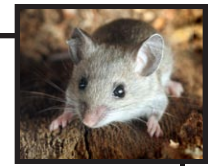

Workshop on

The scientific foundation for sustainable forest biomass harvesting guidelines and policy

February 18-21, 2008
Toronto, Ontario

Program and Abstracts

SUSTAINABLE FOREST MANAGEMENT NETWORK
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Workshop on

The Scientific Foundation for Sustainable Forest Biomass Harvesting Guidelines and Policies

Toronto, Ontario, 18-21 Feb. 2008

Program and Abstracts

Revised and up-dated for post-workshop circulation

31 March 2008

The Organizing Committee thanks the many people who have made this workshop possible:

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Introduction

The forest bioproducts and bioenergy sectors are developing rapidly across Canada. Thus far, these sectors have depended largely on waste wood left over from industrial processing; however, slash is an emerging and potentially important source of industrial feedstock. In Canada, relevant research on the impacts of removing slash on ecosystem processes has been conducted for over 30 years. Industrial and regulatory agencies across the country are now developing science-based guidelines and regulations for sustainable biomass removal. This scientific knowledge can also be used to develop criteria and indicators to assure markets that increased biomass harvesting will not compromise the integrity of our forest ecosystems in the future.

Sharing what we know about the impacts of biomass removal in different Canadian forests will create synergies and reduce duplication among different agencies across the country as they conduct work relevant to their own ecosystems and circumstances. By working together, experts with diverse backgrounds and interests can develop answers to key questions, such as: What do we know about biomass removal impacts on different Canadian ecosystems? What are the most important gaps in our knowledge, and how can they best be filled? What research approaches are most appropriate for answering key questions? What synergies and efficiencies can be achieved through networking? What approaches would allow direct comparisons among different regions, while still addressing local research priorities? What tools would facilitate rapid uptake and efficient transfer of new and existing knowledge across Canada? What lessons can we learn from experience in other countries?

To answer these questions, this workshop has been organized to bring scientists, government regulators, industry, and environmental non-government organizations together, with the following objective: *Identify what is known, and what needs to be known, to develop sustainable biomass removal guidelines and policies in the different jurisdictions across Canada.*

To achieve this objective:

- Participants will share updates on the state of forest biomass removal knowledge across Canada;
- Gaps related to development of sustainable biomass removal guidelines, policies, criteria and indicators, and certification systems will be identified;
- Priorities for research will be debated and collated so that they can feed into strategic planning by agencies across Canada;
- Common approaches to research methodologies will be determined to maximize synergy and increase application and comparability of results across Canada;
- Tools that will facilitate storage, access, and use of knowledge will be identified and prioritized, and agencies will be identified to develop and/or maintain them;
- Ways in which knowledge can be generated, synthesized, made more useful, and applied will be identified, including: adaptive management frameworks, development of generic guideline systems, meta-analysis, approaches for synthesizing information for land managers;
- Long-term research networks will be formed that increase synergy and cooperation in research, field trials, and monitoring of operational biomass removal;
- Long-term inter-agency networks will be formed that will increase transfer of ideas, experience, and knowledge in research and in guideline and policy development.

Program

Monday 18 February

6:00-8:00 PM **Registration and reception** (Delta Chelsea Hotel)

Tuesday 19 February

8:00-8:30 AM **Registration and breakfast** (Faculty Club)

Opening

8:30 AM Welcome

The Canadian context for forest bioenergy - where, when and how does science fit in?

Policy drivers – where, when and how does science fit in?
Bill Thornton (Assistant Deputy Minister, Ontario Ministry of Natural Resources, ON)

Opportunities and challenges to biomass harvesting in Canada: an operational perspective
Mark Ryans (FPInnovations – FERIC Division, Pointe-Claire, QC)

Biofibre utilization: a conservation context
Trevor Hesselink (Director, Forests Program, Canadian Parks and Wilderness Society (CPAWS) Wildlands League, Toronto, ON)

Refreshment Break

Expanding our understanding of where science fits into the big picture

Linking science, policy and operations through sustainable forest management frameworks
Brenna Lattimore (Faculty of Forestry, University of Toronto, ON), Jim Richardson (CANBIO & IEA Bioenergy, Ottawa, ON) and Tat Smith (Faculty of Forestry, University of Toronto, ON)

Interactive Discussion

Lunch

Canadian science: what do we know, and what are the key issues?

A review of research on biomass removals and site productivity relevant to the Canadian context

Evelyne Thiffault, David Paré (Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, Ste-Foy, QC), Brian Titus and Doug Maynard (Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC)

Panel presentation: **Current site productivity research in Canada**

Shannon Berch (BC Ministry of Forests and Range, Victoria, BC)
Dave Morris (Ontario Ministry of Natural Resources, Thunder Bay, ON)
David Paré (Natural Resources Canada, Laurentian Forestry Centre, Ste-Foy, QC)
Paul Arp (University of New Brunswick, Fredericton, NB)

Interactive Discussion

Refreshment Break

An overview of Canadian research on biomass removals and biodiversity

Jay Malcolm (Faculty of Forestry, University of Toronto, ON), Wayne Bell (OMNR), Shannon Berch (BC MOFR), Bill Chapman (BC MOFR), Dave Morris (OMNR), Steve Newmaster (University of Guelph), Dan Puddister (OMNR), and Ian Thompson (NRCanada, GLFC)

Panel presentation: **Current biodiversity research in Canada**

Bill Chapman (BC Ministry of Forests and Range, Victoria, BC)
Steve Newmaster (University of Guelph, ON)
Tim Work (Université du Québec à Montréal, QC)

Interactive Discussion

5:00-6:00 *No scheduled activities*

6:00-7:00 **Poster Session** (authors present) and **Pre-Dinner Social**

7:00-10:00 **Dinner** followed by **Reception**, with posters available for viewing

Wednesday 20 February

8:00-8:30 AM **Breakfast** (Faculty Club)

8:30 Start of Day 2

International science: what do we know, and what are the key issues?

Site productivity lessons from the USA
Jim Burger (Dept. of Forestry, College of Natural Resources, Virginia Tech, Blacksburg, VA) and Andy Scott (USDA Forest Service, Southern Research Station, Pineville, LA)

Site productivity lessons from the Nordic countries
Bengt Olsson (Swedish University of Agricultural Science, Uppsala, Sweden)

Interactive Discussion

Refreshment Break

Biodiversity lessons from the USA
Brenda McComb (Dept. of Natural Resources Conservation, University of Massachusetts Amherst, Amherst, MA)

Biodiversity lessons from the Nordic countries
Anders Dahlberg (Swedish University of Agricultural Science, Uppsala, Sweden)

Interactive Discussion

Lunch

Moving science into guidelines and policy

Biomass harvesting guideline development: the Minnesota experience
Kurt Rusterholz (Ecologist, Minnesota Department of Natural Resources, Division of Ecological Resources, St. Paul, MN) and Dick Rossman (Minnesota Department of Natural Resources, Division of Forestry, Bemidji, MN)

The development of regulations and good-practice guidelines for whole-tree harvesting in Sweden
Hillevi Eriksson, Karin Hjerpe, Hans Samuelsson (Swedish Forest Agency, Jönköping, Sweden) and Heléne Lundkvist (Dept. of Ecology, Swedish University of Agricultural Science, Uppsala, Sweden)

Panel presentation: **Moving science into guidelines and policy - Canadian experience**

Nancy Densmore (BC Ministry of Forests and Range, Victoria, BC)
Larry Skinkle (Ontario Ministry of Natural Resources, Sault Ste. Marie, ON)
Michel Campagna (Ministère des Ressources naturelles et de la Faune, Québec, QC)
Shawn Morehouse (NB Department of Natural Resources, Fredericton, NB)

Breakout Groups

Refreshment Break

Food for thought

Interactive Discussion

5:00-6:00 *No scheduled activities*

6:00-7:00 **Pre-Dinner Social**

7:00-10:00 **Dinner** followed by **Reception**, with posters available for viewing

Thursday 21 February

8:00-8:30 AM **Breakfast** (Faculty Club)

8:30-1:00 **Moving forward: integrating lessons learned and planning for the future**

One of the desired outcomes of the workshop is that everyone, not just invited speakers and panelists, will have an opportunity to contribute to what we know about the sustainability of biomass harvesting. We have planned for discussion and interaction throughout the meeting. Discussions will culminate, however, during the third day, when everyone will be involved in sharing ideas on our state of knowledge, and where we go from here. You do not want to miss the opportunity to provide your insights and to reflect on what we've learned!

A light buffet lunch will be served at noon, so that participants may eat while they complete discussions.

Speaker Abstracts

(*Chronological order*)

Policy drivers – where, when and how does science fit in?

***Bill Thornton**, Assistant Deputy Minister, Forests Division, Ontario Ministry of Natural Resources, Roberta Bondar Pl., Suite 400, 70 Foster Dr., Sault Ste Marie, ON, P6A6V5; E-mail: bill.thornton@ontario.ca, Phone: 705-945-6660*

Forest sustainability is a balance of environmental, social and economic values. Global influences affect policy decisions at a regional level. What the priorities are and the context under which forest policies are developed varies across the country. These same questions also provide challenges and opportunities for which science can inform and play a key role in in policy development. How applied research and science might be relevant and effective in meeting policy needs will also be discussed.

***Bill Thornton** is the Assistant Deputy Minister, Forests Division, of the Ontario Ministry of Natural Resources. He is the top Ontario government official responsible for sustainable forest management, forest licensing, and industry support initiatives. Bill has held a number of positions within the Ontario Public Service over the last 21 years, starting as a field forester in Timmins, Ontario. He later held policy and planning positions in Northeastern Ontario and was general manager of the Northern Ontario Heritage Fund Corporation. Prior to his current position as Assistant Deputy Minister, Bill was director of OMNR's Industry Relations and Forest Management Branches. These responsibilities covered many different business areas, ranging from provincial forest policy and legislation to managing the softwood lumber trade file. Bill serves as a director on the Canadian Forestry Association. He is a member of the Canadian Institute of Forestry and is a Registered Professional Forester. He holds a bachelor of science in forestry from the University of New Brunswick and a Masters in business administration from Dalhousie University.*

Opportunities and challenges to biomass harvesting in Canada: an operational perspective

Mark Ryans, *FPInnovations – FERIC Division, Eastern Region, 580 boul. Saint-Jean, Pointe-Claire, QC, H9R 3J9; E-mail: mark-r@mtl.feric.ca, Phone: (514) 694–1140 ext. 345*

The forest industry is a positive contributor to "green" energy across Canada. Moreover, it is well-positioned to take on a greater role in the emerging sector of renewable energy and chemicals from the forest. The recovery of harvest residues for bioenergy has occurred in Canada for over a decade, although until recently, there were only a limited number of operations. Compared to Nordic countries, we have some catching up to do in terms of our practices, guidelines and knowledge of the environmental impacts. However, time is of the essence if the industry is to seize the opportunity.

This presentation provides an overview of biomass harvesting operations in Canada with some comparisons to Nordic equipment and systems. There are a number of challenges to be addressed including:

- There is a variety of harvesting systems used across Canada with varying forest and site conditions so Nordic practice cannot be directly applied;
- The current value of forest residues is low, but increasing, and the delivered costs are high due to their low bulk and energy densities and high moisture content;
- There is a lack of precise information on the recoverable, economical and available volumes, especially at the local level on which to build a business case and attract capital investment;
- The capital costs for a small contractor to get into the biomass harvesting business are considerable;
- There is a low level of integration between the conventional harvest and recovery operation and a mindset that residues are waste; and,
- There is a perception that biomass recovery operations will leave no or minimal debris on site.

On the other hand, there are numerous opportunities:

- Roadside residues from full-tree harvesting systems have an economic advantage;
- Methods and equipment can be adapted to reduce environmental impacts;
- A biomass market can stimulate the harvest of non-merchantable stands, resulting in better silvicultural practice and stand rehabilitation treatments that can have a positive effect on the AAC;
- There is already a broad knowledge base to develop scientifically-sound best practices.

***Mark Ryans** is a graduate forester from the University of Toronto (1978) and a Registered Professional Forester (Ontario). He worked with the OMNR as a project forester before joining the Forest Engineering Research Institute of Canada (now FPInnovations – FERIC Division) in Pointe-Claire, Quebec. He has worked as a researcher in the areas of harvesting and small-scale operations, road construction and GPS tracking, and was the supervisor of the Silvicultural Operations group for 18 years. Currently, Mark is one of two interim research directors for Eastern Canada and is the Program Leader for three R&D areas: harvesting and regeneration systems, environmental impacts of forest operations and forest feedstocks for a bioeconomy. The Ontario and Manitoba extension offices also come under his direction.*

Biofibre utilization: a conservation context

Trevor Hesselink*, Director, Forests Program, Canadian Parks and Wilderness Society (CPAWS) Wildlands League, 380-401 Richmond St. W., Toronto, ON M5V 3A8; E-mail: trevor@wildlandsleague.org, Phone: 416-971-9453 ext. 33*

Trevor Hesselink *is the Forests program director at CPAWS Wildlands League, where he has been working on forest policy issues for the past two years. Before that, he spent 6 years as a senior policy advisor to the Ministry of Environment, and so has an intimate knowledge of the context and challenges within the civil service in Ontario. Trevor has also maintained an independent consulting practice since 1992, with clients from all sectors, including the Ontario Ministry of Natural Resources. His training is as a professional generalist - with an undergraduate degree in Planning from the University of Waterloo, and a Masters in Urban Design from the University of Toronto, with a focus on sustainability and land-use.*

Linking science, policy and operations through sustainable forest management frameworks

***B. Lattimore**, **J. Richardson** and **C.T. Smith**, Faculty of Forestry, University of Toronto, 33 Willcocks Street, Toronto, ON M5S 3B3; E-mail: brenna.lattimore@utoronto.ca, Phone: (416) 978-5273*

Utilizing expert knowledge to define the parameters of sustainable forest management and translating these definitions into effective policy and sound operations can be a complex and unwieldy process. A great deal of valuable research exists and is constantly evolving with regard to potential impacts of forestry practices on forest ecosystems. However, this research must be relevant and accessible at the forest management level so that its value in developing sustainable systems can be maximized and standards and policies can be adequately informed by science. This paper will discuss the value of mechanisms such as environmental management systems, certification schemes and adaptive forest management to capturing expert knowledge and bridging the gaps between science, policy and management for the development of sustainable forest biomass production systems. Such mechanisms can: give structure and clarification to issues of sustainable forest management; provide a basis for the formulation of policies and the implementation of SFM standards; provide a mechanism for distilling scientific knowledge so that it can be implemented at the operational level; ensure continual improvement through adequate monitoring, assessment and feedback loops; and encourage public SFM dialogue and consumer choice.

***Brenna Lattimore** is currently a researcher at the University of Toronto Faculty of Forestry. She holds an undergraduate degree in Environmental Studies and International Development from Queen's University and a Masters degree in Forest Conservation from the University of Toronto. Since graduating in 2007, Brenna has worked on a variety of projects for the World Wildlife Fund, the University of Toronto, the International Energy Agency and United States Department of Agriculture on environmental risk assessment, mitigations and C&I for sustainable forest bioenergy production.*

***Jim Richardson** is a forester and a private forestry and forest bioenergy consultant based in Ottawa. Jim spent most of his career first as a silviculture researcher and latterly as manager of a forest biomass R&D program for the Canadian Forest Service. Jim currently is Task Leader of IEA Bioenergy Task 31, Biomass Production for Energy from Sustainable Forestry. He is also a founding director of the Canadian Bioenergy Association (CANBIO), Technical Director for the Poplar Council of Canada and a member of the Executive Committee of the International Poplar Commission. Jim obtained his post-secondary education from the University of Edinburgh and the University of New Brunswick.*

***Dr. Tat Smith** is Dean and Professor of the Faculty of Forestry at the University of Toronto. Prior to this, Tat was Professor and Head of the Department of Forest Science at Texas A&M University (1999-2005), Program Manager for the New Zealand Forest Research Institute (1993-1998), and a faculty member at the University of New Hampshire for ten years. Tat received his PhD in Forest Resources from the University of Maine in 1984. His major research interests include forest ecology and soils, with specific focus on assessing the environmental impacts of forest bioenergy production. Tat is currently Associate Task Leader IEA Bioenergy Task 31.*

A review of research on biomass removals and site productivity relevant to the Canadian context

Evelyne Thiffault, *Université du Québec à Montréal and Natural Resource Canada, Canadian Forest Service, Laurentian Forestry Centre, 1055 du P.E.P.S., P.O. Box 10380, Stn. Sainte-Foy, Quebec City, QC, G1V 4C7; E-mail: ethiffault@rncan.gc.ca, Phone: 418-648-4933;* and ***David Paré***, **Brian Titus** and **Doug Maynard**, *Natural Resource Canada, Canadian Forest Service, Laurentian and Pacific Forestry Centres.*

A renewed interest in intensive harvesting of forest biomass as feedstock for bioenergy in North America raises concerns over the impacts that this practice may have on the maintenance of forest soil productivity. In Canada, such concerns were first voiced in the 1970s, and studies were launched to investigate and predict the impact of intensive forest biomass removal on site productivity. Most of these studies were focused on static nutrient budgets. In Canada and around the world, more detailed process models have also been developed to study carbon, nitrogen and base cation cycling under different forest harvesting intensities. However, validity of modelling results has been and still is constrained by our knowledge of the capacity of ecosystems to supply nutrients. A few sets of field trials have been established in Canada to gather empirical data on the impact of biomass removal on soil nutrient reserves, as well as tree nutrition and growth. Although still fairly recent, these field trials, and older ones established in other countries with site conditions and climates similar to those found in Canada, provide opportunities to refine our understanding of the resilience of ecosystem processes, and of the impacts of intensive biomass removal on ecosystem function and site productivity.

Evelyne Thiffault *has a degree in forest engineering (2001) and a PhD in forest sciences (2006), both from Université Laval. Her PhD studies focused on the biogeochemistry of whole-tree harvesting in the boreal zone of Quebec. She has been a postdoctoral fellow since 2007, and conducts research on the effects of intensive forest harvesting and fast-growing plantations on nutrient cycling and site productivity.*

David Paré, ***Brian Titus*** *and* ***Doug Maynard*** *are research scientists with Natural Resources Canada, Canadian Forest Service. Between them, they have a combined total of over 60 years of experience in forest soil and nutrient cycling research in Alaska, BC, Alberta, Quebec, Newfoundland and Scotland. This has included field trials and studies on the effects of slash removals and organic matter on ecosystem processes in a range of temperate and boreal forest ecosystems across Canada and in Scotland.*

Panel presentation: Current site productivity research in Canada

Shannon Berch *is Research Scientist with the Research Branch, British Columbia Ministry of Forests and Range working in forest soil conservation and non-timber forest products, and adjunct professor with the Faculty of Land and Food Systems, University of British Columbia, and with the Centre for Non-Timber Resources, Royal Roads University. She is Principal Investigator for the BC Long Term Soil Productivity Study and involved in the development of a program to monitor the effectiveness of the soil conservation provisions of the Forest and Range Practices Act and regulations.* ***Contact information:*** *Research Branch, BC Ministry of Forests and Range, PO Box 9536 Stn Prov Govt, Victoria, BC, V8W 9C4; E-mail: Shannon.Berch@gov.bc.ca, Phone: (250) 952-4122*

Dave Morris *received both his BScF and MScF from Lakehead University and his PhD from the University of Guelph. Dave has been a research scientist with the Ontario Ministry of Natural Resources since 1986, and is currently the Stand Ecology Program Leader at the Centre for Northern Forest Ecosystem Research in Thunder Bay, ON. He is also an adjunct professor at both Lakehead University (Faculty of Forestry and the Forest Environment) and the University of Guelph (Dept. of Environmental Biology). Dave's research program focuses on nutrient cycling in boreal systems, with particular emphasis on evaluating the impacts of harvesting systems on stand structural development, stand nutrition, and productivity.* ***Contact information:*** *Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources, c/o Lakehead University Campus, 955 Oliver Rd., Thunder Bay, Ontario, P7B 5E1; E-mail: Dave.M.Morris@Ontario.ca, Phone: (807) 343-4024*

David Paré *is a research scientist with the Canadian Forest Service, Laurentian Forestry Centre in Québec City. He earned a B.Sc. in forest engineering from Laval University (1985) and a PhD in forest soils from the University of Alaska (1990). His research program is centered on best management practices to conserve forest soils with respect to intensive biomass harvesting, changes in forest composition and soil disturbance due to forest operations. Since 2002, he has co-authored more than half-a-dozen scientific publications dealing specifically with the sustainability of biomass harvesting in Canadian forests. He has published an indicator of site susceptibility to whole tree harvesting designed to be applicable to large land bases with information that forest managers already have on hand. He co-authored several articles documenting the impacts of whole tree harvesting on different combinations of vegetation-site types as well as the impact of plantations of fast growing tree species on soil. His research is providing guidance for the development of validated indicators of site susceptibility to intensive biomass production.* ***Contact information:*** *Natural Resource Canada, Canadian Forest Service, Laurentian Forestry Centre, 1055 du P.E.P.S., P.O. Box 10380, Stn. Sainte-Foy, Quebec City, QC, G1V 4C7; E-mail: dpare@rncan.gc.ca, Phone: 418-648-7598*

Paul Arp *graduated with a B.Sc. (Hon.) in Chemistry from Carleton University, and with a Ph.D. (Physical Chemistry) from McGill University. He is Professor of Forest Soils at the Faculty of Forestry and Environmental Management at UNB, where he has worked since 1976. His research deals with quantifying and modeling biomass, nutrient and hydro-thermal responses of forest soils and watersheds to forest disturbances, including forest operations and changes in weather and climate. He has worked in this area for about 30 years, and has authored about 100 peer-reviewed publications.* ***Contact information:*** *Faculty of Forestry and Environmental Management, P.O. Box 44555, 28 Dineen Drive, University of New Brunswick, Fredericton, NB, E3B 6C2; E-mail: arp2@unb.ca, Phone: 506-453-4931*

An overview of Canadian research on biomass removals and biodiversity

Jay Malcolm[1], ***Wayne Bell***[2], ***Shannon Berch***[3], ***Bill Chapman***[3], ***Dave Morris***[2], ***Steve Newmaster***[4], ***Dan Puddister***[2], *and* ***Ian Thompson***[5]; *[1]Faculty of Forestry, University of Toronto; E-mail: jay.malcolm@utoronto.ca, Phone: 416-978-0142; [2]Ontario Ministry of Natural Resources; [3]British Columbia Ministry of Forests and Range; [4]Department of Integrative Biology, University of Guelph; [5]Canadian Forest Service*

We provide an overview of past and current Canadian research on biodiversity implications of biomass removal. Biomass, especially in the form of downed and standing dead wood, provides food and habitat for a diverse array of organisms, including micro-organisms, fungi, plants, invertebrates, and vertebrates. Many of these species are interdependent (e.g., linked in complex food webs). In some cases, habitat relationships are relatively well-known (e.g., woodpeckers), for others (e.g., arthropods, lichens), such information is in its infancy, although DNA techniques are leading to rapid advances in knowledge for some groups. Biomass also provides important additional roles in the functional diversity of ecosystems, providing a key energy source in carbon cycling, a slow-release nutrient source, a substrate for natural regeneration and species interactions influencing forest pests and diseases, and contributions to soil processes through moisture retention, buffering capacity, and contributions to soil organic matter pools. In a Canadian context, understanding of the implications for biodiversity of biomass removal *per se* is in its infancy because forestry operations have focussed largely on timber and pulp production. At the same time, a variety of research indicates that a principle effect of such operations is through long-term changes in the quality and quantity of woody debris, with increasing intensity of management for fibre removal resulting in increasing intensity of biodiversity effects. Because forest harvesting is a relatively recent phenomenon in Canada, effects have so far been largely restricted to reductions in habitat supply and attendant reductions in populations. Depending on the context of future landscape management, fibre removals also have the potential to affect population viability and the ecological services that organisms provide in support of forest development and productivity. Development of management standards and guidelines has improved prospects for sustaining biodiversity in the face of timber and pulp production. Research is needed to develop comparable guidance for biomass removal. We review relevant research findings, identify key research gaps, and outline guiding principles for policy development.

Jay Malcolm *is an associate professor whose research focuses on the biodiversity implications of anthropogenic activities in forests, especially in north temperate and tropical forests.* ***Wayne Bell*** *is a research scientist who studies the effects of disturbance on the ecology, diversity, and succession of forest flora, with particular research interests in vegetation management alternatives and enhanced forest productivity.* ***Shannon Berch*** *is a research scientist and Principal Investigator for the BC Long Term Soil Productivity Study and is involved in monitoring of the effectiveness of the soil conservation provisions of the Forest and Range Practices Act and regulations.* ***Bill Chapman*** *is a soil scientist with research foci on controlling Armillaria root disease, landing rehabilitation, long-term effects of soil disturbance on forest productivity, and the importance of woody debris.* ***Dave Morris*** *is a research scientist whose research focuses on evaluating the impacts of harvesting systems on stand structural development, stand nutrition, and productivity in boreal systems.* ***Steve Newmaster*** *is an assistant professor especially interested in bryophyte diversity in temperate rainforests, impacts of wildfire and logging on habitats of rare species and plant diversity, and the ethnobotanical value of non-timber forest products.* ***Dan Puddister*** *works with science staff, other MNR section leaders, collaborators, and clients to plan, develop, integrate, deliver, and review MNR's research and science.* ***Ian Thompson*** *is a senior biodiversity research scientist working in the area of vertebrate responses to forest management in boreal Canada, with specific experience conducting research on marten, small mammals, and birds.*

Panel presentation: Current biodiversity research in Canada

Bill Chapman *is a research scientist (forest soil biology) with the BC Ministry of Forests and Range in Williams Lake, BC; Areas of Research: biocontrol of Armillaria root disease with competitive fungi, nitrogen fixation in lodgepole pine tuberculate ectomycorrhizae, long-term soil productivity in managed forests, pine mushroom management, and soil reclamation.* ***Contact information:*** *Forest Sciences, BC Ministry of Forests and Range, 200-640 Borland Street, Williams Lake, BC, V2G4T1; E-mail: Bill.Chapman@gov.bc.ca, Phone: (250) 398-4718*

Steven Newmaster *is Herbarium Director at the Biodiversity Institute of Ontario, Faculty of Integrative Biology at the University of Guelph (PhD, University of Alberta). As a cryptogamic botanist specializing in lichens and bryophytes (mosses and hepatics), Steve has more than 40 publications including the Flora Ontario (http://www.uoguelph.ca/foibis), botanical field guides, book chapters, journal articles on biodiversity including impacts of forest management on plant diversity, vegetation management, patterns of diversity in old growth forests and government reports on ecosystem management and conservation. His research program, the "Floristic Diversity Research Group" (FDRG) has generated over $3 million dollars in biodiversity research. The FDRG is well situated within the Biodiversity Institute of Ontario (BIO) OAC Herbarium here they conduct research in the patterning of floristic diversity, anthropogenic impacts on biodiversity, taxonomy, invasive species biology and ethnobotany. Currently the FDRG is studying DNA barcoding and the impacts of intensive forest management on plant diversity (NSERC/FRP project); this includes structural and compositional diversity, the ecological associations of functional plant groups to wildlife and the value of plant diversity to First Nation Communities in Canada, India and Peru.* ***Contact information:*** *Biodiversity Institute of Ontario, Faculty of Integrative Biology at the University of Guelph; E-mail: snewmast@uoguelph.ca, Phone: (519) 824-4120 x56002*

Tim Work *is a forest insect ecologist at the University of Quebec à Montreal, and a member of the NSERC-UQAM-UQAT Chaire research group in sustainable forest management and the Centre d'étude de la forêt (CEF). He specializes in developing/evaluating silvicultural approaches that maintain biodiversity and its subsequent ecological role in boreal forests. Currently, his studies include evaluations of variable green-tree retention, clearcutting, whole-tree harvesting, gap-cutting, salvage logging, and wildfire on insect biodiversity throughout the Abitibi-Temiscimangue region of Québec. He is also involved in similar studies in Western Alberta and Eastern Québec. Work's research also concentrates on saproxylic species associated with downed woody debris and its relevance for decomposition of deadwood and nutrient release in forest soils. He currently directs 6 graduate students working in these areas.* ***Contact information:*** *Timothy T. Work, professeur sous octroi, Département des Sciences Biologiques, Université du Québec à Montréal, C.P. 8888, Succursale Centre-ville, Montreal, QC, H3P 3P8; E-mail: work.timothy@uqam.ca, Phone: 514-987-3000 poste 2448*

Site productivity lessons from the USA

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The U. S. government is strongly committed to expanding the role of biomass as an energy source. In a biomass as feedstock feasibility study (Perlack et al. 2005), the U.S. Departments of Energy and Agriculture concluded that, of a total 368 dry tons per year from the forestry sector, 136 million dry tons per year could be furnished from forest extractions that include logging residues, fuel treatments, and fuelwood. The study recognized “a particular concern” is the effect of removing the nutrients embodied in the wood materials and residue. The effect of nutrient and organic removals on forest health associated with conventional harvesting and site preparation of plantation and natural forests has been a concern in the U. S. for decades. Energy wood harvest represents an additional increment of removal that may exacerbate sustainability concerns for some forest sites. Several productivity studies show that energy wood removal with the conventional bole wood removal from low to medium quality sites could cause net nutrient and organic matter depletion. It is not clear if nutrient additions from ash or inorganic fertilizer, provided they are available and affordable, can sustain soil functions needed for sustainable production. Acid deposition on some U.S. forests also exacerbates nutrient removal in forest biomass due to accelerated leaching of some nutrients. Several research programs are documenting harvest and acid deposition effects on site productivity, and criteria and indicators are being developed to monitor forest site productivity along quality and management gradients.

***Jim Burger**, the presenting author, is Garland Gray Professor of Forestry and Soil Science in the Department of Forestry at Virginia Tech where he teaches and does research on topics including forest soils, forest site productivity, restoration ecology, and agroforestry. He has a B.S. degree in Agronomy and an M.S. degree in Forestry from Purdue University, and a Ph.D. in Soil Science from the University of Florida. He is a long-time member of the Society of American Foresters and is a Fellow in the Soil Science Society of America.*

***Andy Scott** is a Research Soil Scientist with the Southern Research Station of the USDA Forest Service, in Pineville, LA. He has a B.S.F. in Forest Management from Purdue University (1995), an M.S. in Forestry from Texas A&M University (1998) and a Ph.D. in Forest Soils from Virginia Polytechnic Institute and State University (2002). He currently works on the long-term soil productivity of southern coastal plain forests (the influences of soil type, inherent fertility, and previous land use on soil responses to forest management), on mid-rotation fertility management (influences of soil type on the response of thinned stands to fertilization and weed control, impact of thinning, fertilization, and weed control on soil nitrogen mineralization, importance of forest floor to nutrient cycling). He carries out collaborative research on the long-term soil productivity of loblolly plantations (with a variety of operational silvicultural treatments, including fertilization, burning, herbaceous weed control, bedding, and other treatments), and on modeling the in situ root growth potential of loblolly pine in compacted soils.*

Site productivity lessons from the Nordic countries

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Present knowledge about the effects of intensive harvesting of biomass and of wood ash recycling on site productivity in Nordic countries is based on results from many long-term field experiments with Scots pine (Pinus sylvestris) and Norway spruce (Picea abies), most of them using a randomised block design. The oldest experiments with slash removals (whole-tree harvesting, WTH) at clear-cutting in Sweden date from the 1960s and 1970s. During 1981 to 1985, experiments with WTH at thinning and stump harvesting at final felling were established in Nordic countries. Early Swedish and Finnish field experiments on ash recycling used loose ash, whereas later experiments (from ca. 1987 onwards)used stabilised (hardened) wood ash. In addition, optimum fertilization experiments and nutrient/water stress experiments that included wood ash treatments have contributed greatly to our general understanding of forest nutrition in Sweden and northern Europe.

In general, results show that WTH at final felling can result in growth reductions in the next rotation compared to stem-only harvesting, especially in spruce forests; this effect can also be observed after thinning. WTH at clear-cutting causes no reduction in height increment in young pine stands, but growth reductions of the same magnitude as for spruce are observed for pine after WTH at thinning. , The long-term (> 35 years) effect of WTH on forest growth is unknown, however, because of the moderate age of field experiments. Suggested methods of compensating for growth reductions include nitrogen fertilization, allowing needles to fall off slash before harvesting, and establishing new plantations sooner than would be done when slash is left on site.

A major concern of whole-tree harvesting is the greater acidification of soils compared to stem-only harvesting. Field experiments in Sweden have shown that slash harvesting reduces soil pH, base saturation and base cation pools in the soils. The effect on pH is less long-lasting than the effects on base saturation (>25 years). However, we need to know more about why observed reductions in base cation soil pools and base saturation are less marked than we would expect from theory (i.e., potential effect) or dynamic models. Explanations for these discrepencies likely include the combined effects of reduced tree growth and base cation accumulation rates after WTH, delay in decomposition and nutrient release from logging residues (in the control situation), reduced leaching, and increased weathering of base cations after WTH.

High deposition of nitrogen and sulphur in northern Europe has been identified as a threat to forest health and production. The acidification of soils associated with the removals of base cations with WTH has thus been considered as an additional load, potentially leading to deficiency of nutrient base cations. However, experiments in Nordic countries have shown that the Ca/Al ratio of the soil solution is a poor indicator of nutrient stress in trees, suggesting that trees adapted to acid soils have greater capacity to tolerate toxic Al in soils than previously believed. Furthermore, the discovery of ”rock-eating fungi” suggests that the mineral nutrition of trees is less dependent on the available nutrients in the soil solution than previously believed. However, the quantitative significance of these pathways of mineral nutrition need to be studied. Based on these findings, the objective of ash recycling has become more focused on amelioration of surface water quality (alkalinity) in acidified areas than on its role for forest nutrition in the short term.

Bengt Olsson *is an associate professor in plant ecology at SLU in Uppsala; he has studied whole-tree harvesting, wood ash recycling and fertilization experiments in Sweden since 1984, focusing mainly on nutrient cycling and ground vegetation composition. He teaches ecosystem ecology and plant ecology.*

What do we know and what are the key issues? Lessons from the USA

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Biofuel harvesting guidelines have been prepared for the states of Minnesota and Wisconsin, and currently there are efforts to provide guidance in Colorado and Oregon, as well as national efforts through NCASI and The Wildlife Society. Additional state and national guidelines will undoubtedly follow soon. As with most forest management-biodiversity conservation issues, planning usually starts at a landscape scale to address coarse filter goals of seral stage and plant community representation as well as connectivity and riparian area protection. These plans are then achieved through standards and guidelines applied to harvest units scheduled across the landscape in a manner that achieves these goals. Further, attention to key habitat elements important to a broad suite of species are typically addressed at the stand (mesofilter) level. The risks to loss of biodiversity are assumed to be greater as the intensity, size and frequency of disturbance departs from conditions created by non-human biophysical forces. Hence, elements such as dead wood, legacy trees, and a diverse regeneration provides a more diverse early successional condition but limits complete utilization of all above ground cellulose. This tradeoff between biofuels production and biodiversity conservation are not dissimilar from tradeoffs that have been faced by industrial forest managers in the US for decades.

Brenda McComb *received a BS in Natural Resources Conservation from the University of Connecticut, an MS in Wildlife Management from the University of Connecticut, and a PhD in Forestry from Louisiana State University. She has served on the faculty at the University of Kentucky and Oregon State University and the University of Massachusetts-Amherst, and served as Chief of the Watershed Ecology Branch in Corvallis for US EPA for one year. She is an author of over 100 publications, is currently is on the editorial board for Conservation Biology, and recently published a book on Wildlife Habitat Management. Ongoing research addresses the projection of habitat availability for focal species over the Oregon Coast Range and associations of songbirds with farming practices in Western Oregon.*

Biodiversity lessons from the Nordic countries

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Increasing energy prices and climate concerns have strongly raised interest in using logging residues, initially slash but recently also stumps, as a source of bioenergy in Sweden and Finland during the last few years. Biomass removal has consequences for wood-inhabiting species and any measure affecting the quantity and quality of wood in forests will, to some degree, affect the 7000 Nordic wood-inhabiting species. The lecture will provide a summary of the considerable amount of research that has been conducted over the last 15 years in order to forestall and counteract potential undesired effects on biological diversity in forests that biomass removal may cause.

One key outcome is the need to raise the perspective from short-term effects of biomass removal to consider instead a forest generation and the landscape level to be of biological relevance. Other key outcomes are also the need to distinguish between the biological value of different types of dead wood and that formation of appropriate forest condition for diversity need to be considered in forest management.

In this context does the well-studied effects of slash-removal and recycling of ash imply only small and transient effects on flora and fauna. Species negatively affected are essentially those that have been favoured by increased availability of clear-cut slash during the last century, equivalent to an increase of at least 60% due to intensified management. Furthermore, clear-cut slash, and also stumps, are man-made dead wood qualities. As these types of dead wood are rare in natural forests, only few wood-inhabiting species have evolved and adapted to these qualities. No species of conservation value are specifically associated with slash from conifers, but to some extent from aspen and oak. Modelling demonstrate that slash removal reduce the total inflow and availability of fine woody debris with about 20% considering a whole forest generation. Biologically a more serious effect may instead be that slash removal results in reinforced reduction of logs, despite guidelines of leaving coarse-woody debris.

The effects from recycling of wood ash depend on the quality of the ash, but are in general small and of short duration.

The significance of stump removal is less understood. Studies are ongoing and effects are probably more significant. Nordic managed forests are extremely low in amount of coarse dead wood in comparisons to unmanaged forests and in principal are all about 1000 red-listed wood-inhabiting species, mainly fungi and beetles, confined to coarse dead wood. Stumps constitute about 70% of the total amount of coarse woody debris in managed forests. The largest and most pressing knowledge gap is hence to evaluate the importance of stumps for the diversity.

***Anders Dahlberg** is an associate professor in mycology at SLU. He has worked since 2001 at the Swedish Species Information Centre (www.artdata.slu.se), which is a node in questions of biology and conservation, particularly related to forestry, between researchers, public authorities, trade, industry and NGOs. Contribute in research of clear-cut slash and stump removal impacts on biological diversity. Have made compilations and evaluations of research of biological effects due to forest biomass removal on the behalf of the Swedish Energy Agency.*

Biomass harvesting guideline development: the Minnesota experience

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In response to recent legislation, the Minnesota Department of Natural Resources and the Minnesota Forest Resources Council (MFRC) recently developed a set of guidelines for sustainable harvest of woody biomass from forests and brushlands. These guidelines were developed by a 12-member technical committee over a period of nine months in 2006. Draft guidelines received both scientific peer review and public review. Final guidelines were approved in May 2007 by the MFRC.

In 2005 the Minnesota Legislature expanded the definition of “farm-grown closed-loop biomass” as it applies to public utilities seeking to fulfill the state’s biomass mandate, to include (i) upland and lowland brush harvested as part of brushland habitat management; and (ii) logging slash or residue created by timber harvest, timber stand improvement, fuel management, or insect and disease control or treatments. This legislation was related to a project by the cities of Hibbing and Virginia to replace existing coal boilers with new biomass boilers, thereby partially displacing current coal use with renewable biomass fuel. This project is designed to supply 35 megawatts of biomass-produced power for 20 years to partially satisfy the state's biomass mandate.

The technical committee created two sets of guidelines (*Biomass Harvesting on Forest Management Sites in Minnesota*, and *Woody Biomass Harvesting on Brushlands and Open Lands in Minnesota*) to promote sustainable harvest of woody biomass. They focus on practices for conserving soil productivity, biological diversity and wildlife habitat, water quality, and riparian area functions. These guidelines are additional chapters within the existing site-level forest management guidelines, *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines*.

Our presentation will focus on the guideline development process and how the technical team incorporated science relating to soil productivity, biological diversity and conservation of sensitive communities into the guidelines.

Kurt Rusterholz *(Ph.D. Zoology (ecology), University of Wisconsin, 1979) is a forest ecologist. Prior to joining the DNR Division of Ecological Resources in 1988, his research focused on avian communities and foraging strategies. His research with the DNR has involved white cedar communities, old-growth forests, and vegetation classification. He has been involved in developing DNR’s Old-Growth Forests Guideline, Extended Rotation Forest Guideline, Minnesota's Riparian Forest Management Guidelines, and Woody Biomass Harvest Guidelines; he has also worked on forest certification issues around High Conservation Value Forests and representative ecosystems.*

Dick Rossman *(B.S. Soil Science and B.S. Natural Resource Management, University of Wisconsin at Stevens Point, 1981) has 25 years experience coordinating regional and statewide programs within the Minnesota Department of Natural Resources - Division of Forestry. He is the NW Regional Program leader for the Wildland Fire and the Private Forestry programs. He is also committee chair of the Minnesota Forest Resources Council (MFRC) Biomass Harvesting Guideline Development committee.*

The development of regulations and good-practice guidelines for whole-tree harvesting in Sweden

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In the 1970s, the "oil crisis" demonstrated our sensitivity to oil prices, and concerns also grew about the environmental effects of non-renewable energy production. As a result, interest increased in whole-tree harvesting (WTH) for energy purposes. The WTH practice developed at an irregular pace during the 1980s. After a CO_2 tax on fossil fuels was introduced in 1991 and techniques and logistics settled to some degree, it has increased more steadily. In recent years, WTH were used on about a fifth of the clear-cut area in Sweden. Now, there is also an interest in extracting stump biomass.

Along with the early and growing interest, concerns were also raised about potential risks with WTH: nutrient depletion, loss of acid neutralisation capacity (ANC), negative effects on biodiversity, soil carbon balance, tree plant environment and soil water chemistry. Because of these concerns, an early set of recommendations was adopted by the Swedish Forest Agency (SFA) in 1986. From the mid-1970s and onwards, a range of field and laboratory experiments and modelling studies were conducted. As ash recycling was suggested as a means to counteract certain negative effects, many ash studies were performed as well.

Between 1993 and 1998, new regulations relevant to WTH were included in the Swedish Forestry Act. They state that when silvicultural activities are being carried out, damage to soils and waters shall be avoided or limited; and when tree parts other than stems are being extracted, actions shall be taken before, in connection with, or after harvesting, if needed to avoid damage to the long-term nutrient balance of the forest soil.

In 1997, an environmental assessment study, funded by the SFA, was carried out. Major conclusions were: (i) At most sites, WTH would cause a reduced ANC and base cation status unless compensated for, e.g. through ash recycling; (ii) Sites with valuable biodiversity that are protected from conventional forestry should normally also be protected from extraction of forest fuels; (iii) Ash recycling will cause no significant harm if the ash is treated to reduce solubility and applied in doses not higher than 3 ton d.w./ha; and (iv) A system of WTH and nutrient compensation is likely to be near greenhouse gas neutral. Based on these conclusions and other considerations, SFA and the Swedish EPA developed a new set of guidelines in 1998. The guidelines were further developed by SFA in a process in which a wide range of stakeholders, researchers and other authorities were given the opportunity to affect the final product. The first edition was adopted in 2001. Further knowledge gained motivated a recent revision. It has been subjected to the same process and is now ready to be adopted. Major headlines of the guidelines are: (i) Preserve biodiversity; (ii) Counteract acidification and nutrient depletion; (iii) Use the ash properly; and (iv) Limit damage from vehicles and insects. In each section, specified limitations and directives are stated. The environmental consequences of stump extraction are presently being assessed.

***Hillevi Eriksson** has been a specialist on climate change, bioenergy and soils at the Swedish Forest Agency since 2000. Before this, she was a researcher at the Dept. of Forest Soils, Swedish University of Agricultural Science (PhD in 1996).*

Panel presentation: Moving science into guidelines and policy – Canadian experience

Nancy Densmore** is a forester with the BC Ministry of Forests and Range, Forest Practices Branch. She works predominantly with the government "deadwood" files – provincial wildlife tree policy, the Wildlife Tree Committee, Wildlife/Dangerous Tree Assessors Course and management of coarse woody debris. She is a team lead for biodiversity effectiveness evaluation in the Forest and Range Evaluation Program. Nancy lives in Victoria with her husband, son, daughter and ageing duck tolling retriever.* ***Contact information: *BC Ministry of Forests and Range, Forest Practices Branch, PO Box 9513 Stn Prov Govt, Victoria BC, V8W 9C2; E-mail: Nancy.Densmore@gov.bc.ca, Phone: 250 356-5890*

Larry Skinkle** is the Forest Biomass Coordinator and works in the Industry Relations Branch, Forest Division, Ontario Ministry of Natural Resources. He graduated from U of T Forestry in 1973 and has worked for the Ontario Ministry of Natural Resources ever since, except for a short stint in with the Alberta Forest Service from 1982-1988. Larry's work experience with MNR has included field work as a unit forester and forest management supervisor, and main office assignments related to silviculture information systems, environmental assessment and forest management planning. With the Alberta Forest Service, Larry managed the Timber Revenue Section, for the Timber Management Branch in Edmonton and Timber Management and reforestation and reclamation programs in the Slave Lake area. Most recently, Larry has been engaged as the forest biomass coordinator for Industry Relations Branch and has been working on coordinating a number of projects which include developing Ontario's Forest Biofibre Policy, a strategy for Ontario's Forest Bioeconomy, and numerous other projects including construction and demonstration of a transportable biorefinery, developing a forest biomass inventory and information and analysis tools.* ***Contact information: *E-mail: larry.skinkle@ontario.ca, Phone 705-945-6637*

Michel Campagna** is an RPF (1986) and completed a Masters degree in 1989 on the influence of short-term atmospheric CO_2 enrichment on growth, allocation patterns, and biochemistry of black spruce seedlings at different stages of development. He has worked since 1990 for the government of Quebec, in the Ministry of Natural Resources and Wildlife, Dept. of Environment and Forest Protection (Direction de l'environnement forestier, Ministère des Ressources naturelles et de la Faune). His most recent field of work has been the Kyoto Protocol and carbon sinks, the impacts and adaptation of forests to climate change, biomass and bio-energy, intensive silviculture and sustainable forest management and forest productivity.* ***Contact information: *E-mail: Michel.Campagna@mrnf.gouv.qc.ca, Phone: (418) 627 - 8646 poste 4161*

Shawn Morehouse** graduated from the University of New Brunswick in 1996 with a Bachelor of Science in Forestry and Environmental Management. Shawn has worked for the New Brunswick Department of Natural Resources for the past 10 years in range of duties including forest management planner, operations forester and now as a utilization forester. He is been primarily responsible for the development of New Brunswick's forest biomass harvesting policy for Crown lands.* ***Contact information: *New Brunswick Department of Natural Resources, 1350 Regent Street, Room 340, Fredericton, New Brunswick, E3C 2G6; E-mail: Shawn.Morehouse@gnb.ca, Phone: (506) 453-6694*

Facilitated discussion sessions

***Charlotte Young**, Ph.D., is the Director of Practice at ENVision… synergy. For twenty-five years she has worked to promote sound environmental solutions by:*

- *involving the public and stakeholders in decisions and*
- *improving how governments and non-governmental organizations (NGOs) operate.*

In her work both as a facilitator and evaluator she has been involved with diverse projects. She has developed evaluation tools for a provincial level land use conflict management program. She has worked on environmental assessments for cleaning up nuclear wastes in two Ontario communities. She recently developed an evaluation guide for provincial staff members to use for their stakeholder involvement activities, and designed an evaluation of the City of Toronto's public involvement activities.

She led the facilitation for Toronto's Bio-solids strategy. She led the design and facilitation of the multi-stakeholder initiatives to develop the Fifth National Forest Strategy for Canada as well as activities associated with Ontario's first strategic plan for environmental education. In another project, she designed and facilitated a session on life cycle development for various environmental education NGOs. In addition to designing and leading the implementation of multi-stakeholder processes, she has designed and led training on facilitation, strategic planning, conflict management and program evaluation.

She operates ENVision… synergy -- a small, independent environmental organization that implements project-based work in organizational effectiveness and policy improvement. Prior to ENVision, she designed and launched a professional development "internal university" for natural resources staff at a municipal parks department. She also spent nearly a decade at a national research laboratory developing applied evaluation methods, innovative public consultation programs and researching organizational effectiveness.

Charlotte holds a Ph.D. in environmental psychology from The University of Michigan.

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Poster Abstracts

(*Alphabetical by Author*)

Managing Forests for Biofuels: Assessing the Tradeoffs

Juan A. Blanco, J.P. (Hamish) Kimmins, Anliang Zhong, Brad Seely *and* ***Clive Welham****, Department of Forest Sciences, Faculty of Forestry, 2424 Main Mall, University of British Columbia, Vancouver, BC, V6T 1Z4; E-mail: juan.blanco@ubc.ca, Phone: 604-822-3549*

Presently there is a big concern about the impact of fossil fuel in global environment. A strong case can be made for raising the level of utilization of organic matter from forests in order to reduce fossil fuel combustion. However, it must be pointed out that organic matter plays a critically important role in ecosystems. It is the energy source for critically important microbes and animals, habitat for countless organisms, and the raw material from which develops the humus that helps create soil and maintain soil architecture, store soil water, resist erosion, and facilitate hydrological regulation by soils. It is a source of nutrients for plant growth and fuel for fires which are an important part of the ecology of many forest ecosystems. The need is to be able to identify critical thresholds of organic matter depletion beyond which the benefits of biofuel harvesting are balanced by reductions in many other values desired by society that are dependant on the natural dynamics of organic matter in local and global ecosystems. We are approaching the era of ecosystem management (EM). Under EM, bioenergy is simply one of the many forest products that can be harvested. But under EM there is an absolute requirement to identify impacts of any one resource use on the ecosystem and on other values. Such scenario analysis is deemed necessary to gain a social license for energy forestry. The times scales of ecosystem organic matter dynamics and forest growth require the use of ecosystem management simulation models with which to explore and identify ecosystem responses to biofuel collection treatments in comparison to natural disturbances. These models are needed to examine tradeoffs between the benefits of organic matter harvesting for biofuels and the costs to other resource values.

In this work, we used the forest ecosystem management model FORECAST to assess potential consequences of alternative biofuels harvesting strategies in forests for soil organic matter, forest growth, biofuel sustainability, energy benefit/cost ratios, carbon budgets, and some non-timber forest products. We simulated plantations of Douglas-fir growing in Vancouver Island (BC) for 90 years in two different ecosystems with different stand-replacement disturbances (fire or windthrow), under three different rotations lengths (30, 60 and 90 years) and three levels of utilization (stem only, whole tree or all aboveground biomass, and complete tree or above-and belowground biomass).

Our results clearly showed that managing for some values can have negative consequences in other values. Whereas short and intense rotations increase the production of slash for burning and the ratio of energy benefit / cost, it also reduces soil fertility, production of merchantable timber and economic income from the forest, and it has mixed effects on biodiversity, increasing habitats for understory species but reducing habitat availability for species dependent on old-growth attributes.

All things considered, we conclude that there is no clear right or wrong bioenergy strategy, only tradeoffs between alternative values. The key is the use of appropriate ecosystem management assessment tools to explore the alternatives and their potential outcomes for multiple values and ecosystem functions, as input to policy development and practice in the field of forest bioenergy.

Incorporating bio-energy production into various forest management scenarios for Crown land in New Brunswick: a step toward forest zoning

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In 2005, the government of New Brunswick (NB) commissioned a provincial Task Force to evaluate different land uses on Crown land. The mandate is to develop forest management alternatives that promote healthy wood supply, conservation of natural resources, and the use of renewable sources of energy. The NB has the opportunity with its vast bioresources to take advantage of expected biotechnology markets within the province, and increase energy self-sufficiency.

We are exploring the feasibility of biomass and bioenergy production under various forest management scenarios for all 3.3 million hectares of Crown land in NB. Objectives of this study are to analyse the effects of various biomass and net bio-energy production scenarios over 80 years on 1) the area allocated to various management actions and 2) a variety of socio-economic and environmental variables. Effects of scenarios on the harvest volume by species and products, and the area of various stand types, habitat, vegetation communities, and no harvest zones, are being quantified along with the levels of various forest management actions. The NB Growth and Yield Unit Database is being modified to calculate above-ground biomass as a function of tree size, species, and stand type, in addition to the currently projected timber volume. Spatial Woodstock forest modeling software and linear programming is being used to evaluate 61 scenarios, with varying % of tree available for biomass removal (Branches, foliage, top (25-50-75-100%); pulp (100%); and sawlog (100%), pulp mill and sawmill wood wastes (hog fuels), and 15% and 30% as targets to offset total primary and secondary energy use in NB by 2026. Scenario analyses will provide an effective framework to assist in land-use decisions by identifying trade-offs between forest values, and to elucidate trends in biomass and bioenergy production from various forest management actions.

Nutrient cation budget and removal through harvesting: implications for the boreal forest sustainability

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The cycling of base cations (K, Ca, Mg, Na) was investigated in a boreal balsam fir forest between 1999 and 2005. Base cation budgets were calculated for the soil rooting zone that included atmospheric deposition, soil leaching losses, two scenarios of tree uptake (whole-tree and stem-only harvesting) and three scenarios of mineral weathering, leading to six different scenarios. In every scenario there was a net accumulation of Mg within the soil exchangeable reservoir, while Ca accumulated in four scenarios. Potassium was lost in five of the six scenarios. Contrary to Ca and Mg, immobilisation of K within tree biomass (69 eq ha^{-1} yr^{-1}) was the main pathway of K losses from the soil exchangeable reservoir, being five times higher than losses via soil leaching (14 eq ha^{-1} yr^{-1}). The amounts of K contained within the above-ground biomass and the exchangeable soil reservoir were 3.3 keq ha^{-1} and 4.2 keq ha^{-1}, respectively. Whole tree harvesting may thus remove 44% of the K that is readily available for cycling in the short term, making this forest sensitive to commercial forestry operations. Similar values of annual K uptake as well as a similar distribution of K between tree biomass and soil exchangeable reservoirs at 14 other coniferous sites, distributed throughout the boreal forest of Quebec, suggest that the Lake Laflamme Watershed results can be extrapolated to a much larger area. Stem-only harvesting, which would reduce K exports due to biomass removal by 60%, should be used for these types of forest.

Future Bioenergy – A life cycle perspective on bioenergy options in North America

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Our research at University of Toronto and Michigan State University investigates techno-economic and environmental aspects of bioenergy production. Examples of the research within our group include:

(1) Development of Canadian and U.S. biomass supply estimates for forest, mill and agricultural residues, energy crops and municipal solid waste. Interim results indicate that in the near term, the biofuel industry could be profitably built around forestry and mill residues in Canada and agricultural and mill residues in the U.S.

(2) Examination of land resource issues required for energy crop production. Modeling of both the direct environmental impacts of energy crop cultivation and indirect impacts, resulting from competition with existing commodity markets is being completed so as to evaluate the overall performance of bioenergy production systems.

(3) Investigation of the life cycle environmental and energy impacts of a set of emerging lignocellulosic ethanol conversion technologies. Our findings indicate that compared to gasoline fueled vehicles, E85 (85% ethanol/15% gasoline by volume) vehicles can reduce greenhouse gas emissions between 25% and 130% on the basis of one km driven, depending on the feedstock and conversion technology selected.

(4) Examination of two near-term scenarios for converting lignocellulosic biomass to energy: generating electricity from co-firing biomass in existing coal power plants and producing ethanol from biomass in stand-alone facilities in Ontario, Canada. Results indicate that the biomass electricity co-firing scenario is more cost-effective for mitigating GHG emissions than the stand-alone ethanol production scenario at crude oil prices below $100/bbl.

Recycling wood ash to sustain soil fertility?

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Several thousand tons of wood ashes are generated annually by cogeneration mills in Quebec. A large proportion of these is actually disposed in landfills, as few avenues of ash valorization are currently in place. In light of the Scandinavian experience, we believe the disposal of industrial wood ashes in forest stands could represent an avenue of ash recycling. Beside an immediate reduction in waste disposal, environmental advantages of wood ash application in forest ecosystems depend on its capacity to compensate for losses of base cations and acid buffering substances induced by harvesting and to improve stand nutrition, without causing environmental contamination by hazardous substances. Starting in 2005 and in collaboration with Boralex, a producer of wood-residue energy, and AbitibiBowater, we have implemented a number of fly ash fertilization trials in forest stands subjected to different silvicultural treatments. The general objective of these trials is to assess technical and ecological feasibility of ash fertilization in boreal forests of eastern Canada.

The first experiment, established in 2005, compares the effects of various combinations of ashes (0, 1, 2, and 8 dry tonnes ha-1) and urea (0, 280 kg N ha-1) on soil, nutrition and growth of a 53 years old jack pine stand (Pinus banksiana) treated by commercial thinning seven years prior to fertilization. In the second experiment, implanted in 2006, ash loads were based on SMP single-buffer procedure for a target pH of 5.5, a buffer pH ranging from 5.8 and 6.3 and an ash calcium carbonate equivalence of 35 %. We will assess effects of treatments (0 to 14 dry tonnes ha-1) on nutrition and growth performance of young plantations of hybrid larch, jack pine and black spruce (Picea mariana) established in whole-tree harvested sites. Finally, a third experiment, was established in 2007 and aims at determining the potential of ashes (0, 7,5 and 15 dry tonnes ha-1) applied during site preparation (disking) and placed N fertilization at planting (20 g tree-1) to improve initial growth and competitiveness of young plantations of jack pine and black spruce on sites dominated by ericaceous vegetation.

Preliminary results from the first experiment indicate that low doses of ash have little effect on forest floor characteristics of these coarse-texture soils while nitrogen fertilization reduced base saturation and increase effective CEC. Nonetheless, forest floor pH (CaCl2) increased from 2.80 in the control to 3.38 under the 8 tonnes ha-1 dose. Mineral soil (0 - 10 cm) was more sensitive to ashes and effective CEC increased by 20 % and base saturation increased from 48.7 to 76.7 %. Very little interactions between N fertilization and ashes were observed. Ash treatments had not effect on foliar nutrient concentrations of mature jack pines. Other fields of investigation include nitrogen dynamics, heavy metal concentrations in soil understory vegetation and tree growth response.

The importance of course woody debris for insect biodiversity

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Coarse woody debris (CWD) provides habitat for many forest species, many of which are involved in essential ecosystem processes, including nutrient cycling and decomposition. Both the quantity and the quality of CWD have been shown to affect the suitability of this habitat.

Furthermore, studies from Europe have demonstrated that industrial forest management results in a biologically significant reduction in species diversity. Beetles associated with dead and dying wood (saproxylic) were studied in a variety of habitats at the EMEND research site in Northwestern Alberta. Results of these studies indicate that CWD is important for saproxylic beetles and that should be managed to maintain a diversity of species and age classes. The results of this study demonstrate that course woody debris should be an important part of any forest management plan.

Sustainability Concerns for Bioenergy Programs on USA National Forests: Facts and Legal Actions

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There is currently a lot of interest in the United States to use rapidly accumulating forest fuels as a source for bioenergy development. An example of this is the White Mountains Stewardship Project. Much of the fuel buildup is on Federal land subject to the National Forest Management Act of 1976 (NFMA) and the National Environmental Policy Act of 1969 as amended (NEPA). The Forest Service’s approach to verifying the maintenance of long-term sustainability and function during harvesting and thinning programs has been reliance on its soil quality program. Several recent lawsuits heard at District Court level and appealed to both Circuit Courts and the Supreme Court questioned the Forest Service’s compliance with these statutes based on soil quality. Research has been in progress for 15 years to scientifically document changes in site productivity after soil disturbance through the Long-Term Site Productivity Program (LTSP). This poster examines the facts as developed by science, the allegations presented in lawsuits, and the implication for increased levels of forest thinning to reduce wildfire hazard and provide stock for bioenergy programs.

Biomass Removal and Maintenance of Site Productivity in Loblolly Pine Plantations

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Whole-tree harvesting has been shown to have significant and substantial impacts on pine plantation productivity on nutrient-poor soils in the southern U.S. coastal plain, but the site productivity loss can be ameliorated through fertilization. Across 10 sites covering seven soil series, 10-15 year tree growth response to whole-tree harvesting ranged from no change to a 40% decrease. Soil phosphorus (P), which is commonly low to very low on these upland loamy soils, appeared to be the limiting nutrient most affected by biomass removal. On three selected sites, we applied 50 kg/ha of P fertilizer (diammonium phosphate) at age 4 to additional whole-tree harvested plots, and not only were the productivity declines reversed, but tree growth was up to 15% greater than on the stem-only harvested plots. Unlike soils where other nutrients or organic matter may be limiting, these soils should be able to be sustainably managed for biofuel production with low-intensity fertilization to restore soil P.

An index of forest site sensitivity to intensive biomass removal for the commercial forest land of Quebec (Canada)

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A renewed interest for the intensive harvesting of forest biomass as a source of bioenergy in North America raises concerns over the impacts of increased nutrient exports with increased biomass removal on the maintenance of forest soil productivity. Field trials have indicated that soil capacity to provide base cations (K, Ca and Mg) as weathering products was a good predictor of sites susceptibility to nutritional deficiencies and growth decrease following intensive biomass removal. Such a predictor could thus be used to implement sustainable forest management by avoiding intensive operations on highly sensitive sites and optimizing them on productive ones. In this study, we compiled information from ecological and geological surveys (mineral soil depth, stoniness, texture, and soil and sediment geochemistry) in order to build an indicator of soil base cation providing capacity, and map it for the commercial forest land base of Quebec (Canada). Using foliar and stem data from independent field studies, investigations are undertaken to determine if this indicator is a valid explanatory factor of tree nutritional status and growth. The objective is to see how well this indicator captures the variance in stand nutrition and productivity across the landscape, and also explore nutrition/productivity relationships. Preliminary results on a small set of boreal stands have showed that the index was successful at identifying foliar base cation deficiencies. A provincial-scale validation is now under way.

Dead wood retention and recruitment in the managed forested ecosystems of west-central British Columbia: how much is enough and how big should it be?

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Planning for large scale biomass removal from forests to meet the cumulative timber supply needs of sawmills, pulp mills and bioenergy facilities must incorporate the knowledge-based retention of an adequate quantity and quality of downed wood to meet management objectives for biodiversity and wildlife habitat. From 1999 to 2005, we developed ecologically-based forest harvesting retention objectives and strategies for structural elements related to the persistence of downed woody material (DWM) and its associated biodiversity and habitat values in forested ecosystems. Our focus was the sub-boreal pine and spruce forests of the west-central interior of British Columbia. We adopted the management approach used in the Forest Practices Code Biodiversity Guidebook (Province of BC, 1995), assuming that “all native species and ecological processes are more likely to be maintained if managed forests are made to resemble those forests created by the activities of natural disturbance agents such as fire, wind, insects and disease”. We recognized that management cannot replicate natural dead wood quantities anticipated after natural disturbance due to large scale biomass removal; we therefore aimed to emulate natural patterns of quality and distribution and buffer anticipated troughs in dead wood supply. We did so by:

- describing the differences between DWM in recently harvested (since 1995) and unharvested forests;
- identifying retention targets for the quantity and quality of DWM based on unharvested benchmarks;
- developing operational retention and recruitment guidelines and practices for DWM, as well as standing live (large and immature) and standing dead trees; and
- piloting operational field trials to evaluate the efficacy of guidelines and practices in achieving targets, whilst evaluating the economic implications of doing so.

For retention target development, the most practical site groupings within forest types (biogeoclimatic sub-zones and variants) were identified based on an analysis of DWM volumes of unharvested stands. Site types were sorted into good, moderate and poor groups based on their dead wood potential, and a set of target levels for post-harvest attributes (volume, piece length and diameter) appropriate to each site group was developed. Target levels were then expressed as a field target of number of logs of a pre-determined length per hectare; field targets were intended to act as operationally simple surrogates for retention volume targets. For the forests under study, field targets ranged from 25 to 90 logs per hectare, 10 to 20 metres long, depending on site group. Current provincial regulation for coarse woody debris (CWD) retention in the interior forests of BC requires a minimum of 4 logs per hectare, each being a minimum of two metres in length and 7.5 cm in diameter at one end.

Harvesting impacts on soil and lake chemistry: a critical loads perspective

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The concept of critical loads is widely adopted in Europe as the scientific basis underpinning negotiations with respect to sulphur and nitrogen emissions and is becoming increasingly popular in North America. The critical load calculations are essentially mass balance calculations that include removal of base cations and nitrogen where harvesting occurs and hence inclusion of harvesting has the potential to greatly affect both the critical load and predicted future soil and stream chemistry. For example, the forest area that receives acid deposition in excess of the critical load in Ontario is considerably greater under harvesting versus non-harvesting scenarios and lake calcium levels in acid sensitive regions are predicted to be much lower if harvesting occurs, and in some cases will approach levels that may be limiting for aquatic biota. These calculations are based upon a simple mass balance that considers only the net removal of base cations and nitrogen from the system and ignores several spatial and dynamic features of harvesting that could potentially impact the model calculations. In general however insufficient information is available to better characterize these processes and include them in model predictions.

The Distribution and Role of Coarse Woody Debris in Nutrient Retention and Cycling During Early Stand Establishment

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This study, funded by ARIO and the Government of Ontario, will provide new information about the role of Coarse Woody Debris (CWD) in nutrient budgets of boreal forest ecosystems. Mounting interest in the use of biomass for various purposes, including biofuels, means that we need to understand more completely the impacts of intensive harvest on these sites. This study has two main elements, an initial ex-situ greenhouse study and an in-situ field study.

Three critical research questions will be addressed in this project:

1. What is the contribution of CWD to total nutrient reserves following harvesting, and how does this change over time?
2. Does biomass removal intensity affect the amount or timing of this contribution?
3. Does the species, origin (fire, harvest), and age influence the timing, rate, and spatial pattern of nutrient release from CWD?

The experiment described here addresses Question 3 (a field experiment will address questions 1 & 2).

Greenhouse Study: The purpose of this study is to provide an index of nutrient flux from CWD. It is unique in that it directly compares natural, fire origin CWD to coarse wood left on the site post-harvest. Other factors include: species (spruce, poplar) and time since disturbance (<1 year, 15 years). The trial is set up as a completely randomized design with three factors, each with two variables and five replications, for a total of 40 experimental units plus eight controls (blanks). Coarse woody debris collected in the field was processed into 28-cm sections and placed into individual containers. Besides standard volume and density measurements, the ends of each log were scanned prior to start-up to determine sound wood, decayed wood and air space (cracks, insect activity, etc.). A fixed misting system keeps the logs near saturation where the leachate trickles down from the logs into containers below. The logs are kept at temperatures above 20 degrees C and the system is covered in plastic to increase humidity. This combination of moisture and warmth is designed to decompose the coarse woody debris as fast as possible. The logs will stay in place for four months, and the leachate is analyzed for TON, TOC, N, P, base cations (Ca, Mg, K, Na) and trace metals (Cu, Fe, Zn, Mn) on a weekly basis.

We anticipate that these results will provide baseline information, and correlate to the field study. The field study will use repeated measures data collected from study sites established in 1991 to reflect two commonly-occurring site types (i.e., dry, sandy soil; coarse loamy shallow soil) with site type replicates. These sites include replicated experimental harvest treatments with 4 levels of biomass removal. This data will be used to quantify the change in biomass and nutrient retention over the critical period of time between stand establishment and canopy closure. In combination with existing data (e.g., soil nutrient reserves), this will allow us to assess the contribution of logging slash to total ecosystem nutrient pools.

Arthropod Responses to Ecosystem Management and Changes in Deadwood in Boreal Forests of Abitibi-Témiscamingue

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Alternative silvicultural approaches such as partial cutting have been widely advocated as an effective means to maintain/create stand structure and legacy elements such as deadwood for coarse filter protection of biodiversity. Here we discuss responses of 1) ground beetles (predators), 2) Collembola (soil fauna), 3) saproxylic diptera (flies) within decaying logs and 4) spiders and ground beetles (predators) from replicated, controlled experiments throughout the Abitibi-Témiscamingue region of Québec to these alternative silvicultural approaches with particular emphasis on elements that would necessarily be impacted by additional recovery of biomass for bioenergetic applications. Arthropods were collected from both the SAFE (Sylviculture et aménagement forestier écosystémiques) and RECPA (Réseau de Coupe Partielle en Abitibi) research sites in the Abitibi-Témiscamingue region of Québec. Each site provided replicated treatments of clearcutting and partial cutting ranging from 33-66% at SAFE and 10-66% at RECPA. In addition, treatments that directly manipulated amounts of residual biomass (either through whole tree harvesting or through prescribed burning) were applied. Initial results indicate the following: 1) Intensive harvesting and subsequent removal of deadwood had a strong negative effect on forest beetles and showed no significant recovery even after 7 generations, 2) Loss of deadwood above ground had a significant negative effect on multiple species of soil microarthropod below ground (i.e. within the soil column), 3) Saproxylic diptera species (particular arthropod predators and fungivores) showed clear preferences for individual tree species and decay class of deadwood suggesting that a variety of species and decomposition classes must be maintained within stands to maintain these species, 4) Current retention levels are insufficient to create arthropod communities consistent with natural communities in later successional stages of both mixed and conifer dominated forests. These results based on more than 43,000 individuals from more than 250 species demonstrate that 1). Current retention practices are insufficient for maintaining biodiversity and expansion of forest exploitation for biomass directed towards bioenergetic demands will have significant negative effects on biodiversity, 2) Deadwood constitutes necessary habitat for biodiversity and must be managed to maintain a variety of compositions and age classes similar to what we profess in ecosystem management and 3) Removal of deadwood not only negatively effects resident fauna that require specific species and age classes but also impacts the below-ground fauna.