with the provincial stumpage appraisal system. Above all, there was a need to have good communication so that people understood what was going to happen and were in support of it, before operations began.

In summary, there were some lessons learned that I would like to share with you in this presentation.

CARL VANDERMARK

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BIOGRAPHY:

Carl vanderMark is a professional forester with 20 years of consulting and industry employment experience in ecosystems of northern British Columbia and Alberta. He has a BSc in forestry and a diploma in forestry (Advanced Silviculture) both from UBC. Carl is currently the operations superintendent for Canadian Forest Products Ltd, Houston Operation. His primary responsibility is to ensure the Houston Sawmill has an adequate supply of fibre consistent with the division's business plan and sustainable forest management objectives.

Carl assumed his current role last summer. In his previous position as planning superintendent, he was responsible for the operation's strategic and landscape level operational planning activities. Key accomplishments over the last several years include spearheading the division's push for sustainable forest management certification and participation in the development and implementation of a corporate-wide SFM and environment management system.

Carl is also an outgoing board member of the BV Research Centre.

Complex stand management: Canfor Houston perspective

Canfor's Houston operation operates primarily in mature, even-aged single-storied stands. Shortly after enactment of the Forest Practices Code, as part of pre-harvest planning activities, the operation began classifying stand structure in order to rationalize silviculture system prescriptions. The presenter provides an overview of the operations experience prescribing silviculture systems for complex stands, elaborates on a specific example as a case study, presents considerations in light of the Mountain Pine Beetle epidemic and finally outlines challenges moving forward, from an industry perspective.

STEVE CHATWIN & BRYCE BANCROFT

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Steve Chatwin is the acting director of special projects for the Forest Practices Board. Previously, he was the manager of watershed research for BC Ministry of Forests. He has worked in Tanzania, New Zealand and the northern Yukon on soil and water projects and has his BSc from UBC and MSc from the University of Alberta.

Steve Chatwin

Bryce Bancroft is with Symmetree Consulting Group Ltd. He has his BSc from McGill University, his MRM from Simon Fraser University and 25 years consulting in silviculture and forest ecology.

Lodgepole pine stand structure 25 years after mountain pine beetle attack and implications for streamflow

By Steve Chatwin and Bryce Bancroft

The current MPB attack, which began in 1995, is unprecedented in area. There have been previous large attacks, with the most recent ones being in 1979 in the Chilcotin and southern Quesnel Districts. While most of these stands were salvage harvested, there are remnant areas that were never harvested. These residual stands have developed unique structural and vegetative characteristics. Lodgepole pine regeneration under the forest canopy has led to a multi-age and multi-size stand structure. Stocking density on some of these sites exceeds the target stocking for lodgepole pine clearcuts. The mix of understorey and overstorey trees, the standing and downed coarse woody debris, and the vigorous understorey plants have created a diverse plant community with significant structure. Approximately half of the MPB attacked trees are still standing and are often still sound but checked. That suggests that the shelf life for fibre-based, non-lumber products in these dry, cold ecosystems may be 20 years or more. These drier sites also have relatively low levels of total downed wood and are not a significant fire hazard.

There was significant diameter growth increase (release) on most residual stems; however, the standing live volume was still significantly lower than volumes on comparable sites that were not attacked. Only 30 percent of the sites met the target of secondary structure sufficient to contribute to mid-term timber supply. It is unlikely that these sites will provide sufficient timber volumes in an 80-year rotation. Salvage harvesting and reforestation, or possibly underplanting is needed where timber supply is the goal and full site occupancy is the objective.

The hydrologic effects of beetle-killed stands were examined. The insect-killed trees have a residual canopy that can intercept a portion of snowfall. Also, the mortality is never 100 percent and individual trees continue to intercept and transpire water. The standing dead trees provide considerable shade, reducing radiation and snowmelt rates. In order to determine the scale of these hydrological changes, peak streamflow magnitude, timing and water yield was simulated using a computer model for Baker Creek watershed at Quesnel, British Columbia. The MPB grey-attack of the pine stands resulted in annual peak flow increases of 60 percent and annual water yield increases of 30 percent. Projected salvage harvesting of the dead pine results in a further 30 percent increase in peak flows. Flood frequency will also increase; a former 20-year peak flow discharge will now be expected every five years. These changes represent a major shift in stream flow regime.

Lodgepole pine stand structure 25 years after mountain pine beetle attack and implications for streamflow

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QUESTIONS & ANSWERS

Q: I had a point about volumes being lower. Is it that the stuff that survived got bigger than the other stuff filling in, or was it just because it was gappy?

A: Yes, it was the gappy nature of it and because we looked at 25 years after it had died. There had been that whole period where there was ground that was vacant, compared to if you had cut it and re-harvested with a short regeneration delay, so that was the difference. The actual growth of the trees that were there, they were doing well, and the new regeneration was doing well.

Q: Have you considered burning?

A: Burning is a big issue. When ever I bring that up I say "someone else can light the match". There is a lot of worry that something would get away, but I think from a regeneration point of view, yes, especially in areas where there are serotinous cones it would probably be a good idea to at least look into it. It's part of the natural phenomenon, so yes, I think there is a place for it. From a hydrological perspective, we did not consider the possibility of wildfire in the watershed and what a change that would have on the hydrograph.

Q: Are there any plans to model hydrological projections if salvage was a partial cut or some other different types of salvage options?

A: It could be done. You can use the model for looking at specified changes in the canopy cover, the amount of understorey and under story for example – you could do that, but we are not planning on that at present.

DR. DAVE COATES

RESEARCH SILVICULTURALIST, MINISTRY OF FORESTS

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Dr. Dave Coates has a BSF (UBC), M.Sc. (Oregon State University) and Ph.D (UBC) in silviculture and forest ecology. He has lived in Smithers since 1979 and he has held the position of Research Silviculturist with the B.C. Forest Service since 1989. He is the leader of the Date Creek silvicultural systems experiment; an internationally recognized forest dynamics experiment that has integrated silviculture with forest ecology and provided silvicultural solutions for biodiversity problems. He is a lead developer of the complex stand dynamics simulator SORTIE-ND. He is currently using the SORTIE-ND model to explore silvicultural issues in stands damaged by the mountain pine beetle.

Silviculture and the management of complex stands

For most of the 20th century forest management objectives for private and public forest landowners were well defined and focused, especially in the northern hemisphere. Owners typically had a clear hierarchy of goals focused on a single dominant objective, most commonly timber or revenue production in a sustainable manner. Forest management is now going through significant changes in most parts of the northern hemisphere and elsewhere. Forest management is no longer the sole domain of foresters, forest owners, forest management agencies and the forest industry.

Foresters are being called upon to implement a wider variety of management systems. The primacy of timber as the dominant objective is giving way to broader objectives such as sustaining the function and dynamics of ecosystems, maintaining ecosystem diversity and resilience or protecting sensitive species, while providing for a variety of ecosystem services of value to humanity. This is especially noticeable on public lands in North America and central Europe, but the trend is not limited to public lands or to North America and Europe. Forest management globally is struggling with this paradigm shift and the discipline of silviculture is at a crossroads. Silviculture is struggling to deal with our new understanding of the importance of complexity in forested ecosystems and to develop practices that incorporate complexity.

There will continue to be much debate on how forests should be managed and on how silvicultural foresters should practice silviculture. One's perspective on the debate, what is important and what is not, and the various shades of grey in between, will be coloured by where you live, the type of forest you work in, the history of the area, and your individual background and training. Protection and production of more diverse forest values demands consideration of the fine-scale variability found within forest stands and an understanding of the spatial and temporal response of forest ecosystems to manipulation. Silviculture needs to focus on the spatio-temporal development of forests after disturbance, on maintaining critical processes in forests and on how tree populations and ecosystem processes interact to affect stand dynamics. I will suggest a new roadmap for silviculture that will allow foresters to better incorporate complexity into their management decisions.

Most forest management today, outside industrial short-rotation forestry, must deal with complexity of either species or structural composition in forests. Foresters should not ignore complexity; rather managing for complexity should be seen as a challenge to be met.

DR. DAVE COATES

RESEARCH SILVICULTURALIST, MINISTRY OF FORESTS

Silviculture and the management of complex stands

QUESTIONS & ANSWERS

Q: Human nature is to want to classify and to categorize, and simplify what is out there so that we can better understand it. So what you are asking us to do is to go against that natural tendency of organization of understanding what is out there.

A: Yes, Our understanding of what is out there has to change the way we look at things. If you accept a lot of the literature on complexity, then simplifying forests is dangerous. We have to come up with ways to understand how ecosystems respond to varying gradients of disturbance as opposed to how ecosystems respond to one treatment.

Q: You mentioned that when you were leaving retention behind, often times it was for habitat purposes, for birds or a particular critter. You mentioned that we should be looking at natural processes as well. Do you have any suggestions about how to go about doing that? So that if someone was laying out a block, what would they be looking for to lay out?

A: I think that what we are currently doing is a really good step in the right direction, i.e., that type of structure that we are leaving behind in our stands. It is more for researchers to figure out innovative ways to understand how structure left behind in space and time affects important processes that maintain healthy forests. So, I don't think you can ask operational foresters to do all that. Forestry researchers have to figure the important factors out in order to provide advise on how to manage the forest in order to meet those kinds of objectives.

Q: Isn't it ironic that you are promoting variability while renouncing intensive silviculture? Doesn't that reduce one of the options for management? So I was thinking that doing silviculture as intensively as possible where it is s possible, and doing these new approaches in other areas – wouldn't that be a more balanced approach given that humanity needs wood?

A: Yes I would agree we need a triad approach. New Zealand is a very good example. They have very intensive agriculture-type forestry in part of the land base and basically protected land base elsewhere. Those are all feasible options and I understand completely what you are getting at. My main point I don't want you to think that I think forestry would be less productive, given these measures, I think we could probably grow more trees for society by changing our practices and having potentially more healthy ecosystems. I mentioned a couple of times that a lot of this stuff around complexity – I'm not sure that I buy it all myself. But if you do buy it, these are some of the implications for silviculture. There is no doubt you should have a diversity of practices on the landscape – intensive to less intensive, A diversity of practices is a very good thing to have. Some mixture of intensive agricultural type forestry, short-rotation forestry, mixed in with other levels of management across the landscape would be a good thing. So I agree with you in that context.

DR. DAVE COATES

RESEARCH SILVICULTURALIST, MINISTRY OF FORESTS

Q: I'm curious how you resolve this change in philosophy against natural disturbance regime in the boreal forest where you may have fires as far as the eye can see. Often it is a stand replacing event with one or two species coming in afterward. So one would presume that that pattern evolved over time and therefore has some resilience. So how do you resolve this view that every place needs to be complex against this natural disturbance regime of the boreal forest?

A: Every place does not have to be complex, as I just said. I do think that we need to study the forest at the neighborhood scale, at the scale of individual trees. We need to understand the processes that control what happens to trees at that scale as opposed to a stand scale. We need to study it there. That does not mean that every neighborhood has to be complex. We need to understand what is happening at the appropriate scale. At the moment the scale of our management is at the stand scale using a plot average. I don't think that works for understanding and for being able to predict how forests respond to different types of disturbance. You have to study it at the appropriate scale – and the appropriate scale is not the stand scale using a plot average, in my opinion. So that's one issue. There is a huge difference between a fire coming back to a couple of species, and a clear cut planted to one or two species. There are vast differences, and I could go into those.

DR. CHARLES CANHAM

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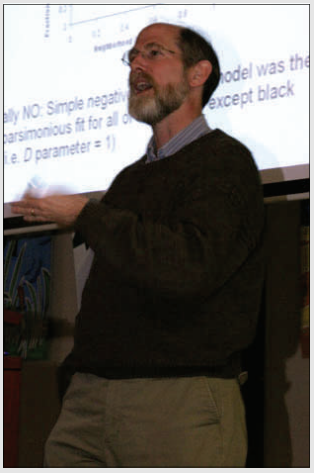
BIOGRAPHY:

Dr. Charles Canham, Senior Scientist, Institute of Ecosystem Studies, Millbrook, New York, is a forest ecologist who specializes in likelihood methods and the analysis of spatial data. He has been an associate editor at Ecology and Canadian Journal of Forest Research and has an extensive list of publications in leading ecological journals. Charles has a BSc in botany from Montana States University, a MSc in botany from University of Wisconsin and in 1985 he received his PhD in ecology and evolutionary biology from Cornell University.



Ecological perspectives on complex stands

For the last 15 years I have worked with Steve Pacala and John Silandar in developing neighbourhood theory. In the study of trees, their interactions tend to be local, on a small scale and non-linear, such that you can't really describe how stands develop by taking averages across the whole system and projecting them through time. There are strong vertical interactions affecting light, nutrient availability and seed dispersal for example, and weak horizontal interactions affecting these same things. The question that we asked ourselves when we started was, can you build up an understanding of the whole system by understanding local neighbourhoods, local interactions? To help us begin to answer that question, we needed a model like SORTIE or its more recent successor SORTIE-ND, where the "ND" stands for neighbourhood dynamics.

SORTIE-ND provides a spatially-explicit neighbourhood analysis of tree growth, where actual growth is expressed as a function of maximum growth rate, minus effects due to competition, size and site. Alternative mathematical functions were derived and parameterized using maximum likelihood techniques, and the best relationships and parameters adopted for input into the model.

In developing SORTIE we asked some basic questions as discussed further in this presentation. For example, do different species competitors have distinctly different effects? How do neighbour size and distance affect the degree of crowding? Are there thresholds in the effects of competition?

There are a few (unproven) beliefs that I have adopted in the process of working on this topic, particularly if our ultimate goal is to develop meaningful and effective guidelines that can be used by foresters to make forest and stand management decisions. Firstly, there is need for extensive empirical, on-the-ground data, coupled with the application of ecological theory and principles in the form of models, to support reasonable predictions. Secondly, the world is changing, making long-term predictions a fleeting hope, but models at least give us tools to incorporate expected changes in the environment so as to better inform our predictions. Lastly, long-term monitoring such as that implemented by the USDA through the Forest Inventory and Analysis (FIA) plot program, while expensive, is critical to success in this endeavour.

QUESTIONS & ANSWERS

For Dave Coates
Q: (Inaudible)

Dave Coates
A: I think we can use our species occurrence guidelines to determine what we want the majority of the trees to be composed of in our managed stands. The change we have to make is that in the past we have managed for one or two species, sometimes three. If other species were there we would often cut them out in some kind of brushing practice, or spacing. In the future the majority of the trees should be from the species selection guides, we want the commercially important species. But we also want to make sure that mixed in with that are all the species that are naturally occurring in that site so that we have a greater diversity of species and a higher density than in our managed plantations. We just need to have more diversity of species and higher numbers than what we traditionally have been doing in the last 20 years.

For Dave Coates
Q: What about climate change?

Dave Coates
A: That's the main reason that I gave the answer that I gave. With change in climate we can't predict which of our species are going to get damaged by some indirect effect of climate change. The *Dothistroma* needle blight fungus around Hazelton is a classic example of the indirect effect of climate change. The climate changed a little bit, became highly favorable for this pathogen that attacks young pine trees, and is killing our pine plantations. And we could never have predicted that. But, that wouldn't be an issue if we didn't have pure pine plantations. If we had more mixed species and one of the species gets hit, there are other tree species that would release and grow well. So I think that a diversity of species can only help us when unpredictable events occur as a result of climate change.

Allen Banner
Comment: It seems that there is a lot of emphasis on the site in the use of those guidelines. And they have not done a very good job of standing back and look at the result at the landscape level. And that's kind of a big mistake, as I see it.

Marty Kranabetter
Comment: It seems like when we have this discussion of complexity, it always seems to come down to patches, and coarse woody debris, species mixes, and that's all great. But I think also if you are talking about ecosystems we have to start looking at stand ages. If you follow that Eastern European philosophy that we talked about, the rotation is 80 years – that's another carry over that does not jive with what we doing here. At some point we have to start looking really seriously at growing some of these managed stands older than 80 years. So when are we going to bite the bullet and have that discussion.

Eugene Runtz
Comment: One of the big problems that we were seeing in our operation is when we got in these stands that were mixed age and were so changed because of fire, is we were trying to completely change what was out there. I'll just give an example, we'd go and clear cut an area and how much of those trees that we brought in were really of minimal value – I mean they were really small. Maybe 30% of the volume. Well why were we doing that? These trees have been growing for 50, 60 maybe 70 years – they would release if you did something out in the woods a little bit different.

So the reason we went into these partial cuts was not because it was more expensive. In reality we got really good costs out of it, but you do things completely differently, you start looking at different philosophy and each tree that's out there has a value and you have to just completely change your approach. So it's a completely different approach in the way you look at forestry. And don't ever get caught into thinking that just because we're using this complex approach over here, that's what we should do everywhere. There are a bunch of other areas where I would just love to clear cut. There are a bunch of other spots where I don't know what the answers are.

You don't have to wait too long on some of these stands. You start seeing results right away. You start walking through them and you see the way the leaders are starting to take off. We were surprised at some of the release on some of the trees. In other cases you are going to have to spend some money on spacing. You have a stand that isn't releasing may be you should do something about it. I'm not sure of that yet, but I think that's the next step. So, look at it completely different than what you traditionally have and you will see some pretty interesting results. We changed ideas because of the will of the people in the area; we did a lot of consultation. The public will looks like it will continue to be there.

For Carl vanderMark
Q: (Inaudible)

Carl vanderMark
A: You don't want to do the same thing everywhere is the answer to most of this stuff. So there are probably the opportunities to have retention at varying levels as well as to have reserves, larger and smaller. I don't think that we do know all the answers, and that's where it comes back to the question I had for Dave, with the direction that we have. A lot of what I think we are talking about today is direction for research, and learning what some of these issues are, so that we can move forward on direction to the operational level. So don't do the same thing everywhere, try some different things and I think that's how we'll have to move forward.

For Charles Canham
Q: I would like to know how does managing for carbon fit into the complexity issue, because I think more and more we are going to be asked about this. So, I was wondering if someone would like to comment on this?

Charles Canham
A: I just wondered when you look into estimates of carbon storage in forests, everybody is using the same crappy data set on soil carbon that was from a single study done somewhere in North America 35 years ago. I would love to see some work on how different management techniques affect soil carbon, because I suspect that's really where predictions are weakest. The above ground part we can do fine analysis with, but the below ground part is the really big wild card. I don't trust any forest carbon estimates at the moment because I don't think that any of them have below ground carbon pools understood and management should have a huge effect on this.

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For Dave Coates
Q: I was going to ask Dave about his comments on complexity. Using the Interior Boreal Forest as an example, you made reference to potentially increasing timber productivity. On the Coast there is quite a history of deviating from European practices and increasing levels of retention, and various variants of partial cutting. I was wondering if anyone would speak to just that – on whether or not this movement away from traditional clear-cutting and even-aged management and retaining greater volumes of older trees has in fact lead to increased productivity, increased growth and yield in particular.

Dave Coates
A: Our current practices of leaving behind 5 to 20% of old stands and regular silviculture around those stands generally results in a reduced yield of that stand compared to a clear cut, because we're leaving these older trees that are growing slowly and that are shading out the younger trees beside them. So, probably from a strict growth and yield point of view, this is reducing yields by that practice. But the issue is that if we go further and we look into some of the stuff that Charlie was talking about, like the different competitive communities that we establish – that's where we can possibly increase yields, compared to our current practices of planting one or two species. So in order to get some of the potential benefits of complexity we have to think about it a lot more and we have to do a lot more studies to work out whether or not it works from a yield point of view. Now leaving behind the structure, let me make a – this is where the stuff gets so flaky, right? Maybe by leaving behind more the structure in the coastal forest we're setting up better insect communities which are protecting the trees in the planted area from being attacked by spruce leader weevil or something. There are all sorts of these kinds of issues that are really hard to quantify that may be occurring out there. So there are a lot of different things going on at once. So, back to your original question from a strict growth and yield point of view we are probably reducing yield on those stands.

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For Charles Canham
Q: On the Sortie model there are very few or no habitat type variables. Perhaps you eluded to that by showing how early pioneering species didn't go where you would think they would go. Does that hold true throughout the life history stages of that tree?

Charles Canham
A: In a sense Sortie is a stand model so you would parameterize it for the site conditions in your stand. What we spent 10 years doing at Great Mountain Forest is trying to understand the spatial heterogeneity in soil resources within stands. We picked our site specifically because according to the soil scientists this was about as uniform a stand as you could find and after 10 years of work it turned out there was all sorts of heterogeneity but it was sort of biotically driven. And so we are still struggling over how to build that into the model, quite frankly, because it takes a tremendous amount of data. Actually we have just sort of finished, we've got a very common invasive tree species in our system, two actually, tree of heaven, you may have it around Vancouver, A*ilanthus altissima*, but we've actually been able to parameterize the footprint of the tree of heaven for its effect on nitrogen mineralization or calcium mineralization, or PH. A very discreet measurable way. It also has a allelopathic effect which we've been able to parameterize in a neighborhood context. So in a sense the question about environmental gradients is a change in scale. So if you want a model that predicts landscape scale distribution of species, you probably should be working with a model that is designed for that, or a whole suite of those models.

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For Charles Canham
Q: I was wondering if having stand level variables and individual tree level variables together in these growth functions may give you a better picture of what's going on at the different scales.

Charles Canham
A: I think it would. We've had a very difficult time to parameterize these functions. We've published some papers for instance where we changed the parameters of the growth to light relationship based on soil nutrient availability. So we asked, does the high light growth change or does the low light growth change. It varies a great deal in model predictions. The shape of that curve is important. We've shown that for different species, different nutrients matter in changing the shape of that curve. To run the model we then have to build in all the feedbacks of the nutrients on the tree species because we know that tree species have huge differential effects on nutrient availability. And that's where we are still struggling – the statistics of that have been bothering me for a couple of years now. If it's just a fixed driver then you just come up with a different parameter file that captures the change, but the feedbacks are different.

For Carl vanderMark
Q: I was wondering if we could talk about the complex practices needed to achieve those complex stands – are these practices self-sustainable. That is, can we afford to do this?

Carl vanderMark
A: The short answer in terms of cost, as everyone knows right now in B.C. the industry is bleeding red ink so any kind of incremental cost right now is really unpalatable. I think another consideration from an industry perspective, that might make it a little more palatable relates to forest policy. The fact that we have these stands for 10 years, until 2009, that has a fairly dramatic effect on how we might actually manage these stands. Some one asked me at the break "So are we planning another entry"? Well of course we're not; we only have that

stand until 2009 so it reverts back to the Crown. So in the short term the answer is no, we cannot afford to do this. In the long term I'm not sure whether as society we can afford not to look at it. In the short term we're here to make a dollar, to be viable, and anything that dramatically increases our costs is not going to be viable.

Eugene Runtz
Comment: When you are looking at costs make sure you don't forget stumpage. Under our system you calculate the values of the trees that are out there, and the government figures out what they want in terms of stumpage. If your costs go up a little higher but those costs are actually aloud to you, what ends up happening is it doesn't cost you anymore for those trees – all you're doing is paying less stumpage. So there is a cost to the government for sure.

As an example, we did a lot of helicopter logging recently. The average stumpage came to about two dollars. The stumpage probably would have been closer to fifteen or twenty dollars if we hadn't done the logging by helicopter. What we made sure is that we were as economic as possible with the helicopter. By that I mean we accumulated the areas so we had more volume, we made sure we had lots of drop zones, we made sure we had proper long flies and short flies, then we put it out to competitive bid. So what we ended up doing is beating the appraisal. The government said for example it costs seventy dollars and in actual case it costs sixty-two. So in actual fact we gained eight dollars, so we really couldn't afford not to do it.

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For Carl vanderMark
Q: You mentioned about pellet production for your operations. I was wondering if there are any viable options for using tree tops and bottoms or using the whole tree for pellet products?

Carl vanderMark
A: I'm not really up on the economics of the pellet operation other than I can tell you its pretty marginal. So that's the reason we're actually converting the white wood waste from the milling process into pellets so if you are going to do whole log shipping it has to be very close to your pellet facility – that is what's been one of the major hurdles in getting pellet operations up and running. So the further away you are from the facility the less viable it becomes. And, there's lots of supply out there.

MARTY KRANABETTER

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Marty Kranabetter has been a soil scientist with the Forest Service for 15 years in Prince George and Smithers, B.C. He is currently undertaking a PhD with Suzanne Simard at UBC, exploring the interaction of light and nitrogen availability on sapling growth in partial cut forests. Marty has a wide interest in soil ecology and forest productivity, especially ectomycorrhizal fungi.

Tradeoffs in understorey light limitations versus nitrogen deficiencies across productivity gradients

Light and nitrogen (N) in forest understoreys limit plant productivity, and the constraint of each resource has been hypothesized to predictably covary with soil fertility. We examined the contrast in understorey light availability versus foliar N attributes of subalpine fir (*Abies lasiocarpa*) across productivity gradients (via plant associations) of old growth boreal forests in British Columbia, Canada. Understorey light declined with productivity, from a high of 30 percent of full sun on poor sites to as low as 15 percent on very rich sites. In contrast, foliar N concentration increased (ranging from 9.5 to 14.0 g kg^{-1}), and was strongly and linearly correlated with soil N availability (dissolved organic N plus inorganic N) and asymptotic stand height (a measure of site potential), despite growing under shade. The rate of increase in foliar N concentration with soil N availability was lower, however, than the rate of increase in stand height. The net trade off in light and soil fertility was reflected by foliar N per unit area, which was at a near equilibrium of 2.0 g N m^{-2} across the productivity gradient. Foliar N concentrations of the understorey were consistent with the overstorey subalpine fir, and both were superior to foliar N concentration of lodgepole pine (*Pinus contorta*). Foliar attributes of N concentration and leaf area effectively integrated the multiple resource limitations acting on trees, and could be used to parameterize growth models by species across spatial scales.

MARTY KRANABETTER

RESEARCH PEDOLOGIST, MINISTRY OF FORESTS

Tradeoffs in understorey light limitations versus nitrogen deficiencies across productivity gradients

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QUESTIONS & ANSWERS

Q: Do you sample at different light levels for different site series? For example, the literature says that foliar nitrogen concentrations differ at different light levels. If you sampled at different light levels would that add more noise to your data?

A: I think subalpine fir is pretty independent of light. I've found very similar relationships between the understorey and the overstorey. The overstorey is in more complete light, even though it's a much taller tree. I took foliar samples and ran it against soil nitrogen, light availability, and soil moisture, and it pretty much came down to soil nitrogen. The R^2 for was .84, so it was really tightly correlated to soil nitrogen. I've looked at other tree species, paper birch for example, the foliar nitrogen of paper birch clearly declines as you get into the shade. I think shade intolerant species tend to have a problem getting those resources out of the soil because they are also trying to get light. I think the literature under-emphasizes that point. The ability of a species to thrive in the understorey probably depends on how well it can access the soil. That's why subalpine fir is in the understorey – because it can do that. If it couldn't it wouldn't be there.

Q: As gaps form presumably that stimulates release of organics and so forth. Do you think that's just noise around the site series mean? Do you think you need to incorporate those transient dynamics of nitrogen availability in your understanding, or is it just sort of noise?

A: Gaps have a significant effect, but they tend to be fairly short-lived, in our experience around here. So maybe the first 5 years. In the long run, when you are trying to look at stand development over 80 years, its probably something we can assume happened and then went away, although I hate to say that as a soil scientist.

Q: I'm wondering about some of these species on very dry sites. On dry sites for example, spruce won't even become established unless it has shade. And similarly with Douglas fir, in the Cariboo, where they have clear cut they have had real problems getting Douglas fir re-established and stands have converted to pine. So I'm just wondering how you would reconcile those observations. At least for smaller trees it seems there are some that are almost shade-requiring. So some of these intermediate shade tolerant species are almost shade-requiring in some of these more extreme conditions.

A: I don't know if they are actually shade requiring or if it just reduces the drought stress. In the Cariboo, those sites are almost pure pine, and then you start to get understorey development. So you are right, they don't seem to come in first, they always seem to come in after the pine has established. I think when its completely exposed, they can't handle the drought stress. I don't know if I call that shade demanding as much as they just are being drought stressed. But I see your point. Then the question is what is the best gap size for establishing these other species.

DR. PHIL COMEAU

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Dynamics of aspen and *Calamagrostis* competition with white spruce and its implications to mixedwood regeneration

Presented by Cosmin Filipescu

In western boreal forests, trembling aspen (*Populus tremuloides*), bluejoint reedgrass *(Calamagrostis canadensis*) and other vegetation compete with white spruce (*Picea glauca*) for light, soil moisture and nutrients and influence other limiting factors such as soil and air temperature. Treatments which reduce levels of competition can (but don't always) result in substantial increases in spruce growth. Interactions also occur between aspen and *C. canadensis*. Some studies suggest that understorey species may be stronger competitors than aspen, while others indicate that the opposite may be the case. These differences are consistent with the expectation that competitive effects will vary depending on availability of the resources for which competition is occurring.

Spruce can benefit from commensal (facilitative) influences of aspen which include: reduction of summer frost and winter (Chinook) injury, and suppression of understorey vegetation. The net effect of aspen and other competitors on spruce growth is the result of the balance between the importance of commensal and competitive effects. Influences of competitive and commensal interactions are likely to vary from site to site and from year to year resulting in substantial variation in the perceived effects of aspen on spruce growth (and in the magnitude of responses to treatments intended to control competition). Knowledge of the contribution of the component interactions is an important basis for understanding the variability in spruce growth responses and for making effective stand tending decisions. The nature and outcomes of some of these interactions and examples of some promising approaches (including spot and patch treatments) for enhancing spruce growth in a mixedwood setting will be discussed.

DR. PHIL COMEAU

DEPARTMENT OF RENEWABLE RESOURCES, UNIVERSITY OF ALBERTA

Dynamics of aspen and *Calamagrostis* competition with white spruce and its implications to mixedwood regeneration

Presented by Cosmin Filipescu

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QUESTIONS & ANSWERS

Q: What are most licensees doing in Alberta, as far as the general practices in dealing with these aspen-dominated sites, or sites with aspen where they are harvesting softwoods?

A: If they are clear cut, there could be a pre-planting site prep, then they are planted. And if there are still problems with aspen they herbicide the sites and normally that would lead to pure spruce stands. That's because the free to grow standards are very restrictive, you are not allowed to have too much aspen around. From what I know you cannot have much aspen around so that pretty much limits the options. However, they are now working on re-evaluating those free to grow standards and they are also looking at understorey protection, succession management, where you harvest the aspen, release the remaining trees, and if there is no advance-regeneration perhaps you could under-plant. That's why I did this project and others are underway to look at other alternatives to that. Up to now in Alberta there has not been a lot of opposition from the public for broad-cast herbicide application, however things are changing. Things may change from broadcast application to some sort of ground-application of herbicides.

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Q: A lot of people here would concur that we in BC have gone through this evolution away from pesticides for various environmental reasons plus all the ecological work that has gone into identifying that it is beneficial to have mixedwood stands. I was in silviculture for years, then I took a bit of a hiatus. So I'm surprised to see at this stage to see that the research hasn't really been implemented. I know this is in Alberta, but when I was last at a workshop like this most of the thought processes were around finding the ideal range of hardwood stocking that would both repress calamogrostis and permit reasonable growth and yield of spruce. There seemed to be a lot of impetus in the direction of mixedwood management.

A: Things are changing in Alberta as well. The overlapping tenures on deciduous and soft-wood forest in Alberta create added complications. Since spruce are later succession species, you are trying to change the forest from deciduous to softwood. There are also changes in designation in terms of land base. People are trying to work through it.

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BIOGRAPHY:

Dr. Rasmus Astrup received his initial forestry education and work experience in Denmark. He received his PhD in quantitative silviculture and growth modelling from the University of British Columbia. Rasmus currently works as a scientist with the Bulkley Valley Research Centre in Smithers. The main focus of his research is stand dynamics and stand-level growth modelling in complex sub-boreal and boreal forests.

The relationship between light availability and understorey spruce growth

In complex stands such as partial-cut stands, mountain pine beetle affected stands, or boreal mixedwood stands, crop trees often grow for extended periods under shaded conditions. Thus, to understand and predict stand dynamics and growth of complex stands it is important to understand and quantify the relationship between light availability and understorey tree performance.

This study investigated the relationship between light availability and understorey spruce growth in different regions of western boreal and sub-boreal Canada. No general species-specific shape of the light-growth relationship was found. Rather, the relationship between light availability and spruce growth was found to vary between approximately linear and asymptotic between the different regions. The observed regional variation in the light-growth relationship can have considerable impact on the success of silviculture that relies on understorey spruce performance and caution should be taken when transferring management practices and experiences across significant environmental gradients. To explain the regional variation in the light-growth relationship, the following three hypotheses were investigated: (1) regional variation in the light-growth relationship is best explained by variation in macro-climatic variables, (2) regional variation in the light-growth relationship is best explained by differences between Picea species, and (3) aspen-dominated and conifer-dominated canopies affects understorey tree growth differently and this explains the regional variation in the spruce light-growth relationship.

DR. RASMUS ASTRUP

SENIOR SCIENTIST, BULKLEY VALLEY RESEARCH CENTRE

The relationship between light availability and understorey spruce growth

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QUESTIONS & ANSWERS

Q: Do you have a definition to distinguish between what is aspen-dominated and what is conifer-dominated?

A: There is not a definite cut-off. Many of the studies that I used don't provide it. The literature often just says aspen-dominated, without definition.

Q: My reading of the early results from Date Creek, Elaine Wright's papers, I seem to recall they were mostly aspen-dominated curves. Now is that just early on?

A: That's just a log-transform that makes a linear relationship. The curves that you actually see in the paper are on the y axis on the log scale, so when you un-transform them they become very non-linear.

Q: Some of the previous studies that you looked at – some of the data came from experimental stands where density was manipulated and reduced, while other relied on natural gradients of density. You dealt mostly with natural stands. So I was wondering if your results could be applicable to some artificially manipulate stands where you do some partial retention, or you have gaps?

A: It's hard to say. There is a lot of variation around those curves no matter what they are. I think the results are strong enough – I do think there is a difference between aspen-dominated and conifer-dominated canopies, and the affect on growth – I'm not sure what the effect of manipulated versus non-manipulated stands are to be honest, without looking at a specific example.

Q: What was the age and size range of your sample?

A: The age range is very big, but the size range is trees smaller than 5 meters.

Q: I would think that the asymptotic nature of the spruce aspen would be very encouraging news for thinking about managing for complexity in those mixedwood stands. That linear relationship pushes you to think about trying to get ever-more openness; whereas where this asymptotic relationship suggest that you can find more clever ways to manage for mixtures.

A: Yes, you certainly can allow a lot more aspen without having an effect on your understory spruce growth.

Q: Can you go backwards to a particular slide. This one. Why don't we see aspen canopy overstory where there are fewer growing degree days. And if you could find such stands would you still expect the asymptotic response?

A: That's a very good point that at quickly skipped over. In the data set there seems to be a slight correlation between growing season length and aspen-dominated canopies. And that is because the growing season length is just a little bit longer where you have a lot of aspen-dominated stands. So whether or not it would completely transfer to a region with a very short growing-season length – I think there would still be an effect, it might not be as pronounced. But on the other hand this correlation is just the way it is in western Canada. You are not going to find a lot of aspen-dominated areas in these places with very short growing seasons. You find them in places with slightly longer growing seasons. Around here you find them in the valley bottoms where you have slightly longer growing seasons. You also find them in the prairies where the summers are a little bit warmer.

Q: So you measured light in aspen stands in the summer. So what if you measured light in the spring before they leafed-out, and used that as your light availability. Maybe that would jive better with the conifer overstory. Then you would have one magical curve.

A: Yes, to be honest I think in a lot of these places that the leaf-off period is quite brief. If you look at the literature there is some literature saying that the effect of leaf-off period is very large, but that comes from studies in places like Vancouver Island where you have fairly warm climates during spring and fall and you have a fairly long leaf-off period where you actually can get a substantial amount of growth. It is a fairly short leaf-off period in boreal conditions – it's normally a question of a couple of weeks where you have soil temperatures that are high enough that you at the same time can have photosynthesis.

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BIOGRAPHY:

Cosmin Filipescu is currently in the last stage of his PhD at the University of Alberta working with Dr. Phil Comeau on dynamics of competition in boreal mixedwoods.

Site and age affect competitive interactions between aspen and white spruce in boreal mixedwoods

By Cosmin Filipescu and Phil Comeau

Effects of aspen competition on growth and survival of white spruce are difficult to interpret and generalize due to incomplete knowledge of underlying processes and the fact that most competition studies are limited in space and time. A better understanding of competition dynamics is needed to refine management options for boreal mixedwood stands. To address some of these shortcomings, two studies were undertaken:

1) The effectiveness of competition indices for predicting light transmittance and white spruce growth in young mixedwoods were examined across aspen density gradients using long-term study sites in Alberta and Saskatchewan. Simple indices based on density (e.g. basal area) were reliable predictors of understory light and spruce growth. Competition-growth and competition-light relationships differed significantly between geographical locations.

2) The influence of stand development/age on competitive interactions was examined using a chronosequence of stands aged 10 to 60 years, located on similar sites in Alberta. More complex competition indices were needed to predict spruce growth. Light importance as a driver of spruce growth seems diminished in these natural stands. Relationships between growth and competition differed between stands younger than 20 years and stands aged 20 to 60 years.

Both studies emphasized the need to include initial spruce size as co-variable in models of growth as a function of competition. Site/age specificity of these relationships may be resulting from shifts in the relative effects of competition (resources, space) and facilitation (protection against frost/chinook damage, insects, reduction of understorey). Changes in understorey composition and abundance, and the interplay between light and other resources (nutrients, water) may also play a role. Results suggest the need for regional/temporal parameterization of models of spruce growth.

The two studies advance our understanding of processes influencing boreal forest dynamics.

COSMIN N. FILIPESCU

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Site and age affect competitive interactions between aspen and white spruce in boreal mixedwoods

By Cosmin Filipescu and Phil Comeau

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QUESTIONS & ANSWERS

Q: It looks like you are using stand averages for basal area in your analysis. Do you think it would make any difference if you used both the basal area and individual trees.

A: Yes. I'm sorry if I didn't get that across. Actually in our research we are looking at the individual tree response and we have a neighborhood type of assessment of competition. So we are looking around the trees. We are using individual tree response and competition is assessed in the neighborhood of those trees.

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Q: It's just a comment rather than a question. It's fascinating to see all this study done. Basically it's driven by production. I think if we let the stands be as they are naturally – let that be your ideal situation for complex stand management. We are trying to manipulate nature for our own sake – it's just a comment.

A: I ask some of these questions myself, many times. The thing is forestry is an applied field and we are trying to modify nature for our own purposes, i.e., we need to have wood etc. We need to have options and alternatives. And in order to have alternatives we need to explore them and to see what their potential implications would be. For management, for production, and for other reasons as well. So, I think the future is quite uncertain. We don't really know what will happen, but in order to be prepared we need many options and we need to know the implications of those options. Perhaps we can be more ready. The mountain pine beetle epidemic is an example. But yes, I think that's a great comment and that's open for discussion in the afternoon as well.

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DR. CHRIS HAWKINS

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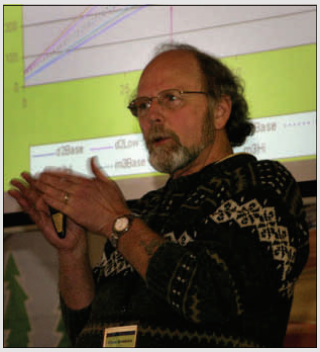
Dr. Chris Hawkins is the FRBC – Slocan Chair of Mixedwood Ecology and Management at the University of Northern British Columbia. He got his PhD a very long time ago from the Australian National University in Canberra. Chris first came to Prince George 20 years ago to work for the provincial government. After a brief tour on the coast with MacMillan Bloedel, he returned to Prince George to work for the BC Forest Service.



Dynamics of young pine stands after the mountain pine beetle

By Chris Hawkins and Kyle Runzer

British Columbia's young lodgepole pine (*Pinus contorta* Dougl. Ex Loud. Var. *latifolia* Engelm.) forests are affected by the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (MPB) epidemic. Post beetle mid-term AAC is dependent on there being no attack in young stands ≤60 years old (age classes 1, 2 and 3). Given that MPB is successful in young pine stands, regeneration and management of younger age class stands will affect mid term timber supply. Our objectives were to quantify the level of MPB attack, document changes in stand dynamics (structure, composition and regeneration) after MPB attack, and suggest management strategies.

More than 90 young (age class 1 to 3, ≤ 60) pine leading stands west and south of Prince George were sampled in 2005 and most were re-sampled in 2006. In re-sampled stands, attack rates in 2005 for age classes 1, 2 and 3 respectively were 1.6, 27.8 and 29.4 percent. This increased to 7.9, 47.3 and 39.1 percent in 2006. At the landscape level, there was ample regeneration in all age classes but it was highly variable. In both years, MPB attack reduced mean age class stand diameter. In 2005, 17.0 percent of the age class 2 stems between 7.5 and 10 cm were attacked, this increased to 31.0 percent in 2006. In age class 2, 9.9 percent of the plots had no regeneration but the average regeneration stocking was 1655 ± 127 sph. About two-thirds of the regeneration was advanced: height = 5.24 m ± 0.23, diameter = 3.54 cm ± 0.14. Mean seedling height was 0.62 m ± 0.03. A TADAM projection based on 50 percent loss (thin to 50 percent of current basal area) suggests the residual volume in 25, 40 and 50 years respectively for current age class 2 sands will be between 110 – 185, 168 – 273, and 201 – 323 m^3 per ha without any intervention or growth of regeneration. In 50 years, a bare ground projection will result in 170 – 204 m^3 per ha. If the growth potential of the regeneration layer is considered, age class 2 stands should be able to mitigate some of the negative effects MPB will have on the mid-term timber supply.

Keywords: lodgepole pine, mountain pine beetle, attack rate, residual trees, regeneration, management, timber supply

DR. CHRIS HAWKINS

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Dynamics of young pine stands after the mountain pine beetle

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QUESTIONS & ANSWERS

Q: Did your growth projections in age class 2 stands assume that the attack levels that we've seen in the last few years would carry on? So following from that, was most of the volume that you forecast from advance regeneration?

A: They were two separate projections: one for what's left of the mature layer, and only in one case that I pointed out did I add the regen to the mature layer for volume. In terms of assuming attack we just assumed that if was 60% in 2006 that it was going to stay at 60%.

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Q: So no further attack?

A: No further attack - bad assumption, but we don't have the data to tell us what it is. The reason that we left it alone is in the south end of the Vanderhoof District we did not find any difference between 2005 and 2006, because the majority of the beetle population was long gone.

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Q: What was the spatial distribution on your regeneration in your stands?

A: It was aspatial and our 2005 data was aspatial. But our 2006 data we've done it by quadrant so we can actually put a variance around the distribution of regen. I realize that the spatial aspect is important for the regen.

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Q: How did you deal with the different scales of variability: between stand, within stand? There is another scale in there it seems to me.

A: Basically we ignored within stand variability. At some point in time shortly we will start to deal with it.

Q: Why did you use this model as opposed to TIPSY?

A: In TIPSY you are limited as to when you can thin. In TADAM you can do it whenever you want. Oscar published a paper a few years ago in Forestry Chronicle comparing his outputs for these three species to TASS and it's very good.

Q: It might be a good experiment – rather than just knocking the dead trees down and starting over, what about just fill-planting where the gaps are in the age class 2 stands?

A: That's certainly a possibility. The one type of data that we don't have and one of the speakers this morning talked about it, is we really don't know what the light levels are in these dead stands at the seedling level. That's the key part before you start spending millions of dollars to under-plant is to have some understanding of what the light levels are.

Q: The flexibility in spatial distribution that you can get by simulating the stands in TASS, these age class 2 stands in particular, would far overwhelm the flexibility in the timing of spacing that you get from using TADAM.

A: In terms of mature layer we don't have spatial data. We have plot data. We have about 2000 plots. To stem map even a small portion of that is a much higher cost than we have the resources for.

Q: What percentage of your land base is age class 2?

A: Basically industrialized forestry came to the interior of BC with the pulp mills in 1964. So pretty much everything in the past 40 years. So in terms of plantations it's a big chunk, but I couldn't give you a figure on it.

DOUG STEVENTON

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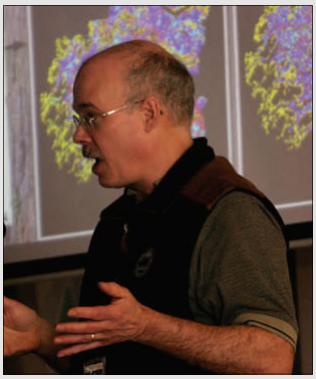
Doug Steventon is Research Wildlife Habitat Ecologist with the research group of the B.C. Ministry of Forests and Range based here in Smithers. He is also an active member of the Bulkley Valley Research Centre. Over the past 15 years he has been investigating the implications of forestry activities on wildlife and biodiversity values.



Frank Doyle is a consulting biologist based here in the Bulkley Valley. He has worked on many species and issues locally and elsewhere, with a particular interest in raptors and recently lynx and hares, and mountain pine beetle impacts on wildlife. Frank is also a member and past director of the Bulkley Valley Research Centre.

Role of complex stands in conserving vertebrate diversity in beetle affected landscapes

By Doug Steventon and Frank Doyle

Along with a mid-term timber supply 'fall-down', there is presumably going to be a habitat supply 'fall-down', at least for species dependent or closely associated with mature pine trees. How bad this might be, how accelerated salvage might influence wildlife communities in the short, mid, and long-term, and what role 'complex' stands may play, will be discussed. Emerging evidence suggests that beetle-killed forest, particularly containing residual live-trees, continues to provide habitat for a host of species that do not use young clearcuts. Mid to long term effects depend on many interacting assumptions of how landscapes will be managed and assumptions of how stand attributes change. The influence of how we manage complex stands through time, using the Nadina District as a test case, is being explored through simulation.

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BIOGRAPHY:

Doug Thompson is the laboratory technician and research associate for the Tree-Ring Lab at UNBC. He currently supervises a large study on the decay and degradation of trees killed by mountain pine beetle, using dendrochronology to determine the year of death of beetle-killed pine. He also provides research support for graduate students and faculty, and maintains the tree ring lab.

Doug completed his master's degree at UNBC, and for that research used tree-ring analyses to examine fine- and intermediate-scale disturbance dynamics in three different ecosystems in central British Columbia.

Relationship between two-year cycle budworm, spruce beetle and western balsam bark beetle: Dendroecological evidence from central interior British Columbia

By Doug Thompson and Kathy Lewis

Using dendroecology, we characterized disturbance in three distinct spruce-subalpine fir ecosystems in central British Columbia. Within each ecosystem, five 1/4-ha plots were established. Increment cores were collected from all live and dead trees ≥15 cm diameter at breast height (dbh, 1.3 m above the ground). We plotted dbh against the year reaching coring height to identify pulses of tree recruitment. Horizontal-line standardization and release from suppression (>100 percent increase in radial growth, consecutive 10-year periods compared) was used to identify periods of increased canopy-tree mortality. Snags and logs were crossdated against live trees to estimate mortality dates and each dead sample was inspected for bark beetle galleries. The frequency of dead samples with beetle galleries was plotted against the estimated mortality dates to identify periods of beetle activity. The host (spruce and subalpine fir) non-host (pine) method was used to distinguished defoliation by two-year cycle budworm from other regional-scale environmental variation. The results of our study identify numerous periods of ring-width growth reduction in spruce and subalpine fir over the last 200 years that we attributed to two-year cycle budworm. Many of these periods were immediately followed by varying degrees of canopy-tree mortality, abrupt and sustained increase in radial growth of seedlings and subtending trees, and increased rates of trees attaining coring height. Furthermore, a synchronicity between the periods of canopy-tree mortality and the presence of spruce beetle and western balsam bark beetle galleries during the last century was demonstrated. This sequence of events suggests that the two-year cycle budworm may be an additional factor that predisposes spruce and subalpine fir to attack by spruce beetle or western balsam bark beetle. Our results identify a poorly understood, yet important disturbance process within spruce-subalpine fir forests of central British Columbia and will be discussed in the context of stand dynamics.

DOUG THOMPSON

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Relationship between two-year cycle budworm, spruce beetle and western balsam bark beetle: Dendroecological evidence from central interior British Columbia

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QUESTIONS & ANSWERS

Q: I understood that budworm is a more significant problem in stands with a lot of vertical structure. So if we are moving in that direction, encouraging more complexity, does that make the problem worse in terms of potential for spruce budworm?

A: These stands already do have a lot of vertical structure. I don't know if we can increase it. You are right in saying that vertical structure probably does have an effect on the biology of the bug. The Douglas-fir tussock moth has the same effect, where you are allowing regeneration in the understory to come up, and the regeneration is getting hit by Douglas-fir tussock moth. I don't necessarily think it is an additive effect, but its something that you would have to consider.

Q: Do you know what kind of growth rate increases you were seeing in these 100 and 200 year old trees?

A: I can't give you an exact number, but it is two-fold at least.

DR. KIRSTIN CAMPBELL

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BIOGRAPHY:

Dr. Kirstin Campbell is currently a postdoctoral researcher working with Bruce Larson at the University of British Columbia. She has a PhD from UBC where she studied disturbance patterns of fire and mountain pine beetle in the central interior B.C. She is also a partner of the consulting firm TerraTree Forestry, located in Duncan, B.C.

Rating options for post-attack cutting in mountain pine beetle affected stands

By K.A. Campbell, B. Larson and R. Astrup

A critical issue for forest managers is management of stands post mountain pine beetle attack. There is a range of options available, from clearcutting and salvage, to taking no action, leaving the stand as a retention area. Determining the best course of action given the uncertainties for future development of forests impacted by the mountain pine beetle can be a complicated issue. To alleviate some of this uncertainty we have developed a decision-making tool that allows managers to easily compare future forest scenarios and treatments in a simple stochastic modelling environment based on Markov chains.

The mountain pine beetle management decision making tool (MPB MDST) is flexible; providing a value index can be assigned, the tool relies on no predefined metric of value, allowing the user to model any possible scenario. For example, cost/benefit, net present value, and mean annual increment metrics can each be modelled to compare future economic and fibre production scenarios under a variety of treatment options.

Future forest conditions are initially “grown” using a growth and yield model such as SORTIE for each treatment or scenario (e.g., clearcut, partial cut, no action). The MPB MDST calculates Markov chain transition probabilities for each value class from the data and builds the structure of a Markov model. The manager generates additional scenarios by manipulating the probabilities to reflect what might happen in the future if stand development does not follow the expected course. By generating such scenarios, the MPB MDST will present forest managers with the information necessary to make a well-founded decision and to set priorities for harvest post mountain pine beetle attack.

The MPB MDST has been tested in the Gavin Lake block of the Alex Fraser Research Forest. Results for this forest area will be presented.

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Rating options for post-attack cutting in mountain pine beetle affected stands

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QUESTIONS & ANSWERS

Q: In your model do you run each scenario dozens of times?

A: The SORTIE runs can be run many times. But because this is non-spatial, the probabilities are going to be the same every time with your values. So our inputs are variable, but we don't run the MARKOV part many times.

Q: If global warming is a factor how do you incorporate that?

A: The probabilities are generated from the SORTIE runs which is a stand simulator. So we can modify the parameters within SORTIE. For climate change, for example, without modifying any of the parameters within SORTIE, and I'm sure there is a way there's a way to do it, it's just not my area of expertise. You could look at the climate change literature and increase or decrease, for example if its volume, depending on what the projections are for climate change.

Q: But if climate change is such a large scale phenomenon, how do you tie in your model when SORTIE is a stand level model?

A: I think although climate change is very broad scale, it will affect the finer scale processes. That's the idea that it is stochastic and you can look at a range of scenarios of future climate change. For example, you could increase the probabilities for whatever metric you were looking at. But you would certainly have to do it with full knowledge from the research or literature on why you are changing those probabilities to have some validity to your results.

Q: SORTIE is often criticized for not being stochastic enough. We've been talking for years about coming up with a new model that incorporates all of these Bayesian estimates of variance in parameters. So, are you essentially doing an error analysis using standard errors and parameter estimates? There are two kinds of stochasticity – there's process error and there is measured error and its not clear whether you want one or both in your uncertainty. Because there is clearly both in our parameterization. The field studies contain both. Jim has been working for years on his Bayesian methods to try to sort out the process and measurement error, and build in one and not the other. But do you have a clear sense of what kind of stochasticity that you want to focus on?

A: Process would be the focus, but I understand you are getting both.

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Q: If you use the standard error estimates of the field studies you would be using both. So it seems a little open-ended in terms of how much stochasticity you incorporate in SORTIE and therefore incorporate into this model and at the end of the day you have to convince a manager that you have an apt description of the uncertainty we have out there.

A: I agree. The Markov modeling is where my expertise is but you have the same issues. You can fiddle with those probabilities, you can have the whole range from 1 to 100% but you have to have justification for why you are looking at that range for a scenario.

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Lead author and presenter **Dr. Valerie LeMay** has a PhD in forest biometrics and is a registered professional forester in B.C. She is currently a professor in forest biometrics and measurements in the Department of Forest Resources Management at UBC. She has over 25 years of experience in researching and applying biometrics to forest inventory and growth and yield problems in B.C., other provinces in Canada and other countries.

Ingrowth and mortality in partially cut complex stands of southeastern B.C. and extensions to mountain pine beetle-affected stands of central B.C.

By Valerie LeMay, H. Temesgen,
A-A. Zumrawi and P.L. Marshall

In order to obtain growth and yield estimates for complex stands in southeastern British Columbia, a single tree, distance independent model developed in the United States called Prognosis (now called Forest Vegetation Simulator or FVS) was adapted for use in B.C. The habitat classification used in the United States for site classification was replaced with the Biogeoclimatic Ecological Classification System (BEC system) for the British Columbia version of Prognosis. Using existing permanent sample plot data, all model components were replaced including mortality, diameter and height growth models, and regeneration/ingrowth models. Replacement of mortality models to predict regular mortality was relatively straightforward, in that the existing modelling philosophy of using logistic models by species to predict tree-level mortality rates, conditioned by stand-level overall mortality rates, was used. Explanatory variables included DBH and measures of competition, particularly basal area per ha of larger trees (BAL). Other approaches such as survival modelling were not tested, since the existing modelling approach resulted in acceptable predictions of mortality for these complex stands. For regeneration and ingrowth following partial cutting in these complex stands of southeastern B.C., several approaches were examined including: 1) a suite of logistic models to predict the probability of regeneration by species (the original approach); 2) multivariate nearest neighbour approaches to predict the amount of regeneration/ingrowth that appears after a fixed period of time following partial cutting for all species jointly. This second approach has the advantages of a multivariate imputation approach, including logical consistency across species. However, extension of the Prognosis^{BC} to project stands following attack by mountain pine beetles has been more challenging, because of the more complex mortality and ingrowth/regeneration dynamics. Alternative approaches were discussed, and the use of a hybrid-modelling approach is now being examined.

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James Goudie began working for the BC Ministry of Forests and Range Research Branch in August, 1985 and has been there ever since. He has developed site index curves, managed and summarized a large PSP database for model calibration and validation, and expanded and improved versions of TASS and associated programs. His particular modelling interest is the modelling of architecture and morphology of crowns and how they affect on wood quality attributes (relative density, knot size and distributions, etc.). He completed a large five-year study of western hemlock and a similar project in lodgepole pine is in its last year. He assumed the leadership role in the stand development modelling group in March, 2003 and is the principle investigator on a project that is upgrading the Tree and Stand Simulator (TASS) to complex structures.

Applications of the Tree and Stand Simulator for complex stand structures and wildlife habitat supply

The Research Branch of the Ministry of Forests supports the development of two stand-level simulation models—the Tree and Stand Simulator (TASS) (Mitchell 1975a, Mitchell and Cameron 1985) and Prognosis^{BC} (Zumrawi et al. 2002). Each model has unique characteristics, capabilities, and applications to ensure realistic projections of the diverse forest conditions in British Columbia. This paper focuses on TASS, a spatially explicit model that most often supports traditional silvicultural decisions and timber supply analysis, but is increasingly used to design, project, and evaluate non-traditional silvicultural systems and stand management strategies. Included in these applications are estimates of wildlife habitat supply (e.g. Greenough et al. 1996; Goudie et al. 2005). This presentation will briefly review the history of the model and recent improvements, illustrate some example applications, and demonstrate the graphic user interface.

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Ian Moss began his career in forestry at the knees of his father who came to Kelowna in 1950 to become a forester. Ian graduated from UBC in 1979 and spent much of his career in the central interior as a silviculturist, including two years in Smithers and 10 years in Prince George.

Ian strives to better integrate silviculture policies and practices with forest level plans so as to produce desired forest-level outcomes. This led him to the conclusion that stand and stock tables are needed for every polygon in the inventory — that it is about value, whether for habitat or timber, rather than volume. It also led him to the conclusion that a system of *Stand Structure Classification* was needed so that when stand structure type A versus B was referred to, all had the same picture in mind of what that meant — particularly in terms of stand and stock table kinds of attributes.

Stand structure classification: Rendering complex stands less complex

In 2004, a newly developed cluster algorithm was used to create a 17-class system of stand structure classification for both even and uneven-aged stands in the Cariboo. The purpose of the classification was to more precisely describe what is meant when referring to stand structure type “A” versus “B”. While even-aged plantations can be neatly divided into seedling, sapling, pole, mature, and old growth stages, the boundaries between these kinds of stands and those consisting of more irregular kinds of structures are ill defined, as are the boundaries amongst and between a wide variety of irregular and multi-cohort stands. Indeed “complex stands” have become known as such in part because their diverse nature seems to defy logical, clear, concise and accurate subdivision. The purpose of this presentation is to briefly summarize the development of 17-class system of stand structure classification using a newly developed cluster algorithm. The desired number of groups was initially set equal to 17 so as to: (1) have enough groups to increase the precision with which different stand structures can be described, but (2) avoid having so many groups as to make it difficult to apply in reality. People can use the classification with the aid of a field guide and also a compiler if plot data is available. The compiler has a 99 percent success rate in terms of correctly classifying the original data relative to the original groups to which they were assigned. As a result it may be used to help different classifiers to become more consistent and accurate in classifying stands without the use of plots, and it may be used to resolve disputes. One example of how the classification might be used will be presented in terms of characterizing stand conditions before and after being attacked by bark beetles.

Stand structure classification: Rendering complex stands less complex

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QUESTIONS & ANSWERS

Q: I'm trying see what the application would be to silviculture prescriptions?

A: Prescriptions options are partly based on what you start with. So, many options are partly framed by what's there already. If you want to start thinking about stocking standards and silviculture regimes you can divide your land base up into stand structure class and start looking at how you would treat those different stands differently. The compiler brings some consistency to it. There are some stand types that are highly variable, and the thing is scalable. So, for example, if you took some of these uneven-aged Douglas-fir stands that are common around Williams Lake, they are quite heterogeneous. So at a plot scale they have quite a bit of within stand variation. You can characterize that variation if you like, according to this classification, and then you can classify the stand as a whole, without getting into these big long label situations. So it has numerous applications, in terms of silviculture and harvesting.

Q: How do mountain pine beetle stands fit in this classification?

A: The short answer is that I just used Dave Coates' data set. We looked at pre- and post-attack and it was useful in describing some of the variability both before and after attack, and looking at what changes had taken place.

Q: Is it useful for the coast at all or did you have to make some changes?

A: What's transferable are the methods used to build it. But the basic problem with the coast is the trees are bigger than were in the data set that I used. Preferably, I would do a separate coastal thing, and there are other changes that I would make based on what I know now. It's a good starting place.

CONCLUSION

As forementioned, many of the advances in complex stand management have been driven by the current mountain pine beetle epidemic. However, these benefits will last beyond this present crisis. By embracing complexity forest managers and silviculturists may help to avert future forest epidemics. This can be considered effective forestry practice and habitat management.

A range of simulation models and decision-support tools were presented and discussed, such as: TASS, TIPSY, SORTIE-ND, and TADAM. These tools have recently been parameterized for complex stands. Moreover, there is now a stand structure classification system for uneven-aged stands, and a MPB management decision support tool (MDST) to aid decision-makers. In short, we are far better informed regarding complex stands than we were a decade ago. Models continue to be modified and improved. All of these models are hugely dependent on reliable long-term field data, and on research into complex stand dynamics, particularly with respect to climate change. This conference and proceedings is a method to distribute this information more broadly, and, to inspire more inter-disciplinary research.

POSTER PRESENTATIONS

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SYBILLE HAEUSSLER

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Ecosystem Recovery – what is it and how long does it really take?

Over the last few decades, the management of British Columbia's forest resources has come under intense scrutiny from local, national and international consumers and environmental organizations. Opposition to clearcut harvesting methods has increased substantially and forest managers are looking for viable options. Development of science-based sustainable forest management (SFM) practices is critical to the maintenance of ecological integrity and indeed to the survival of BC's forest economy.

The overall objective of this project is to quantify selected second growth coastal forest ecosystem attributes in order to provide a field-based assessment of ecosystem recovery following disturbance. This objective is being accomplished through a retrospective examination of existing coastal second growth forest stands (50 to 200 years old) that have developed after man-caused and natural disturbances. On the coast, these disturbances include old A-frame and select-to-cut logging operations, aboriginal burning, and natural disturbances such as windthrow, fluvial disturbances, and landslides. The intent is to characterize the ecological condition and level of ecosystem recovery toward 'old-growth' stand conditions. Ecosystem attributes being assessed include overstory and understory species composition and cover, growth and yield, epiphytic composition, soil properties, and stand structure. This will provide a basis for comparison with the same attributes in old-growth plots that have been collected largely within the provincial Biogeoclimatic Ecosystem Classification (BEC) Program over the past 30 years. Field sampling for this ecosystem recovery project began in 2004 on the north coast and will continue until 2007 on the north and central coast.

This poster outlines the approach we are using to study ecosystem recovery in coastal forests as well as our plans to expand this work into the northern interior forests. Based on our preliminary analysis of the data collected to date we provide a synopsis of some of these results and a progress report on the project as a whole.

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Craig Farnden is currently a PhD student at the University of British Columbia. He spent the previous 19 years in Prince George as a consulting forester and as a silviculture research forester with the CFS. Craig considers himself a silviculturist first and foremost, although more and more of his work is in the field of growth and yield. Starting with the Canadian Forest Service and continuing later, he developed a number of Stand Density Management Diagrams for use in British Columbia and Alberta. He has also worked extensively with and/or done operational testing for other models such as MGM, TIPSY and SORTIEBC, and has been the primary instructor for courses in the use of PrognosisBC.

An analysis framework for developing SFM-based regeneration standards

In order to integrate sustainable forest management concepts into operational practice, forest managers need better planning tools for linking stand level activities to broad landscape level objectives. Part of the problem that occurs is a temporal disjunct, whereby desired forest attributes are often defined primarily for older stands, but important silvicultural decisions for achieving those attributes must be made at the reforestation stage. To this end, an analysis framework has been developed which links a cut-block scale silviculture survey simulator with a variety of pre-existing individual tree growth models.

In the survey simulator, algorithms have been developed to map individual juvenile trees while mimicking species, size and spatial diversity typically experienced under a range of operational conditions. Stand attributes can be quantified using a wide diversity of survey techniques and metrics. Simulated stands can then be 'grown' using models to assess adherence to future desired stand conditions. By repeating this process for a many sets of different initial conditions, various juvenile stand metrics can be evaluated for their utility in predicting desired future conditions, and thresholds for acceptable versus unacceptable juvenile conditions can be determined.

A contrived example is presented to illustrate how regeneration standards could be developed to help achieve species composition targets in an aspen-white spruce landscape in northeastern B.C.

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Sybille Haeussler is a professional forester and research scientist whose work addresses the dynamics and diversity of plant communities and ecosystems — with a special interest in complex systems dynamics and the role of self-organizing processes in maintaining ecosystem diversity. Sybille currently works as a Killam (honorary) and NSERC post-doctoral research fellow for the Forest Sciences Department, University of BC, and before that was self-employed for more than 20 years as the proprietor of Skeena Forestry Consultants, based in Smithers, B.C.

How does self-organization influence ecosystem diversity, resilience and restoration success?

British Columbia is known worldwide for its outstanding diversity of relatively intact ecosystems, but these ecosystems are under cumulative stress from human activity. There appear to be three main interacting sources of ecosystem diversity: (1) environmental variation, (2) disturbance dynamics and (3) self-organizing process. The first two have been well-studied in BC; the third has been largely ignored. My study used a complex systems approach to examine how two emergent, self-organizing processes, succession and soil formation, influence resilience and restoration success in a degraded boreal mixedwood and a degraded coastal floodplain. Site preparation experiments were established in 1986 at both sites to restore alder-dominated “brushfields” to their original spruce-dominated state. Twenty years later, spruce performance at the boreal mixedwood site was strongly positively correlated with the intensity of site preparation, whereas at the coastal floodplain the results were opposite. I hypothesized that positive feedback loops driven by facilitation and incipient podzolization were required to restore spruce-dominated forests on the coastal floodplain, but not required in the boreal mixedwood. Early results support this hypothesis. Vegetation and soil data indicate that at the boreal mixedwood the spruce and alder-dominated communities lie within a single broad stability domain with high ecological resilience. At the coastal floodplain, strong positive feedbacks associated with high soil nitrogen and removal of coarse woody debris inhibited spruce regeneration and reinforced the alder-dominated state. Maintaining BC’s outstanding ecosystem diversity and restoring damaged ecosystems will require understanding the complex above- and below-ground processes, including self-organizing behaviour, that underlie ecosystem resilience.

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Brian Harvey earned his B.Sc at the University of New Brunswick, his M.Sc. at the Université du Québec à Montréal and his Ph.D. at Laval. His research interests include forest ecological classification, post-harvest vegetation dynamics and natural disturbance-based approaches to silviculture and forest management.

He's been a research professor in silviculture in the Applied Sciences Department at the Université du Québec en Abitibi-Témiscamingue since 2002 and has been Director of the Lake Duparquet Research and Teaching Forest since its creation in 1995.

Partial cutting as a surrogate to stem exclusion and dieback in aspen-dominated boreal mixedwoods: Implications for deadwood dynamics

By Brian Harvey and Suzanne Brais

The application of silvicultural treatments as surrogates to ecological processes working at the stand level constitutes an important component of forest ecosystem management. In this respect, low thinning in even-aged stands may be perceived as mimicking mortality associated with natural self-thinning, and crown thinning may, in some respects, be akin to stand dieback or a transition phase toward more complex stand structure and composition. The SAFE Project, a series of experiments undertaken in the Lake Duparquet Research and Teaching Forest in the southern part of the Canadian eastern boreal forest, tests an ecosystem management model based on natural dynamics. In the winter of 1998-99, two partial harvesting treatments that removed 33 (“1/3”) and 61 percent (“2/3”) of stand basal area were applied to even-aged aspen (*Populus tremuloides* Michx.) stands and compared with control (uncut) stands. Stands in the 1/3 treatment were low thinned with non-vigorous stems removed, while stands in the 2/3 removal were crown thinned with co-dominants and dominants preferentially selected. Coarse woody debris dynamics was assessed during the following six years by means of permanent sampling plots and downed wood inventories. Between 1999 and 2004, tree mortality was respectively 17, 22 and 38 percent in control stands, 1/3 and 2/3 harvesting treatments. Snag density varied between 226 and 373 stem ha^{-1}. Downed wood volume increased by 35 m^3 ha^{-1} in the control and by 25 m^3 ha^{-1} in the 2/3 harvesting treatment, while it decreased by 7 m^3 ha^{-1} in the 1/3 harvesting treatment. Most of the fresh wood originating from harvesting was in a more advanced stage of decomposition. Very few large and well decomposed logs were found in the 2/3 treatment. Our results show that specific goals for CWD maintenance in managed stands can be set in silviculture prescriptions and that the type, timing and intensity of partial cutting are crucial to the outcome.

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Marty Kranabetter is a soil scientist with the Forest Service for 15 years in Prince George and Smithers, B.C. He is currently undertaking a PhD with Suzanne Simard at UBC, exploring the interaction of light and nitrogen availability on sapling growth in partial cut forests. Marty has a wide interest in soil ecology and forest productivity, especially ectomycorrhizal fungi.

An investigation into factors causing height suppression of understorey conifers

By J.M. Kranabetter, S.W. Simard, R.D. Guy, and K.D. Coates

A challenge in modelling forest development in multicohort stands is the interaction between tree size and light availability on sapling growth rates. These complex growth patterns were apparent at the Date Creek silvicultural systems research forest in northwestern British Columbia. The height increment of understorey (25 percent light availability) hybrid white spruce (*Picea glauca* x *Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) saplings had declined by 60 percent and 27 percent, respectively, in the last five years. Three hypotheses, including acute moisture stress, reduced foliar nitrogen concentrations, and diminished light availability were tested as possible causes of height suppression by comparing these understorey saplings with trees of the same age located in large forest gaps. Xylem potentials of understorey and gap trees were consistent throughout the summer, with no indication of extreme moisture stress, despite the narrower radial increments accrued under shade. Foliar nitrogen concentrations were also not significantly different across understorey and gap microsites, or between species. The natural abundance of ^{13}C in radial wood increments from the five-year period was significantly different between understorey and gap trees, as expected, but did not change sufficiently over time to suggest ongoing declines in light availability for understorey saplings. Rather than physiological constraints to photosynthesis, we suggest the reduction in growth rates associated with larger, shaded trees was most likely due to the growing respiratory demands of nonphotosynthetic biomass. The ratio of foliar to wood biomass was more responsive to light availability for western hemlock than hybrid spruce, which likely contributed to differences in shade tolerance between species. The ongoing changes in understorey growth rates as a function of tree size and species should be considered in stand development models.

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Assessing the effectiveness of management strategies in creating and maintaining stand-level biodiversity on large-scale mountain pine beetle cutblocks in the Arrow Boundary Forest District

By Alyson McHugh

The mountain pine beetle epidemic has facilitated large-scale harvesting across the province to minimize economic loss. However, the repercussions on biodiversity are unknown, and environmental and social concerns have arisen over the rapid degradation of land in such a short time period. By creating and maintaining appropriate stand-level biodiversity, some of this concern could be alleviated. Detailed knowledge on the quantity and quality of stand characteristics in retention areas is required for creating and maintaining appropriate stand-level biodiversity. Currently this information is lacking in many areas which prevents strategies from being effectively evaluated. This project seeks to ascertain the effectiveness of management strategies in creating and maintaining stand-level biodiversity on large-scale mountain pine beetle cutblocks in the Arrow Boundary Forest District. Several large-scale MPB treatment areas were sampled prior to harvest operations in an attempt to identify appropriate target configurations of stand-level structures in order to maintain biodiversity. A post-harvest assessment of the same cutblocks will build on the foundation of pre-harvest stand-level data collected and allow for direct comparison to produce natural benchmarks for the district. The analysis will include a variety of forest types; therefore this research will generate a better understanding of how the MPB is impacting habitat indicators associated with stand-level biodiversity in complex forest stands. Further, by studying the effectiveness of different management strategies in creating and maintaining stand-level biodiversity, forest managers will immediately be able to mitigate the ecological loss generated by large-scale MPB harvesting operations.

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Grant Nishio was hired by FERIC in 2006 to initiate a series of studies investigating understorey protection in mixed species stands attacked by mountain pine beetle.

FERIC understorey protection project

The purpose of this study is to address concerns related to the predicted mid-term wood supply shortage. Any mid-term timber contribution can only come from the secondary stand structure of non-pine species and understorey trees presently living. Further, much of this potential mid-term supply existing in some pine-leading stands will soon be lost due to the clearcut strategy widely used to address the current MPB infestation. It is the intent of this study to develop and determine partial harvesting methods that can effectively protect enough of the secondary structure to leave the residual stand fully stocked and free-growing at the completion of the harvesting treatment. This study will identify harvesting methods that are effective at protecting secondary structure. The composition of the secondary structure that is present in a stand before harvesting will indicate what type of stand can potentially be produced. This means the selection of suitable sites to use this type of protection harvesting is crucial to creating future stands that provide the volumes, species mixtures, and age/size classes that meet the mid-term wood supply shortages. Other key factors include the effectiveness of protecting the secondary structure and remaining economically viable trees, the issue of survivability (windthrow, sunscald, etc.) and the release potential of the residual understorey.

The three main study objectives are:

1) what are the different levels of protection that can be achieved using various harvesting equipment combinations and methodology,

2) will the residual stand survive and release well, and

3) what are the differences in cost using the selection harvesting methods.

To date, three hand faller trials and one feller buncher/grapple skidder trial have been completed in Prince George, but the study will expand to other areas and harvesting methods in the coming field trials.

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Derek Sattler has worked for six years as a forestry consultant in Alberta and Saskatchewan, Canada. Much of his work has focused on forest modelling, including predictive ecosite mapping and simulating successional pathways. He is currently working towards the completion of his Masters Science in Forestry, specializing in forest biometrics.

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Estimating natural regeneration in mountain pine beetle affected stands using SORTIE-ND and Prognosis^{BC}

A hybrid model that combines the strengths of the processed-based and empirically-based functions of SORTIE-ND and Prognosis^{BC} was evaluated for estimating natural regeneration under unsalvaged mountain pine beetle-affected stands. Combining the respective models involved identifying their strengths in predicting seed distribution, seedling recruitment, seedling and adult tree growth, and mortality. While Prognosis^{BC} performs well when projecting small and large tree growth under conditions for which empirical relationships have been developed, it cannot provide a dynamic simulation of natural regeneration establishment in MPB-affected stands. The proposed hybrid model approach uses SORTIE-ND to simulate seed dispersal, seedling recruitment and seedling growth in MPB affected stands. In predicting regeneration, SORTIE-ND tries to match the recruitment-generation process with empirical sub-models that include functions for substrate-dependent germination and snag fall down rates. Thus, regeneration predictions are more likely to reflect actual regeneration in MPB-affected stands.

To date, predictions of natural regeneration using SORTIE-ND have resulted in mixed results for the IDF and SBPS BEC subzones. To improve our results, crown allometry functions that introduce various measures of density have been tested. Further work will focus on developing new height and diameter allometric relationships. The best point to transfer the regeneration projections from SORTIE-ND to Prognosis^{BC} will be tested by running simulations using various stages of seedling growth and time since MPB attack. Following the hand-off to Prognosis^{BC}, stand growth projections will be compared to field data that was collected from a variety of site conditions and different levels of MPB attack.

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