International Symposium

On dynamics and ecological services of deadwood in forest ecosystems

Rouyn-Noranda, Quebec, Canada
May 15-19, 2011

DEADWOOD AND DYING TREES
A MATTER OF LIFE AND DIVERSITY

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IUFRO

The symposium is sponsored by the International Union of Forest Research Organizations (IUFRO) Division 8.02.02 – Forest biodiversity and resilience.

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Comité organisateur
Organizing committee



Bienvenue

C'est avec beaucoup de plaisir que nous vous accueillons aujourd'hui en Abitibi-Témiscamingue dans le cadre du Symposium international sur la dynamique et les services écologiques du bois mort dans les écosystèmes forestiers.

Dans le contexte énergétique actuel où les demandes exercées sur les forêts comme source d'approvisionnement en carburants s'intensifient, nous considérons que la tenue d'un tel évènement de nature multidisciplinaire trouve maintenant plus que jamais sa pleine justification. Le simple constat que ce symposium regroupe plus de 110 communications scientifiques et que les quelques 125 participants proviennent d'au-delà de 20 pays illustrent bien la pertinence de celui-ci.

Nous tenons à remercier les membres du comité scientifique pour leur enthousiasme et leur collaboration à toutes les étapes de la préparation de ce symposium. Nous sommes reconnaissants à l'ensemble de nos partenaires financiers sans qui cet évènement n'aurait pas eu lieu.

Enfin, nous adressons des remerciements particuliers à l'Université du Québec en Abitibi-Témiscamingue et à l'Université du Québec à Montréal pour leur appui indéfectible non seulement en regard de la tenue de cet événement, mais pour le soutien général de ces institutions au développement de la recherche en écologie forestière.

Welcome

It's with great pleasure that we welcome you today to Abitibi-Témiscamingue for the International Symposium on dynamics and ecological services of deadwood in forest ecosystems.

Increased pressure on forests as fuel sources more than justifies the need for the current symposium, and the scientific program, with more than 110 papers presented by over 125 participants from 20 countries, is an eloquent testimony of its scientific relevance. We hope that this symposium will spark discoveries, meaningful exchanges and new collaborations for all the participants.

We would like to thank the members of the organizing and scientific committees for their enthusiasm and their collaboration during all of the Symposium preparations. We would also like to acknowledge our financial partners, without whom we could not have organized this event.

Finally, we would like to offer sincere thanks to the Université du Québec en Abitibi-Témiscamingue and and the Université du Québec à Montréal for their tireless support not only of this event but also of the development of the forest ecology research group.

Suzanne Brais et/and Louis Imbeau
Co-présidents du comité organisateur
Co-presidents of the organizing committee

International Symposium
On dynamics and ecological services of deadwood in forest ecosystems

Comité scientifique
Scientific committee



Mot de bienvenue

Chers participants,

C'est avec un vif plaisir et un très grand enthousiasme qu'au nom du comité scientifique je vous souhaite la bienvenue au Symposium international sur la dynamique et les services écologiques du bois mort dans les écosystèmes forestiers, dans la région de l'Abitibi-Témiscamingue. Cette initiative s'inspire d'évènements antérieurs tenus tant en Europe qu'en Amérique du Nord, dont le « Symposium on the Ecology and Management of deadwood in Western Forests » à Reno, aux États-Unis en 1999, le « Symposium nordique sur l'écologie des débris ligneux grossiers dans les forêts boréales » qui a également eu lieu en 1999, à Umeå, en Suède et le colloque « Bois mort et à cavités » tenu à Chambéry, en France en 2004. J'ai eu l'occasion de participer à deux de ces événements soit le Symposium de Reno et le colloque de Chambéry. Ces événements scientifiques ont su nourrir ma curiosité scientifique pour le bois mort et les processus écologiques qui y sont associés, et ce, dans des contextes écologiques fort différents, c'est-à-dire, les forêts de l'ouest des États-Unis et celles d'Europe. Ils m'ont également interpellé quant aux défis à relever pour intégrer le bois mort dans la gestion durable des forêts. Enfin, ces rencontres internationales m'ont convaincu du bien-fondé d'agir comme président du comité scientifique du présent symposium à un moment où la science sur le bois mort est sollicitée pour son importance dans les processus de certification de l'aménagement durable des forêts.

L'objectif de ce symposium est d'établir des ponts entre les disciplines, les perspectives et les continents en rassemblant des spécialistes internationaux oeuvrant dans les services écologiques et la dynamique du bois mort dans les écosystèmes forestiers. La réunion de ces expertises vise à identifier les défis communs ainsi que des avenues possibles à la gestion du bois mort dans les forêts aménagées. Au nom du comité scientifique, j'exprime l'espoir que ce sera pour vous tous l'occasion de découvertes, d'échanges fructueux et de collaborations nouvelles.

Welcome

Dear Participants,

It's with great pleasure and much enthusiasm that I welcome you, on behalf of the scientific committee, to the International Symposium on dynamics and ecological services of deadwood in forest ecosystems in the Abitibi-Témiscamingue region. This conference follows in the footsteps of previous events in Europe and North America, notably the "Symposium on the Ecology and Management of Deadwood in Western Forests" in Reno, USA in 1999, the "Nordic Symposium on the Ecology of Coarse Woody Debris in Boreal Forests" that also took place in 1999 in Umeå, Sweden and the "Deadwood and Cavity Trees Conference" in Chambéry, France in 2004. I had the chance to attend two of these conferences, Reno and Chambéry. These scientific events were incredible drivers for scientific knowledge acquisition on deadwood ecology and its functional processes in quite contrasted forest ecosystems, i.e., western forests in the United States and Europe. I have also learned about the challenges associated with the maintenance of deadwood as a key structural element in sustainable forest management. These international conferences convinced me of the importance of participating in the organization of this conference at a time when there is growing awareness of the importance of deadwood in sustainable forest management, particularly with regards to forest certification.

The objective of this symposium is to establish bridges among disciplines, perspectives, and continents and to bring together international specialists working on ecosystem services and deadwood dynamics in forest ecosystems. We hope to identify common challenges as well as possible routes towards deadwood management in industrial forests. On behalf of the scientific committee, I wish you all a symposium full of discoveries, interesting exchanges and new collaborations.

International Symposium
On dynamics and ecological services of deadwood in forest ecosystems

Pierre Drapeau
Président du comité scientifique
President of the scientific committee

Université du Québec en Abitibi-Témiscamingue



Mot de bienvenue

Bienvenue au Symposium international sur la dynamique et les services écologiques du bois mort dans les écosystèmes forestiers!

Qui n'a jamais entendu quelqu'un affirmer qu'il fallait se débarrasser du bois mort dans une organisation, la personne entendant par là que l'on devait éliminer un élément inefficace ou improductif! Dans l'esprit de bien des gens encore, le bois mort demeure synonyme d'inutile, de laid ou même de déchet.

En dehors du monde des spécialistes, cette conception erronée du bois mort persiste. Je me réjouis donc de la tenue de ce symposium à Rouyn-Noranda, car il contribuera très certainement à dresser un tableau plus juste de son rôle essentiel dans la perpétuation des forêts. Cette réflexion m'apparaît d'autant plus pertinente que le tarissement prévu des réserves pétrolières pousse la biomasse à l'avant-scène comme nouvelle source d'énergie. Le thème du symposium « Bois mort et arbres sénescents, question de vie et de diversité » n'en devient que plus pertinent. C'est aussi avec bonheur que je constate que des scientifiques provenant de disciplines diverses et de continents différents s'y sont donné rendez-vous, car ce n'est que par le partage des connaissances qu'il sera possible de maintenir une véritable biodiversité.

Bravo aux organisateurs. Merci aux scientifiques de partager leur savoir. À tous les participants, un excellent symposium! Que votre séjour à Rouyn-Noranda soit des plus agréables et des plus profitables.

« Ce qu'il y a de plus beau dans la vie, et dans toute espèce de vie, c'est sa continuité. »

***« The most beautiful thing in life, and in all species of life, is its continuity*."**

Sylvie Angel, pédopsychiatre, psychanalyste et écrivaine française, dans *Chant de notre Rhône*/French child psychiatrist, psychoanalyst and writer, from *Chant de notre Rhône.*
*Translated for the program

Welcome

Welcome to the International Symposium on dynamics and ecological services of deadwood in forest ecosystems!

We have all heard the expression that we need to "prune out the deadwood" of an organization, with the understanding that the inefficient and unproductive elements have to go! For many, deadwood remains a synonym for useless, ugly or even garbage.

Outside the group of specialists, undoubtedly this misperception of deadwood persists in society. Therefore, I am very pleased that this symposium is being held in Rouyn-Noranda as it will definitely contribute to "righting the wrongs" committed against deadwood by highlighting deadwood's essential roles in forest ecosystems. Improving the image of deadwood is even more important, in my opinion, as wood biomass is being pushed to the forefront in the search for new energy sources as oil reserves dry up. In this context, the theme of the symposium, "Deadwood and dying trees, a matter of life and diversity" is particularly relevant. I am also very happy to see the wide variety of disciplines and continents represented at this conference as it is only by sharing our knowledge that we will be able to maintain a real diversity of life.

Bravo to the organizers of this conference. Thank you to the researchers who will share their knowledge. To all participants, I hope you have an excellent symposium! And may your stay in Rouyn-Noranda be most pleasant and profitable.

Johanne Jean
Rectrice de l'Université du Québec en Abitibi-Témiscamingue
Rector of the Université du Québec en Abitibi-Témiscamingue

Université du Québec en Abitibi-Témiscamingue

Chaire en aménagement forestier durable
Sustainable Forest Management Chair



Mot de bienvenue

La Chaire industrielle CRSNG-UQAT-UQÀM en aménagement forestier durable (Chaire AFD), au nom de l'ensemble de ses partenaires du milieu forestier de l'Abitibi-Témiscamingue et du Nord-du-Québec, est heureuse de vous accueillir dans le cadre du Symposium international sur la dynamique et les services écologiques du bois mort dans les écosystèmes forestiers.

La Chaire AFD a pour mission d'assurer le développement et la qualité de la recherche, de la formation ainsi que du transfert des connaissances nécessaires à l'élaboration et à la mise en oeuvre de pratiques d'aménagement forestier durable. Par la collaboration soutenue de ses partenaires, la Chaire AFD définit les priorités de recherche et participe à des actions concertées qui répondent aux enjeux régionaux et nationaux en matière d'aménagement forestier. Ces actions interpellent l'apport conjoint des expertises de différents organismes de recherche universitaires, gouvernementaux et industriels.

La gestion du bois mort constitue un des enjeux majeurs d'un aménagement durable des écosystèmes forestiers. Que ce soit pour la préservation de la biodiversité, le cycle des nutriments ou le bilan en carbone, le bois mort joue un rôle essentiel au maintien d'écosystèmes diversifiés, productifs et en santé. Ce symposium est d'autant plus important que la pression sur la collecte de la biomasse forestière pour des fins énergétiques s'est grandement accrue. Un colloque sur les attributs du bois mort ne peut que contribuer à accroître et à échanger nos connaissances de façon à pouvoir aménager les forêts de façon plus durable.

En mon nom et au nom de tous les membres et partenaires de la Chaire AFD, je vous souhaite la bienvenue et un excellent symposium.

Welcome

The NSERC-UQAT-UQÀM Industrial Chair in Sustainable Forest Management (SFM Chair) is pleased to welcome you to the "International Symposium on dynamics and ecological services of deadwood in forest ecosystems" on behalf of its partners in Abitibi-Témiscamingue and Nord-du-Québec.

The mission of the SFM Chair is to ensure the development of quality research and training as well as the necessary tech transfer for the development and deployment of sustainable forest management. With the continued cooperation of its partners, the SFM Chair defines research priorities and engages in concrete actions that deal with regional and national forest management issues. These actions require the collective expertise and concerted action of the different organizations (universities, governments and industries) that make up the Chair.

Deadwood management is one of the dominant issues facing sustainable forest management. Whether via its role in biodiversity preservation, in nutrient cycles or in the carbon budget, deadwood plays an essential role in maintaining diverse, productive and healthy ecosystems. This symposium is timely as there is increasing pressure on deadwood as the harvesting of forest biomass for energy production has grown significantly. A symposium on the attributes of deadwood will contribute to the continued growth and exchange of knowledge in this domain, which will ultimately allow us to manage forests in a more sustainable manner.

On behalf of myself and all of the members and partners of the SFM Chair, welcome, and have an excellent symposium.

Chaire
INDUSTRIELLE CRSNG - UQAT - UQAM
en aménagement forestier durable

Yves Bergeron, directeur/director,
Chaire industrielle CRSNG-UQAT-UQÀM en aménagement forestier durable/
NSERC-UQAT-UQÀM Industrial Chair in Sustainable Forest Management

Centre d'étude de la forêt
Centre for Forest Research





Mot de bienvenue

Chers participants,

C'est avec enthousiasme et intérêt que le Centre d'étude de la forêt (CEF) a le plaisir de vous accueillir à ce Symposium international sur la dynamique et les services écologiques du bois mort dans les écosystèmes forestiers. Le CEF est particulièrement fier d'être associé à cet événement international compte tenu de l'importance du bois sénescent et mort dans la programmation de recherche d'un contingent important de ses chercheurs, et ce, tant sur le plan de son écologie que de son intégration à l'aménagement durable des forêts.

Le CEF regroupe 87 chercheurs actifs et plus de 350 étudiants gradués répartis dans 10 institutions académiques au Québec, dont l'Université du Québec en Abitibi-Témiscamingue (UQAT) et l'Université du Québec à Montréal (UQÀM) qui co-organisent cet événement. Ce regroupement universitaire unique au Québec et au Canada fait le lien entre l'étude des écosystèmes forestiers et la conception d'alternatives innovatrices en matière de gestion des forêts.

En plus d'accueillir des conférenciers invités de renom, la programmation du symposium s'ouvre sur des communications scientifiques couvrant un vaste spectre de thèmes liés à l'écologie et à la gestion du bois sénescent et mort dans les écosystèmes forestiers à l'échelle mondiale. Voilà une formidable tribune pour favoriser les échanges et de nouvelles collaborations scientifiques. Nous tenons donc à remercier chaleureusement tous les membres du comité organisateur et du comité scientifique qui n'ont pas ménagé les efforts pour la tenue de cet évènement.

Nous vous souhaitons à toutes et à tous un excellent symposium!

Welcome

Dear Participants,

The Centre for Forest Research (CEF) welcomes you to the international Symposium on dynamics and ecological services of deadwood in forest ecosystems with enthusiasm and great interest. The CEF is particularly proud to be associated with this international event as research on the ecology and sustainable management of dead and dying wood makes up an important part of the research program of many of its members.

The CEF brings together 87 active researchers and more than 350 graduate students in 10 academic institutions across Québec, including the Université du Québec en Abitibi-Témiscamingue (UQAT) and the Université du Québec à Montréal (UQAM) which are co-organizing this symposium. This university-based research group, which is unique to Quebec and Canada, links the study of forest ecosystems and the development of new innovative strategies in forest management.

In addition to the prestigious invited speakers, the symposium program includes research contributions on a wide variety of themes linked to the ecology and management of dead and dying wood in forest ecosystems worldwide. This represents a wonderful template that favours exchanges and new scientific collaborations. We would like to warmly thank all the members of both the scientific and organizing committees who have worked tirelessly to put together this event.

We wish you all an excellent symposium!

Pierre Drapeau et/and Louis Bernier
Co-directeurs du Centre d'étude de la forêt
Co-directors of the Centre for Forest Research

cef
Centre d'étude de la forêt

Service canadien des forêts
Canadian Forest Service



Mot de bienvenue

Le Service canadien des forêts de Ressources naturelles Canada souhaite à tous les participants et conférenciers la bienvenue au Symposium sur la dynamique et les services écologiques du bois mort dans les écosystèmes forestiers, à Rouyn-Noranda en Abitibi-Témiscamingue.

En cette Année internationale des forêts, ce symposium s'inscrit dans les objectifs énoncés par le Secrétariat du Forum des Nations Unies sur les forêts. En effet, celui-ci invite la communauté internationale à se regrouper et à coopérer avec les gouvernements, les organismes internationaux et les citoyens, et ce, afin de veiller à la gestion durable de nos forêts dans l'intérêt des générations présentes et futures. Par les conférences, les présentations d'affiches, les échanges d'idées et les collaborations potentielles entre les scientifiques provenant de plus de 20 pays, le symposium permettra, j'en suis certaine, de pouvoir améliorer la gestion des forêts d'une manière durable.

Le Centre de foresterie des Laurentides du Service canadien des forêts compte plus de 30 chercheurs dédiés à la compréhension des écosystèmes forestiers et la biologie des ressources forestières. Plusieurs de nos chercheurs ont en effet comme axe de recherche la biodiversité, la dynamique forestière, la productivité forestière ou l'étude des vieilles forêts.

Ressources naturelles Canada est heureux d'être associé à cet événement et de faire partie du comité organisateur et du comité scientifique. Je tiens à remercier tous les membres de ces deux comités pour leur travail et leur dévouement à l'organisation de ce symposium international.

Je vous souhaite à tous et à toutes un excellent symposium.

Welcome

The Canadian Forest Service of Natural Resources Canada welcomes all participants and speakers to the International Symposium on dynamics and ecological services of deadwood in forest ecosystems taking place in Rouyn-Noranda in the Abitibi-Témiscamingue region.

During this International Year of Forests, this symposium reflects the objectives established by the Secretariat of the United Nations Forum on Forests. The symposium is an invitation to the international community to come together and cooperate with governments, international organizations and citizens to ensure the sustainable management of our forests for the benefit of present and future generations. Through lectures, poster presentations, the exchange of ideas and potential collaborations between scientists from over 20 countries, I am sure that the symposium will make it possible to improve forest management in a sustainable fashion.

The Canadian Forest Service, Laurentian Forestry Centre has over 30 researchers dedicated to understanding forest ecosystems and the biology of forest resources. In fact, many of our researchers work in the fields of biodiversity, forest dynamics, forest productivity, and the study of old-growth forests.

Natural Resources Canada is pleased to be associated with this event and to be part of the organizing committee and the scientific committee. I thank all the members of both committees for their hard work and dedication in organizing this international symposium.

I wish everyone an excellent symposium.

Ressources naturelles Canada | Natural Resources Canada

Canada

Jacinthe Leclerc, Directrice générale /Director General
Centre de foresterie des Laurentides, Service canadien des forêts, Ressources naturelles Canada
Laurentian Forestry Centre, Canadian Forest Service, Natural Resources Canada

International
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On dynamics and ecological services of deadwood in forest ecosystems



Practical information

Location

The symposium takes place in the Rouyn-Noranda Hotel Gouverneur. Welcome and keynote sessions will take place in room La Grande (#5). Parallel sessions of contributed presentations will take place in the following rooms: La Papetière (#1), La Coulée d'or (#3) and l'Anode (#4). Posters will be exhibited in La Capitale (#6) during the whole week with a dedicated poster session Monday evening during the cocktail.

Please turn off the ringers of all your electronic devices at all times, out of respect for the presenters.

Breakfast and lunch are free for all Symposium participants in La Grande (#5).
The banquet will be held Wednesday night in La Grande (#5).

A shuttle service is available between the conference centre and your hotel.
See the information desk for details or call 819-277-2726.

? To contact a member of the organizing committee or a volunteer, go to Youville (#2) or the information desk at any time.

Field tour

A one-day field excursion is planned to visit the Lake Duparquet Research and Teaching Forest (http://ferld.uqat.ca) on Wednesday, May 18. The visit will emphasize deadwood in the context of forest dynamics, natural disturbance, old growth, forest ecosystem management, intensive silviculture, biomass harvesting, and functional roles of dead and dying wood with respect to biodiversity and soil processes. Lunch at the Lake Duparquet Forest Research Station will highlight the regional cuisine of Abitibi-Ouest.

Please note that the bus leaves at 7:30. Breakfast will be available from 6:30 in La Grande (#5).
Bring boots and a raincoat and dress appropriately for the weather.

Early morning birding trips

For visiting ornithologists, it will be possible to go birding during the early morning at some local sites within a short distance of the hotel. Bird trips will be offered early each morning of the conference (May 16, 17, and 19). All trips will leave from the main lobby entrance at 6:00, and will strive to return by 8:00 for breakfast, before the first keynote speaker. Birding trips are free but you have to register by contacting Louis Imbeau at the information desk.

Detailed schedule

Sunday, May 15

16:00	Registration opens
18:00	Welcoming ice breaker—Sponsored by *La ville de Rouyn-Noranda*

Monday, May 16

7:30	Breakfast in room #5 « La Grande »—Sponsored by *Fonds québécois de la recherche sur la nature et les technologies* (FQRNT) Registration/Poster set up		
8:45	Welcome		
9:15	Keynote speaker: **Martin T. Moroni** Forest CSI: deadwood carbon in forests on opposite ends of the earth		
10:15	Coffee break—Sponsored by *Norbord inc.*		
	Room #1 La Papetière	Room #3 La Coulée d'or	Room #4 L'Anode
	Deadwood functions in carbon and nutrient cycles (A) Moderator: Kajar Koster	Deadwood recruitment and dynamics in natural and managed forests (A) Moderator: Tomas Vrska	Senescent trees, snags and logs and their importance to biodiversity (A) Moderator: Michel Saint-Germain
10:40	**Steffen Herrmann** - Interactive effects of moisture, temperature and decomposition stage on respirational carbon loss from coarse woody debris (CWD) of important European tree species	**Karine Grotte** - Old-growth characteristics of disjunct *Thuja occidentalis* stands at their northwestern distribution limit, central Canada.	**Michael Ferro** - Diversity of Saproxylic Coleoptera in Great Smoky Mountains National Park
11:00	**Tiemo Kahl** - Does dead wood leave a footprint in the soil?	**Tor-Bjorn Larsson** - Deadwood in European forests	**Andrea Norris** - Reproductive trade-offs by red-breasted nuthatch (*Sitta canadensis*) imposed by a community-wide resource pulse of mountain pine bark beetles (*Dendroctonus ponderosae*) in interior British Columbia
11:20	**Suzanne Brais** - Carbon pools and nutrient dynamics associated with deadwood under two contrasting boreal species	**Martin T. Moroni** - Debris Down Under: coarse woody debris loads in the cool temperate forests of Tasmania, Australia	**Kris Vandekerkhove** - Past and present state of dead wood and senescent trees in the Sonian Forest (Belgium), a woodland of great importance to kings and emperors, and old-growth biodiversity.
11:40	**Ulrike Hagemann** - Disturbance history influences downed woody debris respiration	**Nicolas Debaive** - First large-scale assessment of the amount of CWD in strict French forest reserves.	**Diana Rubene** - Spatial occurrence patterns and habitat requirements of a threatened beetle, *Upis ceramboides*, in a managed boreal forest landscape
12:00	**Jessica Iraci** - Contribution of downed woody debris to biomass and nutrient pools in boreal mixedwoods of northeastern Ontario		**Simon Grove** - A decade of change in the saproxylic beetle fauna of eucalypt logs in the Warra long-term log-decay experiment, Tasmania
12:20	Lunch in room #5 « La Grande »—Sponsored by *Conférence régionale des élus de l'Abitibi-Témicamingue* (CRÉAT)		
13:30	Keynote speaker: **Christophe Bouget** Sustainable use of woody biomass resources and conservation of deadwood-associated biodiversity		
	Forest fires, deadwood and saproxylic organisms (A) Moderator: Thomas Ranius	Senescent trees, snags and logs and their importance to biodiversity (B) Moderator: Jay Malcolm	
14:30	**Jonathan Boucher** - The origin of dead wood does matter for saproxylic beetles	**Yoan Paillet** - Influence of tree characteristics and forest management on tree microhabitats	
14:50	**Sébastien Bélanger** - Modelling woodborer damage in recently burned logs, as a function of temperature	**Laurent Larrieu** - Tree-microhabitats in the montane Beech-Fir forests of the Pyrenees (France): Revealing girth thresholds correlated with microhabitat occurrences	
15:10	**Ermias T. Azeria** - Differential contribution of post-fire habitat legacies towards beta-diversity components of saproxylic beetles	**Louis Imbeau** - Use of tree cavities by the northern flying squirrel in the eastern Canadian boreal mixedwood forest	
15:30	Coffee break—Sponsored by *Chantiers Chibougamau*		
	Deadwood conservation and restoration in managed landscapes (A) Moderator: Jenna Jacobs	Effects of forest management on deadwood functions (A) Moderator: Ermias T. Azeria	Deadwood in the context of biomass harvesting for energy production Moderator: Christian Hébert
15:50	**Therese Johansson** - Assemblage composition and diversity patterns on created dead wood in a managed forest landscape	**Jay Malcolm** - Boreal small mammal, fungi, and insect communities as a function of variation in downed woody debris quantity and quality	**Philippe Deuffic** - To burn biodiversity for energy savings: Is deadwood conservation an environmental issue for forest owners?
16:10	**Matthew Pyper** - Restoring boreal ecosystems using coarse woody debris: an application for oil and gas operators	**Michel Saint-Germain** - Response of saprophagous wood-boring beetles (Coleoptera: Cerambycidae) to severe habitat loss due to logging in aspen- and spruce-dominated landscapes	**Mats Jonsell** - Harvest of bioenergy wood and effects on wood living insects
16:30	**Joakim Hjältén** - Habitat and substrate associations of red-listed saproxylic beetles in old growth reserves and managed forests: implications for conservation	**Pierre Drapeau** - Are forest remnants in managed landscapes of the Eastern Canadian boreal forest suitable breeding habitats for cavity nesting birds?	**Thomas Ranius** - Modeling dead wood dynamics to predict effects of biomass harvesting for energy production
16:50	**Jörgen Olsson** - Restoration fire and wood-inhabiting fungi in a Swedish *Pinus sylvestris* forest	**Stephen Pawson** - Climate change mitigation: Potential effects of future plantation management on beetles associated with deadwood	**Timothy T. Work** - Post-harvest recovery of coarse woody material and its influence of litter dwelling arthropods
17:30	**Poster session**: Cocktail buffet—Sponsored by *ministère du Développement économique, de l'Innovation et de l'Exportation (MDEIE)*		

Tuesday, May 17

	Room #1 La Papetière	Room #3 La Coulée d'or	Room #4 L'Anode
7:30	Breakfast in room #5 « La Grande »—Sponsored by *ministère de l'Emploi et de la Solidarité sociale (MESS)*		
8:30	Keynote speaker: **Juha Siitonen** Large-scale effects of forest management on saproxylic species in Fennoscandian boreal forests		
	Effects of forest management on deadwood functions (B) Moderator: Simon Grove		Deadwood recruitment and dynamics in natural and managed forests (B) Moderator: Tor-Bjorn Larsson
9:30	**Timothy T. Work** - Estimating species loss of saproxylic insects under scenarios of reduced coarse woody material (CWM) in eastern boreal mixedwood forests		**Thomas Fournier** - Post-fire variation of coarse woody debris in oak-pine Mediterranean forest
9:50	**Jon Andersson** - Saproxylic beetle assemblages on low stumps, high stumps and logs: Implications for ecological effects of stump harvesting		**Nicolas Fauvart** - Tree mortality patterns in *Picea mariana* forests during break up stage in two regions of boreal Quebec
10:10	**Julie Barrette** - Recently dead merchantable stems from the boreal forest of Québec		**Chafi Chaieb** - Dead wood diversity and their decay-class dynamics in the northwestern boreal black spruce forests of Quebec
10:30	Coffee break—Sponsored by *Ministère des Relations internationales* (MRI)		
	Forest fires, deadwood and saproxylic organisms (B) Moderator: Mats Jonsell	Effects of forest management on deadwood functions (C) Moderator: Ian Thompson	Deadwood recruitment and dynamics in natural and managed forests (C) Moderator: Nicole Fenton
10:50	**Christian Hébert** - Insect succession in postfire black spruce forests: a 10-year study	**Myriam Paquette** - Diversity of bryophytes in relation to available coarse woody debris: does it differ between a post-fire and a post-clearcut forest succession?	**Brian Harvey** - Mortality and dead wood dynamics following forest tent caterpillar outbreaks in aspen stands: A model for partial cutting?
11:10	**Therese Johansson** - Short-term responses of beetle assemblages to wildfire in a region with more than 100 years of fire suppression	**Manuella Strukelj** - Deadwood and fine litter dynamics following complete and partial harvesting	**François Guillemette** - Patterns of tree mortality after partial cutting in northern hardwood stands along an ecological gradient: implications for deadwood recruitment
11:30	**Pierre Drapeau** - Interactions between logging and fire: their effects on the dynamics of a keystone primary excavator in the eastern boreal forest of North America	**Tiemo Kahl** - The effect of forest management intensity on the diversity of wood-decaying fungi and dead wood decomposition (FunWood)	**Sayoko Naito** - Deadwood recruitment and its spatial distribution in unmanaged and selection harvested stands of a mixed forest in northern Japan
11:50	**David J. Gervais** - Distribution of wood-boring beetle damage in fire-killed black spruce (*Picea mariana* Mill.) in Northwestern Quebec	**Jérémie Poupart Montpetit** - Accounting for dead wood (debris and snags) characteristics and quantity in managed stands: a comparison of selection cut (SC) and 2 diameter cuts (SC) in Sugar Maple/Yellow birch stands of Témiscamingue	**Frédérik Doyon** - Snags and downed-woody debris in recent and old windthrown and windthrown-salvaged Sugar Maple/Yellow Birch forests of Témiscamingue, Québec
12:10	Lunch in room #5 « La Grande » —Sponsored by *ministère des Ressources naturelles et de la Faune (MRNF)*		
13:30	Keynote speaker: **Kathy Martin** Nest Web communities and tree decay dynamics: the formation, persistence and wildlife use of tree cavities		
	Senescent trees, snags and logs and their importance to biodiversity (C) Moderator: Timothy T. Work	Senescent trees, snags and logs and their importance to biodiversity (D) Moderator: Jean-Michel Roberge	Deadwood recruitment and dynamics in natural and managed forests (D) Moderator: Brian Harvey
14:30	**Thibault Lachat** - Population trend of the Rosalia longicorn (*Rosalia alpina*) in Switzerland	**Philippe Cadieux** - The importance of senescent or dead trembling aspen (*Populus tremuloides*) for cavity nesters along a chronosequence of naturally disturbed mixedwood boreal forests in eastern North America	**Tomas Vrska** - Deadwood cycling in old-growth temperate forests: what are the differences between diverse forest types?
14:50	**Thomas Ranius** - Metapopulation dynamics and conservation of a beetle, *Osmoderma eremita*, living in hollow trees in Europe	**Pierre Drapeau** - Foraging ecology and use of dead wood by woodpeckers in Eastern Canadian boreal forests	**Mark Ducey** - 3P sampling of downed deadwood
15:10	**Charlene Wood** - Saproxylic beetle communities of trembling aspen deadwood	**Nobuhiko Kotaka** - Nest site characteristics of the Okinawa Woodpecker Dendrocopos noguchii in the subtropical evergreen forest "Yambaru"; Consequences of land-use history and pine-wilt disease	**Virginie-Arielle Angers** - Morphological attributes and snag classification of four North American boreal tree species: relationships with time since death and wood density
15:30	Coffee break—Sponsored by *Pierre Corbeil, Ministre de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ)*		

Detailed schedule

Tuesday, May 17

	Room #1 La Papetière	Room #3 La Coulée d'or	Room #4 L'Anode
	Deadwood recruitment and dynamics in natural and managed forests (E) Moderator: Frédérik Doyon	Deadwood functions in carbon and nutrient cycles (B) Moderator: Steffen Hermann	Senescent trees, snags and logs and their importance to biodiversity (E) Moderator: Bengt-Gunnar Jonsson
15:50	**Virginie-Arielle Angers** - Mineralization rates and factors influencing snag decay in four North American boreal tree species	**Ulrike Hagemann** - Buried wood – or the role of bryophytes in the deadwood cycle of humid boreal forests	**Pascal Drouin** - Molecular diversity of saproxylic fungi and wood decay along a forest disturbance gradient
16:10	**Amy Milo** - Wood decay rates reconsidered: contrasting density and volume depletion	**Fabio Lombardi** - Time-since-death, decay classes and decay progression in beech and silver fir forests in the central Apennines (Italy)	**Kimiko Okabe** - Ecological characteristics of mushroom mite assemblage in temperate deciduous forests
16:30	**Loretta Garrett** - National woody debris decay model for New Zealand	**Samuel Olajuyigbe** - Decomposition of above and below-ground deadwood in managed Sitka spruce forests in Ireland	**Adrian Smolis** - The hidden and unknown biodiversity of dead wood: Saproxylic Collembola in forests of Northern Hemisphere
16:50		**Kajar Köster** - Nutrient (N, C, S) concentrations and wood decomposition in windthrow areas in Estonia	**Aurore Lassauce** - Deadwood as a surrogate for forest biodiversity: Meta-analysis of correlations between deadwood volume and species richness of saproxylic organisms
17:10		**Christophe Bigot** - Consideration of coarse woody debris as protection against rockfall in mountainous forest	**Jean-Michel Roberge** - Effects of intensified forestry on the landscape-scale extinction risk of dead-wood dependent species
17:30	Cocktail		
17:45	**Business meetings (Room #1 La Papetière)** Symposium follow up: Where do we go now ? Chaired by Simon Grove		
18:30	8.02.02 Forest Biodiversity and Resilience IUFRO working party meeting Chaired by Stephen Pawson		
19:00	Free evening in town		

Wednesday, May 18

6:30	Breakfast in room #5 « La Grande »
7:30	Departure for the **Field trip** at the Lake Duparquet Research and teaching forest *Forest ecology and management of deadwood in the eastern boreal mixedwood forest* Lunch sponsored by *Centre local de développement de l'Abitibi-Ouest*
18:30	Cocktail
19:00	**Banquet** with Stephen Burman at the piano —Sponsored by *Université du Québec en Abitibi-Témiscamingue*

Thursday, May 19

7:30	Breakfast in room #5 « La Grande »
8:30	Keynote speaker: **Daniel Vallauri** Restoring deadwood and naturalness: European perspectives

	Room #1 La Papetière	Room #4 L'Anode
	Effects of forest management on deadwood functions (D) Moderator: Ulrike Hagemann	Deadwood conservation and restoration in managed landscapes (C) Moderator: Pierre Drapeau
9:30	**Julie Arseneault** - Bryophyte diversity associated with black spruce woody debris in boreal forests	**Simon Grove** - A deadwoodologist's digest: an A-to-Z of learnings from a decade of research in Tasmania
9:50	**Dominique Fauteux** - Home range and stand scale effects of coarse woody debris on boreal small mammals	**Bengt Gunnar Jonsson** - Extinction debt among wood fungi in small fragmented boreal forest stands
10:10	**Jenna Jacobs** - Biodiversity, structure and process: changes in saproxylic beetles, deadwood and decomposition rates following forest harvest	**Joakim Hjältén** - Dead wood diversity promotes saproxylic biodiversity
10:30	Coffee Break—Sponsored by *Location Dion*	
10:50	Keynote speaker: **Ian Thompson** Dead wood in the context of global forest conservation efforts	
11:50	Closing remarks	
12:10	Lunch in room #6 « La Capitale » —Sponsored by *Natural Resources Canada*	
13:30	**End of Symposium**	
15:30	Departure for the post-symposium excursion—Sponsored by *Société d'énergie de la Baie-James, Hydro-Québec and the Conférence régionale des élus de la Baie-James*	

KEYNOTES
SPEAKERS
ABSTRACTS

Sustainable use of woody biomass resources and conservation of deadwood-associated biodiversity

Christophe BOUGET, Ph.D
Research Institute for Engineering in Agriculture and Environment (Cemagref), Forest Ecosystems Research Unit



Christophe Bouget, 36 years old, is interested in applied research in the areas of forest management and forest biodiversity, and the use of tools in landscape and community ecology. Since earning his PhD on the effects of windthrow gaps on forest beetle diversity and the comparison between natural and human forest disturbance, he has worked as a research scientist in the Forest Ecosystems Unit at the Cemagref Institute (Nogent-sur-Vernisson, France). In addition to his educational activities (M.Sc. and PhD student supervisor and referee), he is leading research projects dedicated to the study of forest insects. Currently his research is focussed on the relationships between saproxylic species assemblages and deadwood habitat features, with applications in forestry. His main projects examine the role of the volume and quality of coarse woody debris in biodiversity conservation, and the impact of forestry intensification, habitat fragmentation (the study of retention patches, isolated woodlots and set-aside forest reserves) and historical continuity on beetle diversity. His current research interests also include the optimization of insect sampling methods and the development of databases on species ecology. He is also the web manager of a national database on saproxylic beetle ecology and conservation values (http://frisbee.nogent.cemagref.fr/index.php/en/). He is also exploring the research field of bee pollinator diversity at forest edges.

Abstract

The implementation of Climate Change Mitigation Activities has led to increased interest in intensive biomass production in forests. Woodfuels provide a renewable, carbon-neutral source of energy to reduce Greenhouse Gas emissions. However woodfuel production could have consequences for other environmental issues such as soil fertility and erosion. Moreover, increased woodfuel production may conflict with biodiversity conservation efforts. This talk focuses on the main risks of woodfuel production to forest biodiversity, in developed countries (particularly Europe).

Forest practices related to intensifying woodfuel production and shaping forest biodiversity are examined. Many of these concerns apply to most types of forest management, but some are particularly “relevant to” or “increased by” intensified woodfuel harvests. One of the most pressing issues is the increasing cumulative surface area of harvested stands due to extensive thinning and clearing, the felling of previously unmanaged woodlots in agricultural landscapes, and the potential use of protected forests for woodfuel (policy pressures). A second pressing issue is a change in harvesting practices, from traditional fuelwood collection towards the removal of deadwood that was formerly partially left on site (small trees, slash, logging residues, logs of low quality, stumps) after early thinning or final felling. Other pressing issues are the shortening of forestry cycles, the development of forest roads, and the conversion of native forests into mono-specific plantations or short-rotation coppices of fast-growing species. Combined these practices can have both positive and negative effects on species diversity, at landscapes, habitats, species, and gene levels.

Large-scale wood biomass removal is especially of concern, since it may jeopardise the amount of substrate available for food and habitat for saproxylic organisms. Deadwood-associated communities may also be affected by changes in the deadwood profile, linked with the decreasing density of some deadwood components (Fine Woody Debris and stumps, for instance). Ecological trapping by log piles may also be amplified. Other impacts include the decreasing density in old stands of veteran trees, potential changes in forest microclimate, enhanced disturbance to fauna and habitat fragmentation. Several potential benefits to biodiversity are eventually alluded to. All these predictions clearly depend on local history and environmental conditions. Adequate knowledge would help determine what and how much habitat should be left, and where to direct intense harvesting in the landscape. Recommendations on how to maximize benefits to biodiversity while minimizing negative impacts, requires further research and manipulative experiments designed to test the effects of biomass removal on biodiversity.

Selected papers

Bouget, C., Nusillard, B., Pineau, X., and Ricou, C., 2011. Effect of deadwood position on saproxylic beetles in temperate forests and conservation interest of oak snags. Insect Conservation and Diversity, in press.

Bouget, C., Brin, A. and Brustel, H., 2011. Exploring the "last biotic frontier": are temperate forest canopies special for saproxylic beetles? Forest Ecology and Management 261: 211–220.

Bouget, C., Brustel, H., Brin, A. and Valladares, L., 2009. Evaluation of window flight traps for effectiveness at monitoring dead wood associated beetles: the effect of ethanol lure under contrasting environmental conditions. Agricultural and Forest Entomology 11: 143-152.

Bouget, C. and Nageleisen, L.M. (Eds), 2009. Forest insect studies: methods and techniques. Key considerations for standardisation. An overview of the reflections of the "Entomological Forest Inventories" working group (Inv.Ent.For.). Les Dossiers Forestiers no. 19, Office National des Forêts, 144 p.

Bouget, C., 2005. Short-term effect of windstorm disturbance on saproxylic beetles in broadleaved temperate forests. Part II : effects of gap size and gap isolation. Forest Ecology and Management 216: 15-27.

Bouget, C. and Duelli, P., 2004. The effects of windthrow on forest insect communities: a literature review. Biological Conservation 118: 281-299.



Notes

Tree decay dynamics promote biodiversity in the World Wide Nest Web

Kathy MARTIN Ph.D
Forest Sciences Department, University of British Columbia, Vancouver and Environment Canada, Pacific and Western Region, Delta BC



Dr. Kathy Martin is a Professor of Wildlife Ecology in the Forest Sciences Department at the University of British Columbia, and a Senior Research Scientist with Environment Canada in Vancouver, BC. She completed her BSc at the University of Prince Edward Island and postgraduate degrees at the University of Alberta and Queen's University, Canada. Kathy has always been fascinated by how species persist in extreme and challenging environments. For several decades, she has conducted research on population ecology and life history variation of alpine and arctic grouse and songbirds, especially in relation to environmental variability. Since 1995, she and her students have conducted research on the community ecology of cavity nesting vertebrates, and other forest birds in relation to forestry activities and insect outbreaks in cooperation with industry and provincial and federal agencies in Canada. Her research on tree conditions and wildlife biodiversity had immediate applications to forest operations across Canada and in several South American forest systems. Recently, Dr. Martin has applied her nest web model of community structure and function to forest wildlife communities globally.

Abstract

From a biodiversity perspective, much of the world is chronically short of tree decay. Dead and dying trees provide the critical resources for nesting and roosting cavities, as well as foraging and cover substrates for forest wildlife. Tree cavity formation depends on the presence of heart rot fungi that soften the heartwood. Cavities can form slowly with the presence of other decay or physical processes or they may form quickly when avian excavators penetrate the outer sapwood and remove the decayed heartwood. In forest and savannah ecosystems, 20-40% of vertebrate species (over 1000 species globally) depend on tree cavities to reproduce or for other critical life activities.

I developed the Nest Web concept to describe the interdependence of cavity producers and consumers in structured-nidic guilds where species interact through the creation of and competition for nest trees and nest cavities. In the Nest Webs of North America, woodpeckers function as keystone species as they excavate over 90% of the holes used by secondary cavity nesting (non-excavating) birds and mammals. On other continents, secondary cavity nesters primarily use cavities formed by decay or external damage, even when woodpeckers are present. Although hole formation processes differ across continents, non-excavating cavity nesters from both temperate and tropical systems select nests sites based on the characteristics and availability of cavities, rather than the formation agent. Decay-based hole formation has the advantage of forming a wider range of cavities sizes than excavators produce, but this process often involves several centuries in large and old trees with many of the resultant cavities unsuitable for nesting. Woodpecker-facilitated cavity formation can result in a higher density of cavities in smaller and younger trees, many of which will be suitable nesting cavities. The rates of cavity formation and persistence vary across continents and within forest ecosystems across time and space. Although generally there are unoccupied cavities in most systems, there is also a strong positive relationship between cavity availability and the abundance and diversity of cavity nesting vertebrates, suggesting a limitation of this critical resource in both managed and primary forests in North and South America.

To maintain forest biodiversity it is critical to understand the role of decay and excavators as structuring agents in wildlife communities. In North America, this involves predicting and retaining the suite of tree types and conditions (e.g., unhealthy and dead aspen) that woodpeckers will consider suitable for excavation (i.e., woodpecker-friendly forests). In tropical forests with decay-based nest webs, it will be important to alter harvest regulations such that a supply of the oldest trees with advanced decay are retained to maintain wildlife populations in these high biodiversity ecosystems.

Selected papers

Cockle, K.L., Martin, K. and Wesolowski., T. 2011. Woodpeckers, decay and the future of cavity-nesting vertebrate communities worldwide. Frontiers in Ecology and the Environment, In press, April 2011.

Drever, M.C., and Martin, K. 2010. Response of woodpeckers to changes in forest health and harvest: implications for conservation of avian biodiversity. Forest Ecology Management 259: 958-966.

Norris, A.R. and Martin, K. 2010. The perils of plasticity: Dual resource pulses increase facilitation but destabilize populations of small-bodied cavity-nesters. Oikos 119: 1126-1135.

Drever, M.C., J. R. Goheen, and K. Martin 2009. Species-energy theory, pulsed resources, and the regulation of avian richness during a mountain pine beetle outbreak. Ecology 90:1095-1105.

Martin, K. and J.M. Eadie 1999. Nest Webs: a community wide approach to the management and conservation of cavity nesting birds. Forest Ecology and Management 115: 243-257.



Notes

Forest CSI: deadwood carbon in forests on opposite ends of the earth

Martin T. MORONI Ph.D
Forestry Tasmania



Martin Moroni grew up in Hobart, Tasmania, and completed a Bachelor's and a PhD in the school of Agricultural Science at the University of Tasmania. Interest in forests commenced at the honours level examining nitrogen nutrition of Eucalyptus plantations, which continued into his PhD. After completing the PhD he sold his belongings and, with his new wife, bought a 1-way airfare to Vancouver in 2000. Unfortunately no one told him that Weyerhaeuser had just bought MacMillan Bloedel! With no work in Vancouver, he found work in Corner Brook Newfoundland with Natural Resources Canada. With NRCan his research on forest carbon commenced, leading him to deadwood. He studied deadwood in subarctic boreal Labrador, boreal Newfoundland and Acadian hardwoods in Nova Scotia, examining harvested, burned, insect killed, gap driven and old growth forests to fill holes in empirical knowledge and to evaluate forest C accounting tools. In 2009 he was offered a forest carbon research position in his home town of Hobart with Forestry Tasmania. Since his return to Tasmania, he has been compiling available knowledge on forest, which includes data on dead wood from over 4000 inventory plots.

Abstract

Deadwood forms a dynamic and potentially substantial forest carbon pool. The significance of this pool to forest C stocks, and fluxes to and from it, are as variable as forests are themselves variable. In some forests dead wood is transient and forms a relatively large C pool for short periods. In other forests dead wood is a large, medium to long term forest C pool, where the maximum possible abundance of dead wood exceeds the maximum possible abundance of live wood. Understanding dead wood carbon dynamics requires an understanding of how the dead wood came about: what sort of forest grew it and how did it die.

Thus, the study of dead wood stocks and fluxes takes on characteristics of the occupation or TV show implied in the title. The above will be illustrated in various forest types from opposite ends of the earth: Atlantic Canada and Tasmania. These locations encompass forests occupied by some of the largest, long lived trees that generate enormous quantities of persistent dead wood, to forests occupied by some of the smaller dimensioned production forest trees that generate short lived pulses of dead wood. These forests have contrasting ecologies and environments that have an interesting impact of dead wood abundances and cycles.

Selected papers

Newfoundland and Labrador

Moroni, M.T., Shaw, C.H. and Otahal, P. 2010. Forest carbon stocks in Newfoundland boreal forests of harvest and natural disturbance origin I: Field study Canadian Journal of Forest Research 40: 2135-2145.

Moroni, M.T., Shaw, C.H., Kurz, W.A., and Rampley, G.J. 2010. Forest carbon stocks in Newfoundland boreal forests of harvest and natural disturbance origin II Model evaluation. Canadian Journal of Forest Research 40: 2146-2163.

Moroni, M.T., Hagemann, U. and Beilmann, D. 2010. Dead wood is buried and preserved in a Labrador boreal forest. Ecosystems 13: 452-458.

Hagemann, U., Moroni, M.T., Gleissner, J, and Makeschin, F. 2010. Disturbance history influences downed woody debris and soil respiration. Forest Ecology and Management 260: 1762-1772.

Hagemann, U., Moroni, M.T., Gleissner, J. and Makeschin, F. 2010. Accumulation and preservation of dead wood upon burial by bryophytes. Ecosystems 13: 600-611.

Moroni, M.T. and Harris, D.D. 2010. Snag frequency, diameter and species distribution, and input rate in Newfoundland boreal forests. Forestry 83: 229-244.

Hagemann, U., Moroni, M.T. and Makeschin, F. 2009. Dead wood abundance in Labrador high-boreal black spruce forests. Canadian Journal of Forest Research: 39: 131-142

Nova Scotia

Moroni, M.T. and Ryan, D.A.J. 2010. Dead wood abundance in recently harvested and old Nova Scotia tolerant hardwood forests. Forestry 83: 219-227.

Tasmania

Moroni, M.T., Kelley T.H. and McLarin, M.L. 2011. Carbon in trees in Tasmanian State forest. International Journal of Forestry Research. vol. 2010, Article ID 690462, 13 pages, 2010. *doi:10.1155/2010/690462*



Notes

Large-scale effects of forest management on saproxylic species in Fennoscandian boreal forests

Juha SIITONEN M.Sc. (Agr. & For.)
Finnish Forest Research Institute, Finland



Juha Siitonen has worked as a senior researcher at the Finnish Forest Research Institute since 1995. He has studied the effects of forest management on dead wood and saproxylic species, mainly beetles and polypores, for more than 20 years. However, the interest on this subject stems from much earlier time and from having beetle collecting as a hobby. The first visits into natural old-growth forest at the late teenage were an eye-opener: He was amazed to find so many saproxylic beetles that he had never seen before while collecting in ordinary managed forests. During the recent years, Juha Siitonen has lead research projects examining the effects of biodiversity-oriented management (including key habitats, retention trees and voluntary protection) on biodiversity. He is a member of the Finnish beetle working group, and has taken part to the red-list assessments of the Finnish fauna.

Abstract

A conservative estimate for the total number of saproxylic species in Fennoscandia (the biogeographic area including Finland, Sweden, Norway and Russian Karelia) is 6000–7000 species, accounting for 20–25% of all forest-dwelling species. Large parts of the boreal forests in Fennoscandia have been intensively used for more than hundred years. The long history of forest-use and the current intensive management regime are reflected in the average volume of dead wood. For instance, in southern Finland the average volume of dead wood ≥ 10 cm in diameter is only 3.2 m^3/ha according to the National Forest Inventory. In natural forests the average volume is 60–120 m^3/ha. The effects of this reduction on the species richness of saproxylic species can be estimated on the basis of general species-area relationship. A decline of over 90% in available habitat, in the amount of dead wood, can be expected to lead to the disappearance of a fifth to a third of the original saproxylic species from managed forests in the long term.

However, it is difficult to directly observe and assess the long-term and large-scale effects of forest management on species assemblages because the regional extinction of species caused by habitat loss and fragmentation takes place with time delays. An extinction debt is the number of extant species whose populations are deemed to go extinct gradually because of the environmental changes that have already taken place – even if the amount of suitable habitat is not further reduced. There are regional gradients in forest-use history, and these offer interesting possibilities to empirically study its long-term effects. In Finland the duration and intensity of land use declines from the southern and western parts towards north and east. This can be seen e.g. in threatened saproxylic beetles as the proportion of regionally extinct species is the largest in the hemiboreal zone and the smallest in the northern boreal zone. Some of the regional extinctions had obviously taken place already in the 1800s.

Some of the most abrupt changes in forest management and structure occur on the Finnish eastern border, between Finland and Russian Karelia. Forestry in Finland has been very intensive while in Karelia it has been rather extensive until lately (e.g. no thinnings, long rotations, a lot of dead wood). Several studies have taken advantage of this large-scale "experiment" and have shown that rare and threatened saproxylic species are strikingly more abundant in Karelia. Regional comparisons can yield important insight, and can be used for developing forest conservation and biodiversity-oriented management.

Selected papers

Stokland, J., Jonsson, B. G. and Siitonen, J. (eds.) 2011. Biodiversity in dead wood. Cambridge University Press (submitted book manuscript).

Laaksonen, M., Murdoch, K., Siitonen, J. and Várkonyi, G. 2010. Habitat associations of *Agathidium pulchellum*, an endangered old-growth forest beetle species living on slime moulds. Journal of Insect Conservation 14: 89-98.

Hottola, J. and Siitonen, J. 2008. Significance of woodland key habitats for polypore diversity and red-listed species in boreal forests. Biodiversity and Conservation 17: 2559-2577.

Siitonen, J. 2001. Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. Ecological Bulletins 49: 11-41.

Siitonen, J., Martikainen, P., Punttila, P. and Rauh, J. 2000. Coarse woody debris and stand characteristics in mature managed and old-growth boreal mesic forests in southern Finland. Forest Ecology and Management 128: 211-225.



Notes

Dead wood in the context of global forest conservation efforts

Ian THOMPSON Ph.D
Natural Resources Canada
Canadian Forest Service



Ian Thompson is a forest ecologist and wildlife scientist who has worked in boreal ecosystems for more than 30 years and is the senior biodiversity scientist at Canadian Forest Service. His past research has assessed the impacts of forest management practices on mammals, birds, arthropods, and salamanders and he has long worked towards influencing sustainable forest management practices in Canada. Currently he is actively involved in a project on boreal forest caribou habitat ecology and in a continuing project on the relationship between dead wood and biodiversity in boreal forests near Kapuskasing, Ontario. He has represented Canada at numerous international forest science and policy initiatives, including the Convention on Biological Diversity, IPCC, IUFRO, Millennium Ecosystem Assessment, and the North American Forest Commission. Recently he began work with the UN Food and Agriculture Organization on the development of criteria and indicators for assessing forest degradation.

Abstract

The global forest governance mechanism is comprised of multiple intergovernmental organizations, international treaties, NGOs, and various funding bodies. These include such groups as the Convention on Biological Diversity, International Tropical Timber Organization, UN Framework Convention on Climate Change, World Conservation Monitoring Centre, the UN Food and Agriculture Organization, and World Bank. Many of these organizations fund forest development programs or provide advice to forest managers and verify the results, in a large number of developing countries.

More recently, considerable funding has become available for so-called REDD-plus initiatives (**r**educing **e**missions from **d**eforestation and **d**egradation) as a global mechanism to reduce greenhouse gas emissions from forestry. REDD is a form of payment for ecosystem services. All agencies, programs, and projects have established conservation of biodiversity as a key objective or criterion in projects that are funded. However, global criteria and indicators and most operational guidelines for forest management, among these agencies, do not consider dead wood except in the context of carbon storage calculations. At the regional level, some regional indicators processes such as MCPFE (European forests) address dead wood but most others, such as the Montreal Process (for boreal and temperate forests) do not.

Finally, national forest inventories either developed autonomously or funded internationally rarely include dead wood measurement, except in the context of a carbon biomass pool. Forest ecologists have a large challenge remaining to influence global forest policy and governance about the importance of biodiversity issues generally, and more specifically about the functional roles of forest structures, including dead wood. One clear mechanism is to provide guidance through REDD-plus initiatives for forest ecosystem conservation by providing explicit guidelines for biodiversity consideration including forest structures. However, the focus at the global scale on climate related issues should not be at the expense of efforts at the conservation of biological diversity.

Selected papers

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Notes

Restoring deadwood and naturalness: Perspectives from temperate Europe

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Daniel Vallauri is 43 year-old and graduated (PhD) from the University of Marseille (France) in forest restoration ecology (1997). After several experiences abroad, he has been responsible for the WWF's forest biodiversity conservation program in France since 2000. In this position he has been acting nationally and overseas. The achievements of this program have dealt with the temperate forests of France and Europe, the Mediterranean basin and some tropical countries (Malaysia, Madagascar). He is the main author of reports aiming to raise the awareness of deadwood issues in France and initiated conferences that facilitated the debate on that topic, especially with forest managers. He has been the leading editor of four recent books, including one on forest restoration worldwide (2005, in English), on deadwood biodiversity and management (in French, 2005) and on forest naturalness (in French, 2010). He is currently both working on restoration of degraded forests, sustainable management and conservation of ancient/old-growth forests. His work promotes the use of naturalness valuation methods as a tool to better define conservation policies and to improve forest management rules (including the design of networks of leave islands, deadwood retention measures, ecosystem management).

Abstract

Veteran trees, cavities and deadwood are key components for conservation of biodiversity and forest functions in Europe. They are practical features emphasizing the importance of naturalness of forest ecosystems as a whole, the later concept including also other relevant criteria like ancientness, nativeness, stand maturity and structure, functional integrity, disturbances and resilience, and spatial continuity. However obvious the importance of deadwood is for any forest ecologist with an old-growth forest background, its importance is still a subject of preliminary research and of vivid debates with forest managers across most of the continent, especially in its western and Mediterranean parts.

The historical context, past forest resources depletion, specific management cultures and the lack of old-growth forests to serve as an obvious reference, has led to the mismanagement of deadwood in Europe. Each hectare of temperate old-growth forest in Europe could contain on average: 40 to 200 m^3 of deadwood, 40 to 140 dead trees, 10 to 40 large snags, and at least 10 trees with at least one cavity. However, most managed forests conserve less than 10 m^3 of deadwood per ha, and often far less. The loss of micro-habitats and food resources associated with deadwood therefore severely threaten a rich species diversity, especially cavity dwelling birds and saproxylic species (fungi and invertebrates). The potential impacts of this loss on ecosystem functioning, especially on soils and carbon cycles underestimated.

Over the two last decades, forest ecologists in temperate Europe have been: 1) searching to document the biological relationships between biodiversity and deadwood micro-habitats, in managed or reference forests; 2) struggling to make their concerns understood by forest managers; 3) and more recently, they have been lobbying for a stricter integration of deadwood in management rules and to develop tools to guide restoration at various scales (creation of new strict reserves, set up of networks of leave islands, single tree retention...).

This paper tries to: 1) give an overview of the scale of the current problem in temperate Europe, available knowledge, gaps and threats on biodiversity; 2) present some examples of the significant achievements to restore deadwood in protected or managed forests; 3) discuss the current challenges for deadwood restoration in Europe, relevant possible approaches, and the reasons that lead to the integration of deadwood in a broader definition of naturalness.

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Notes

ORAL PRESENTATIONS ABSTRACTS

The authors of each abstract are solely responsible for the content.

Saproxylic beetle assemblages on low stumps, high stumps and logs: implications for ecological effects of stump harvesting

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A range of conservation measures, based on legal demands or certification requirements are implemented in today's forestry. One potential drawback in the conservation work are new management plans, which not only include the harvesting of tree stems, branches and twigs, but also low stumps that were earlier left to decay in situ after cutting operations. However, our knowledge of the role of low stumps as habitat for saproxylic organisms is sparse to say the least. The aim of this study was therefore to determine, quantitatively, the extent to which low stumps are utilized by saproxylic beetles and whether the beetle assemblages in low stumps are similar to those of other dead wood substrates (i.e. high stumps and logs). The sampling was conducted at 10 clear-cuts in northern Sweden with emergence traps. No significant differences in beetle abundance or species richness were detected between substrate types. However, there were clear differences in assemblage composition between all substrate types. Our results suggest that low stumps created at final felling support as many species and individuals per volume dead wood as other dead wood substrates and that they are therefore overlooked as substrates for wood living organisms. Consequently, harvesting of low stumps might have negative effects on the diversity of saproxylic beetles, as up to 80% of the dead wood remaining on clear-cuts is in the form of low stumps.

Keywords: low stump harvest, saproxylic insects, biodiversity

Morphological attributes and snag classification of four North American boreal tree species: relationships with time since death and wood density

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Degradation classification systems of snags based on external morphological attributes are widely used but are not always significantly related to elapsed time since death or wood density. Furthermore, these classification systems rely on the global aspect of snags, and the predictive ability of specific attributes has rarely been investigated. We determined which morphological attributes best predicted time since tree death (TSD) and wood density in the snags of four major boreal species in eastern North America: trembling aspen (*Populus tremuloides* Michx.), balsam fir (*Abies balsamea* [L.] Mill.), jack pine (*Pinus banksiana* Lamb.) and black spruce (*Picea mariana* [Mill.] BSP). Sampling was conducted in northwestern Quebec, Canada. For each species, 37 to 65 snags were sampled and TSD was determined using dendrochonology. A first set of multiple linear regressions showed that bark cover was the only morphological attribute common to the models of all species and was the sole predictive variable for TSD in balsam fir. In other species, additional predictors of TSD varied. A second set of multiple linear regressions showed that the combination of predictors for wood density was also species-specific and that wood penetrability was a common predictor for all species. This study indicates that compared to classical degradation classification systems, species-specific models built according to significant morphological attributes do not represent more time- or resource-consuming field assessments and provide more precise measurements of TSD and wood density.

Keywords: snag, decay classification, wood density, dendrochronology, boreal species

Mineralization rates and factors influencing snag decay in four North American boreal tree species

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Mineralization rates (measured as wood density loss) were assessed in snags of four boreal species: trembling aspen (*Populus tremuloides* Michx.), balsam fir (*Abies balsamea* (L.) Mill.), jack pine (*Pinus banksiana* Lamb.) and black spruce (*Picea mariana* (Mill.) BSP). Wood density and variables potentially influencing decay rates (time since death; age; average radial growth; diameter at breast height; Cerambycidae activity, and Scolytinae activity) were measured on discs of 207 snags from northwestern Québec, Canada. Mineralization rates varied significantly among species. Trembling aspen exhibited a more rapid rate of loss than conifers (k = 0.0351). Jack pine was the second most rapid species to lose wood density (k = 0.0152), followed by balsam fir (k = 0.0094). Black spruce was particularly resistant to mineralization (k = 0.0065). Time since death coupled with Cerambycidae activity was associated with lower wood densities in trembling aspen, balsam fir and jack pine, whereas slower growth rates and smaller diameters were associated with a decreased mineralization rate in black spruce. We suggest that stand environmental conditions could explain why time since death has less influence on black spruce wood decay.

Keywords: snags, mineralization rates, wood density, dendrochronology, boreal species

Bryophyte diversity associated with black spruce woody debris in boreal forests

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Bryophytes account for a large proportion of plant diversity in the boreal forest. Coarse woody debris (CWD) represents a substrate propitious for the establishment of rich bryophyte communities. However, CWD amounts and characteristics vary in time as it decomposes. Harvesting applies a negative pressure on woody debris reducing inflow and relocating and crushing existing woody debris. This project aims to measure the effects of two harvesting techniques on the spatial repartition of black spruce (*Picea mariana*, (Mill.)) coarse woody debris, on CWD characteristics and on the associated bryophyte diversity. Our main hypotheses are: (1) total richness of bryophytes species will be higher in sites with all decomposition classes represented, and (2) canopy openness reduces woody debris quality, leading to loss of epixilic species and favouring the establishment and growth of some *Sphagnum* species. The three study sites are located in homogenous black spruce stands prone to paludification in western Quebec. Within each site, a careful logging (CL), a partial cut (PC) and an old growth forest (OG) stand were sampled. Woody debris quality was recorded for 225 woody debris pieces. On each piece of debris, microplots were sampled for bryophytes and samples were taken from 45 of these debris. Results suggest a tendency towards species loss, a dominance of sphagna and fewer available pieces of woody debris after CL, while PC seems more similar to OG. Environmental factors that differed among treatments influenced CWD characteristics and associated bryophyte diversity.

Keywords: coarse woody debris, bryophytes diversity, managed landscape, *Picea mariana*, (Mill.), *Sphagnum* species, paludification

Differential contribution of post-fire habitat legacies towards beta-diversity components of saproxylic beetles

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The attraction of Saproxylic beetles towards recently burned boreal forests is well known. Yet, explaining how variations in post-fire habitats drive beta-diversity patterns remains a central question for both ecology and conservation. A range of indices have been devised to measure different aspects of beta-diversity. We adopted a recently proposed framework that distinguishes the pure "spatial" turnover and nestedness components of beta-diversity, and examine how tree species, gradients in tree size, and burn severities contributed to beta-diversity of saproxylic beetles emerging from tree boles. We simultaneously model both the within- and between habitat classes variation of betadiversity. Our results show that the turnover and nestedness components of beta-diversity of saproxylic beetles are dependent upon different habitat attributes. The turnover component of beta-diversity was primarily explained by tree species, turnover within jack pine as well as between jack pine and black spruce being higher than within black spruce stands. Among tree size classes, turnover was higher among mid-sized trees (12-16cm and 16-20cm) than within smaller (8-12cm) or larger (20-24cm) trees and between them (8-12 vs. 20-24cm). However, the nestedness component of beta diversity was primarily driven by variation in tree size, with highest scores being obtained between the smallest and largest trees, and the lowest scores within and among the largest and mid-sized trees. The two beta diversity components also responded differently to burn severity.

Keywords: Beta diversity, boreal forest, forest fire, habitat gradients, species composition

Recently dead merchantable stems from the boreal forest of Québec

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Recently dead, merchantable stems frequently do not show signs of decay under the bark. Besides its important ecological role, it can be used by the forest industry, but this raises many questions related to wood quality. In the public forests of Québec, recently dead merchantable stems been added to the annual allowable cut as an offset for the drastic reduction in the allocation in live wood. Due to the long intervals between natural fires, the boreal forests of Québec's North Shore region are characterized by important volumes recently dead merchantable stems that may have a significant impact on the economic viability of the industry. To help forest industries plan their activities, this project was designed to: i) determine the temporal variation of standing recently dead merchantable stem volume through a chronosequence after fire; and ii) compare volume recovery, lumber value, lumber strength and stiffness of two states of wood decomposition based on Hunter's classification (decay stages 3 and 4) and live trees. Our results showed that pre- and post-disturbance, recently dead merchantable stems tend to follow a pattern similar of that of coarse woody debris. They also indicate that one thousand board feet (approx 2.4 m3) of lumber produced from Hunter's class 4 trees is worth CAD $48.69 less than if it was produced from live trees. It may be preferable to avoid harvesting trees from this stage of decomposition.

Keywords: recently dead merchantable stems, wood quality, wood decomposition, dead wood dynamic

Modelling woodborer damage in recently burned logs, as a function of temperature

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Because of a decrease in timber availability, salvage logging is used to maintain wood supply for the forest industry. In boreal forests, recent burns are the main areas targeted by this strategy. However, the quality of this wood for the sawmill industry is rapidly deteriorated by woodborers. These insects take advantage of the sudden availability of an abundant food resource and their larvae cause damage by burrowing galleries into the wood. These galleries decrease the economic value of wood products. This project aimed to reduce economic losses caused by woodborers, by modeling the seasonal progression of their damage as a function of temperature. We exposed logs of recently burned black spruce (*Picea mariana*) and jack pine (*Pinus banksiana*) to females of the woodborer *Monochamus scutellatus scutellatus* for 48 hours. Then, logs were placed in different temperatures (12, 16, 20, 24 and 28°C) and scanned regularly with an x ray tomograph to monitor larval gallery progression. This was done by reconfigurating three-dimensional images with the MATLAB© software. Our analyses showed a rapid rate of progression of larvae into the logs submitted to high temperatures (24 and 28°C).

Keywords: x ray tomograph, boreal forest, *Monochamus scutellatus scutellatus*, salvage logging, recent burns, larvae damage

Consideration of coarse woody debris as protection against rockfall in mountainous forest

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Each year in mountains, natural hazards generate extensive damage and sometimes even casualties. During rockfalls, forests can play an important role of passive protection by increasing the energy dissipation of falling rocks. Up to now, many studies have shown the efficiency of standing forests in protection against rockfalls, but these studies are have only considering living trees. In Austria and Switzerland, managers have been using stumps, logs and other timber products to create natural dams against rockfalls over the last twenty years. Today, French foresters have adopted these techniques, but there is still a lack of knowledge on the efficiency and the lifetime of such protective structures. The main objectives of this research are to quantify the mechanical resistance loss according to wood decay kinematics. The studied materials include logs, stumps and roots. Preliminary works have been done in order to select experimental plots in the Alpine Area. The species studied are: silver fir, norway spruce, european beech and pinus nigra. Wood decay rates are quantified by using a chronosequence approach. Different methods are used to quantify wood density loss. A specific protocol, based on both non-destructive and destructive tests, has been built for analysing the loss of mechanical resistance of these woody elements. The final objective is to integrate, in 3D rockfall trajectory simulation models, the actions of these biological engineering protective works taking into account the evolution in their efficiency within their lifetime.

Keywords: protection forest, wood decay, mechanical resistance, rockfall, mountain, protective work

The origin of dead wood does matter for saproxylic beetles

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Saproxylic species have evolved with dead wood dynamics characterizing their habitat range. Since wildfires are the main source of snags in northern boreal forest, fire killed trees are thus a key component for many saproxylic species. So far, we do not know the relative contribution of fires for maintaining biodiversity, compared to other disturbances. In this context, our study aimed at discriminating burn-associated species from those associated with unburned recently killed snags, in the northern boreal forest of Quebec, Canada. In June 2008, we collected 80 logs from Black spruce and Jack pine snags that were either burned by wildfires in 2007 or girdled in 2006. Each treatment (tree species × perturbation) was replicated 5 times. In each site 2 trees were cut down, from which we harvested 2 logs, one at 0.7 m from the ground and the other at 1.3 m. Logs were reared in a field insectarium over 17 months. We identified 22 648 insects distributed among 35 species and 7 families (*Cerambycidae, Cleridae, Corylophidae, Curculionidae, Lathridiidae* and *Salpingidae*). Abundance patterns were mainly explained by disturbance type with girdled trees yielding more individuals than burned trees. Species richness was higher in black spruce than in jack pine. More species were found to be associated with girdling and with black spruce, without considering disturbances. We found a clear distinction in assemblages between disturbances. The effect of tree species on assemblages was greater within girdled logs.

Keywords: burn-associated species, boreal forest, saproxylic species, snags, girdling, fire ecology

Carbon pools and nutrient dynamics associated with deadwood under two contrasting boreal species

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Decaying wood contributes to the biochemical and structural heterogeneity of forest soils. The magnitude of this contribution could however depend on tree species and wood decay stage. This study took place in an 85-year old, post-fire aspen – jack pine forest in northwestern Quebec, Canada. Inventories and sampling of trees, logs and forest floor originating from buried wood (lignic FF) and from fine litter (alignic FF) were conducted in fifteen 400 m2 sample plots (9 jack pine, 6 aspen) equally distributed and nested within three sampling sectors. Relative nutrient availability in the mineral soil was assessed under fresh and well-decomposed logs and under lignic and alignic FF using PRSTM probes. Data were analyzed by GLM using a compound symmetry approach to model correlations between nested observations. Despite higher well-decomposed log volumes in jack pine stands, no significant differences between covers were found for the proportion of C and nutrients contained in biomass + necromass pools. Lignic FF was characterized by a higher C to N ratio and exchangeable acidity and a lower cationic exchange capacity than alignic FF and its nutrient concentrations were halfway between those of alignic FF and logs. Nutrient availability in the mineral soil was not linked to nutrient concentration of overlying necromass and higher Ca and Mg availability was observed under logs than under alignic FF. Differences in wood characteristics may explain some of the differences in soil properties observed between aspen and jack pine stands and usually attributed to fine litter quality.

Keywords: carbon, nutrient availability, buried wood, soil properties, aspen, jack pine

The importance of senescent or dead trembling aspen (*Populus tremuloides*) for cavity nesters along a chronosequence of naturally disturbed mixedwood boreal forests in eastern North America

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The availability of cavity-trees plays an important functional role in maintaining the biodiversity of forest ecosystems. The overall objective of this project is to better understand the use and selection of nesting trees for forest dwelling cavity nesters along an age gradient of naturally disturbed boreal mixedwood forest stands. Between 2003 and 2010, twelve 24 to 40 ha plots ranging from 61 to 245 years since the last fire were surveyed in the Lake Duparquet Research and Teaching Forest (FERLD) in Abitibi, Quebec, in order to detect cavities with active nests. We present nest webs for mature and old growth boreal mixedwood forest. These are composed of 5 primary cavity excavator species (woodpeckers), two weak cavity excavator species (nuthatches, chickadees) and 7 secondary cavity users (ducks, birds of prey, squirrels). Secondary users have strong links to specific excavators, the Pileated woodpecker (*Dryocopus pileatus*) cavities being the most exploited resource. Cavity nesting assemblages remained similar throughout the age gradient. However, despite a lower abundance of nests, there was greater complexity in the conifer old-growth nest web. In addition, we show that even in old-growth forests, primary excavators select large diameter trembling aspen (*Populus tremuloides*) in varying states of decay to excavate their cavity. Although a substantial proportion of cavities were excavated in live aspen trees, most of these trees were infected by fungal heart rot (*Phellius tremulae*). The presence of senescent or dead large diameter trembling aspen is necessary to maintain cavity-nesting assemblages in mixedwood boreal forests under natural disturbance regimes.

Keywords: cavity nesters, boreal mixedwood forest, forest succession, nest tree selection, trembling aspen, community structure

Dead wood diversity and their decay-class dynamics in the northwestern boreal black spruce forests of Québec

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In unmanaged boreal forests standing dead trees and coarse woody debris are an important component of stand structure, but knowledge on their quantities and dynamics in the boreal black spruce *Picea mariana* (Mill.) BSP forest is limited. To determine the influence of time since last fire (TSF) on the abundance of standing dead trees in old-growth black spruce forest and to explain the diversity of the diameter structure of snags and the diversity of decay classes of coarse woody debris, 129 pure black spruce stands, based on maps derived from forest inventories, were sampled in an area of over 14 000 km2 in Abitibi, Quebec. Data include measurements of age structure, coarse woody debris volume, number of snags and several environment variables. A multimodel analysis proves that TSF and stand origin were the two variables that best explained the variability in the abundance of standing dead trees. However, a comparison of the snag abundance among three age classes (mature, overmature, old-growth forest) did not indicate any significant differences. Nevertheless, multinomial analysis indicated a greater likelihood of having a high snag abundance in overmature stands (120 to 180 years TSF). Overmature stands were also significantly richer in coarse woody debris (volume and abundance) then the youngest and the oldest stands. They also had the most diverse snags and coarse woody debris diameter structure. Unmanaged overmature forests must be preserved to ensure better availability of dead wood in the landscape.

Keywords: boreal forest, standing dead trees, coarse woody debris, overmature forest, diversity of diameter structure, diversity of decay classes

First large-scale assessment of the amount of CWD in strict French forest reserves

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Deadwood, whether expressed in volume, diversity or continuity, is nowadays widely acknowledged as being an important component of forest ecosystems and has therefore been addressed in most recent studies dealing with forest conservation and management. However, and despite the growing use of the concept of naturalness in the management plans of French forest reserves, deadwood dynamics remain greatly unknown in European temperate forests. In this context and to answer a growing demand arising from reserve managers, a long-term monitoring scheme has been launched in 2005. Preliminary results from 42 French forest reserves will be presented in this talk. A comprehensive data set of living and dead tree measurements have so far been collected on more than 4000 permanent plots. Sampling is systematic but the density of plots is adjusted to the reserve size, habitat diversity and management practices. Overall, French forest reserves host an average of 35.1 m3/ha of deadwood. More than 2/3 of the reserves had deadwood volumes between 20 and 40 m3/ha, and were considered “deadwood rich”. For more than 1/3 of these reserves, the estimated volume was even greater than 40 m3/ha, indicative of forests growing under nearly natural conditions. Although most of the reserves showed a significant amount of deadwood, the gap with old-growth forests is still of great magnitude. The following surveys should allow us to better understand these differences.

Keywords: deadwood dynamics, longterm monitoring protocol, french forest reserves

To burn biodiversity for energy savings: Is deadwood conservation an environmental issue for forest owners?

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In their daily practices, forest owners are confronted with environmentally-friendly – but contradictory – discourses. Ecologically-oriented NGOs argue that deadwood should be left in the forest to preserve biodiversity, to provide habitat for small organisms and to maintain soil quality through wood decay. Conversely industrial stakeholders and some public decision makers advocate deadwood harvest to save fossil fuels. Based on a sociological constructionist framework and qualitative interviews, we will first analyze French foresters’ environmental opinions and values and their attitudes towards biodiversity, in particular regarding deadwood conservation. We identify various types of attitudes towards deadwood which could be seen as a waste, a non-profit by-product or a part of the ecosystem. We then study the arguments that make them choose between deadwood conservation and deadwood harvesting for biomass production. On the one hand, they are interested by short-term profitability and pest reduction and on the other hand, they fear potential loss of fertility. Finally, the paper will show that specific approaches to deadwood conservation ought to be negotiated at a local scale, pending further scientific study on biodiversity impacts of deadwood and the development of more positive attitudes toward ecological concerns in the forest owners’ community

Keywords: forest owners, environmental controversy, forest management choices, energy production, sociology

Snags and downed-woody debris in recent and old windthrown and windthrown-salvaged Sugar Maple/Yellow Birch forests of Témiscamingue, Québec

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Windthrow is a disturbance that exerts a dominant influence on dead wood dynamics in temperate deciduous forests. Monitoring was implemented to understand the effects of windthrow and subsequent timber salvaging on dead wood. We sampled 35 Sugar Maple/Yellow Birch stands in Témiscamingue, Québec, of which 21 were located in an area windthrown in 2006 (7 windthrown, 7 windthrown-salvaged and 7 stands undisturbed), and 14 others in an area windthrown in 1983 (7 windthrown and 7 undisturbed stands). Snags were described in 400 m2 sample plots and DWD (diameter ≥ 15.1 cm) using a 90 m line intersect. Snag diameter (36 cm), basal area (11 m^2 ha-1) and density (78 ha-1) were the highest in the 2006-windthrown plots while almost no snags were observed in the 2006-windthrown-salvaged plots. However, 24 years after the windthrow, snag characteristics in the windthrown plots were not different from the control plots. Small DWD volume was about 2,5 times higher in windthrown and windthrown-salvaged plots (≈ 75 m^3/ha) than in control plots. Although large DWD volume was not different among treatments because of its large variability, it was two times greater in the 2006-windthrown plots (133 m3/ha) than in the others. These results suggest that dead wood dynamics are very fast after windthrow and timber-salvaging reduces the snag pool available for future recruitment to DWD, short-cutting dead biomass cycling.

Keywords: dead wood dynamics, temperate deciduous forest, salvage harvesting, wind storms

Are forest remnants in managed landscapes of the eastern Canadian boreal forest suitable breeding habitats for cavity nesting birds?

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In Canada's boreal forest, even-aged management has resulted in extensive landscapes of aggregated clearcuts. Regenerating clearcuts that lack mature trees are generally considered unsuitable habitat for most forest birds. Mature forest cover in these landscapes is maintained through variable retention strategies that range from single tree retention in clearcuts to habitat patches or remnant forests mostly concentrated in linear strips (either cut-block separators or riparian buffers). Such habitats may be used as movement corridors, or for foraging and nesting by some forest dwelling species. We conducted a study on woodpecker nesting activity that assessed cavity occupancy, nesting success and productivity in linear remnants of forests in managed landscapes and compared these parameters with those of breeding woodpeckers in continuous unmanaged landscapes. We found nesting activity for most species in linear remnant habitats. Nesting success and productivity were comparable to continuous forest tracks. These results suggest that linear remnant habitats in even-aged managed landscapes provide quality habitats for woodpecker species, a clear indication of their conservation value. Consequently, we recommend that no further harvesting be conducted in these remnant forests and that they should be maintained as permanent retention habitats in even-aged managed landscapes.

Keywords: woodpeckers, productivity, cavity abundance, secondary cavity users, cavity occupancy, permanent retention

Foraging ecology and use of dead wood by woodpeckers in Eastern Canadian boreal forests

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We quantified and compared tree selection patterns, foraging and relative use of dead wood of six bark-foraging woodpeckers - downy woodpecker (*Picoides pubescens*), hairy woodpecker (*Picoides villosus*), American three-toed woodpecker (*Picoides dorsalis*), black-backed woodpecker (*Picoides arcticus*), yellow-bellied sapsucker (*Sphyropicus varius*) and pileated woodpecker (*Dryocopus pileatus*) - in eastern boreal forests of North-America. A total of 266 foraging observation bouts made on more than 700 trees were recorded at three study sites characterized as mixedwood, conifer and conifer-burned. Wood dissection was conducted on a subset of 47 foraging trees used by the four Picoides species to identify potential prey and corroborate foraging tree selection with behaviour. Dead wood represented an important foraging substrate for four of the six species. Woodpeckers were categorized according to their selection for specific stages of tree degradation. The yellow-bellied sapsucker and the pileated woodpecker represented opposite ends of this gradient, being respectively associated with earlier (live trees) and later (degraded snags) tree degradation stages whereas *Picoides* species occupied intermediate positions on the degradation gradient. Although Picoides species in general made extensive use of dead wood, our results highlight significant differences in species specialization in substrate use, associated wood-dwelling arthropods and foraging behaviour. We emphasize that providing foraging substrates for most woodpecker species in these forests not only requires maintaining dead wood but also considering the underlying dynamics of dead wood (e.g. recruitment and degradation).

Keywords: woodpeckers, snags, snag degradation, foraging behaviour, wood-dwelling arthropods, foraging substrate

Interactions between logging and fire: their effects on the dynamics of a keystone primary excavator in the eastern boreal forest of North America

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The black-backed woodpecker (*Picoides arcticus*) is considered a fire specialist throughout its breeding range. Given its high abundance in recent burns, it has been hypothesized that these habitats may be source habitats for this primary excavator. We conducted a 3-year post-fire study in high-severity burned black spruce forests that varied in pre-fire age in central Quebec, Canada. Our objectives were (1) to evaluate the occupancy and reproductive success of black-backed woodpeckers and (2) to examine factors involved in the selection of cavity snags and nest site selection. Pre-fire forest cover conditions were an important component of the quality of black-backed woodpecker's nesting habitat. Reproductive success was higher in areas with high proportions of burned late-seral forests than in areas dominated by burned early-seral stages. Burned forests likely functioned as source habitats for the first two years following fire, although this status varied with pre-fire forest age. Post-fire forests may thus significantly contribute to black-backed woodpeckers population levels. Current forest management which reduces late-seral forest cover can affect, however, the quality of post-fire habitats important to the black-backed woodpecker and other cavity users.

Keywords: reproductive success, pre-fire conditions, fire severity, foraging tree selection, nesting tree selection, burns as source habitats

3P Sampling of downed dead wood

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The irregular form and decay of downed dead wood presents challenges for the accurate assessment of carbon and nutrient pools. The prism sweep technique of Bebber and Thomas uses a familiar variable-probability approach to sampling downed logs, but its accuracy may be limited by the assumption of Huber's equation for volume. It also requires measuring the length of tallied logs. We show how 3P (Probability Proportional to Prediction) sampling approaches to timber inventory can be adapted to dead wood inventory. 3P sampling can be used to reduce field inventory costs, and to reduce or eliminate bias associated with Huber's equation. 3P approaches may also be useful in other variable-probability sampling methods for downed wood, such as point relascope sampling.

Keywords: inventory, variable probability sampling, multistage sampling, carbon budgets, deadwood volume

Home range and stand scale effects of coarse woody debris on boreal small mammals

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Coarse woody debris (CWD) are actively selected by small mammals to protect themselves against predators, to feed, and for more efficient energy expenditures. We studied the importance of CWD for several small mammal species in the spruce-moss zone of western Quebec boreal forests. Specifically, we compared the effects of CWD on small mammals in clearcuts, partial cuts, and control stands. We analyzed small mammal abundance by using a spatially- and temporally-structured trapping system which allowed us to study the effects of CWD at two spatial scales: home range and stand. Our results showed that most sampled species were affected by well-decayed logs at different spatial scales. At the home range scale, red-backed voles (Myodes gapperi), a species usually associated with mature and undisturbed stands, consistently selected sites with the highest volumes of well-decayed logs across all three treatments. Predictions from our models suggested that patches of partial cuts composed of high volumes of well-decayed logs may maintain similar abundances of red-backed voles as patches in control stands with small volumes of logs. Meadow voles (Microtus pennsylvanicus) selected logs at the stand scale. This last observation suggested that microhabitat selection for this species was mainly driven by density-dependent factors. Our study indicated that CWD legacies should be considered as much as live tree retention when managing forests for biodiversity. We recommend maintaining patches of standing trees and snags that will contribute to CWD dynamics over time in clearcuts and partial cuts.

Keywords: woody debris, small mammals, partial cut, biodiversity

Tree mortality patterns in *Picea mariana* forests during break up stage in two regions of boreal Quebec

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During stand development, transition between mature and old-growth forest is characterized by augmentation of mortality of dominant and co-dominant trees which are established after a large perturbation. These induce notably an augmentation of dead woods, diminution of merchantable volume of wood which could affect forest management and modification of stand structure by the recruitment of new stems in the canopy. However, characterization of mortality patterns especially during break up stage is still scare. In this study we examine the temporal variation of mortality along a chronosequence of 100 years in two regions whose differ by their soil, climate and perturbation dynamic. Twenty seven stands between 100 and 200 years old on clay and till in Abitibi and northern Lac Saint-Jean were sampled. The year of death was cross-dated on 940 discs from logs and snags and potential cause of mortality were noted (e.g. senescence, wind). We expect that disturbance agents like spruce budworm outbreak or windthrow will cause episodic mortality events on an otherwise, when mortality is induce by senescence, mortality patterns will be asynchronous and continuous. Moreover, we expect that pattern of mortality will be more condensed in rich soil comparatively to less rich soil. These results imply that regional specificities have to be considered in forest management. Furthermore, development of adapted sylvicultural practice that is inspired of this mortality patterns is necessary to maintain integrity old-growth forest into managed landscape.

Keywords: black spruce, senescence, stand break up, dendrochronology, succession, boreal forest

Diversity of saproxylic coleoptera in Great Smoky Mountains National Park

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A study of saproxylic beetles was conducted during 2006 and 2007 in Great Smoky Mountains National Park, Tennessee, USA. Six sites, three each in primary and secondary forests were sampled. Emergence chambers were used to collect beetles from dead wood of two sizes (fine = 2.5-7.0 cm diameter, coarse = 8.0-20.0 cm diameter) and three decay classes from each site. Primary forest sites had a significantly higher volume of CWD than secondary sites. During two years a total of 5692 adult Coleoptera specimens representing 50 families, 226 genera, and 275+ species were collected with emergence chambers. Samples (three each) of leaf litter and CWD decay class 5 were collected at each site during fall and spring, resulting in the collection of 4263 adult Coleoptera specimens in 143+ genera. During summer 2007 flight intercept traps (FIT) were used to collect beetles at one primary and one secondary forest site resulting in the collection of 2472 adult Coleoptera specimens. Preliminary results include: 1) the collection of numerous saproxylic beetle species that are presumed to be rare, many species not previously reported from the park, and several undescribed species; 2) conclusive evidence that leaf litter and CWD decay class 5 have distinctly different beetle communities; 3) and data showing that short term FITs are a poor collection method for saproxylic beetles, but does yield beetle species not collected from litter or emergent from wood.

Keywords: coleoptera, coarse woody debris (CWD), emergence, Great Smoky Mountains National Park

Post-fire variation of coarse woody debris in oak-pine Mediterranean forest

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Wild fire is the most important disturbance in Mediterranean ecosystems acting on plant communities both in terms of diversity and structure. With time since last fire, Alepo pine (*Pinus halepensis*), which is sustained by wildfire, appears to be substituted by oaks (*Quercus ilex*; *Q. pubescens*) leading to a drop in pine numbers and biomass. Here, we test the effect of time since last fire, which alters the plant community, on the load of woody debries (WD). Tree species' dynamics should trigger the structure of the WD. The sampling design is based on Mediterranean woodlands with differing time since last disturbance: 50, 75, 85, 95 and 130 years. The date of the last disturbance was determined by the age structure of Aleppo pine populations. Coarse and fine WD was sampled according to size classes and, characterized in terms of stump, snag and log. Results show that the maximum of Aleppo pine biomass was found in plots with shorter time since the last disturbance (<75 years, which are also characterized by lower CWD). The amount of pine decreases in older plots and the CWD is inceases until the 130 year-old stand. The high value of CWD in the oldest plots is correlated to the drop in pine numbers and biomass. Fine WD tends to increase all along the chronosequence. The hazard of fire spread should increase up to 130 years after the zero event.

Keywords: Mediterranean woodland, fire events, Alepo pine, oak-pine succession, coarse woody debris, dendrochronology

National woody debris decay model for New Zealand

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Woody debris carbon pools make an important contribution to carbon stocks and changes in planted forests in New Zealand. The amount of woody debris (stem, branch and coarse root) in planted forests is dynamic and arises from thinning and harvesting activities. In order to accurately report on the woody debris pools, an improved understanding of the factors that influence the rate of decay of these dynamic carbon pools is required. *Pinus radiata* comprises 90% of the plantation forests in New Zealand. Decay rate estimates for stems using a chronosequence method and coarse roots using a time series method from P. radiata plantation forest sites over New Zealand were used to generate a national decay model. The model tested for the effect of mean annual temperature, mean annual rainfall, and diameter on the mean decay constant. Branch decay was compared to stem decay. Small to medium sized stems and branches, typical of the debris arising from thinning and harvesting operations, decayed at approximately the same rate. A larger range of stem diameters from young to mature trees showed a diameter effect on decay rate. Coarse root decay was similar or faster than stem decay. Exponential models incorporating mean annual temperature for P. radiata stems plus an initial lag time for coarse roots, provides the best estimate of woody debris decay in New Zealand. Accurately predicting woody debris carbon stocks and changes will improve full accounting of carbon pools in New Zealand's planted forests.

Keywords: decay rate model, woody debris, *Pinus radiata*, temperature, New Zealand

Distribution of wood-boring beetle damage in fire-killed black spruce (*Picea mariana* Mill.) in Northwestern Québec

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Fires in the boreal forest generate unique habitats that are quickly colonized by saproxylic coleoptera that utilize newly available dead or moribund trees to feed and reproduce. Several of these colonizing species produce larvae that feed on the phloem in the first instars before entering the xylem where they excavate deep galleries to complete their development (families *Cerambycidae*, *Buprestidae* and *Curculionidae*, genera *Scolytinae*). Recent studies show that the pattern of wood-boring beetle damage is not homogeneous throughout the landscape; some trees display high rates of attack, with several hundred entry holes within the first meter of tree trunk whereas others show very little or no damage. Although several environmental factors have been related to the observed heterogeneity, none can conclusively describe the pattern. We evaluated the relationship between fire severity/intensity (measured as scorch height), tree size, elevation and the landscape-scale distribution of beetle damage in black spruce. Sampling was carried out over the summer of 2007 in four 2-year old fires north of Chibougamau in the James Bay region of Northern Quebec. Damage was quantified in a total of 749 trees by counting entry holes within the first 1.5 meters of tree trunk. Results showed that beetle damage increased with fire intensity, tree size and elevation. Results are discussed within the framework of post-fire salvage logging management and industry standards for the grading of beetle damaged lumber.

Keywords: boreal forest, wood-boring, forest fires, beetle damage, black spruce

Old-growth characteristics of disjunct *Thuja occidentalis* stands at their northwestern distribution limit, central Canada

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Old-growth northern white-cedar (*Thuja occidentalis* L.) stands were examined in the Mid-Boreal Lowlands of west-central Manitoba. These stands represent the northwestern limit of distribution of the species are disjunct from its continuous range limit in North America. The objectives involved characterizing the vegetation – environmental relationships, forest structure and old-growth attributes of these stands. The environmental control on these communities was explored with both cluster analysis and canonical correspondence analysis. Three *T. occidentalis* stand types over 250 years of age were identified, each representing a specific moisture regime and successional pathway. *Thuja occidentalis* co-occurred with jack pine (*Pinus banksiana* Lamb.) in the xeric sites, white spruce (*Picea glauca* (Moench) Voss) and balsam fir (*Abies balsamea* (L.) Mill.) in the mesic sites, and tamarack (*Larix laricina* (Du Roi) K. Koch) in the hydric sites. Snag density, basal area, frequency of occurrence by species and decay class was determined. Coarse woody debris (CWD) was also quantified to determine volume and decay. The more productive mesic stands had larger trees, a higher density and basal area of snags and a significantly greater volume of CWD than the other two stand types. The variation of volume of deadwood found in these stands reflects the differences in site productivity and species assemblages. Being that the mesic sites were not the oldest studied the results indicate that deadwood accumulation in these forests is more reliant on stand dynamics than age.

Keywords: boreal forest, northern white-cedar, disjunct populations, old-growth, coarse woody debris, forest succession

A decade of change in the saproxylic beetle fauna of eucalypt logs in the Warra long-term log-decay experiment, Tasmania

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The first decade of eclector-trap sequential and cyclical sampling of twelve freshly-felled Eucalyptus obliqua logs at Warra, Tasmania has allowed us to document a rich but poorly described saproxylic beetle fauna, and to compare the fauna of larger-diameter (>60 cm) logs originating from mature eucalypts with that of smaller-diameter (<40 cm) logs originating from regrowth eucalypts. Neither obligately nor facultatively saproxylic beetles dominated, but predators predominated over other larval feeding guilds, and winged species predominated over functionally flightless species. The distribution of individuals among species was typically skewed. The two log-classes supported different assemblages. The mature log-class hosted consistently more species, more unique species, and proportionally more obligately saproxylic species than the regrowth log-class; this effect could not readily be attributed to having sampled a larger amount of log. Assemblages changed seasonally and year-to-year. Assemblages in the two log-classes, while following similar trajectories of change, nevertheless remained distinct at every point in time. These differences remained apparent when considering a range of sub-sets of the assemblages based on the rarity of the species involved, their flightedness, saproxylicity and larval feeding guild, indicating that all sub-sets are responsive to the log-size differences and to succession. The experiment is still in its infancy, and is intended to run for as long as it takes the logs to decay – some two hundred years.

Keywords: saproxylic beetles, decomposition, succession, tasmania, eucalyptus, long-term ecological research

A deadwoodologist's digest: an A-to-Z of learnings from a decade of research in Tasmania

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This presentation outlines findings from a decade of targeted research on dead wood, its dynamics and its biodiversity in the cool temperate eucalypt forests of Tasmania, Australia. These have many parallels with other parts of the world, but also many differences. Rather than attempting a formal synthesis from this web of research, an eclectic yet informative set of findings is presented in sequence, one or more for each letter of the alphabet. Together these provide evidence for dead wood being a fundamental and prominent component of this ecosystem, and provide pointers for how to sustain the ecological values of dead wood in managed forest landscapes.

Keywords: deadwoodology, conservation, forestry, saproxylic beetles, forest dynamics, wildfire

Patterns of tree mortality after partial cutting in northern hardwood stands along an ecological gradient: implications for deadwood recruitment

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Management of northern hardwood stands under the selection system raises concerns about the possible development of a scarcity of deadwood over the long term because of recurring stand improvement associated with harvest performed approximately 20-years or so. To address this issue, we studied dead tree recruitment 10 years after partial cutting (25 to 35% basal area) in 280 stands across southern Quebec. Recruitment of large dead trees (diameter at breast height > 29 cm) was 1.1 ha-1 yr-1 in treated stands, which is 40% lower than in untreated stands. This amount varied significantly among ecological regions. More than half of dead trees were found dead standing (snags), while others were wind-broken or uprooted. Tree-level mortality probabilities were modelled to test the significance of some tree-level, stand-level and environmental variables. On one hand, tree-level variables, such as species identity and a risk-product classification, were strongly associated with the probability of becoming a snag. Although the highest quality trees were three to five times less likely to become snags than damaged trees, they still had a considerable probability of becoming snags (1.1 to 1.6% 10 yrs-1). On the other hand, environmental variables, such as mean annual temperature and longitude, were strongly associated with the probability of a tree dying from wind-related causes (stem breakage or uprooting). Wind-related tree death was more likely in western regions with higher temperatures. Overall, our results indicate the presence of different regional dynamics of tree mortality, which has regional implications for deadwood recruitment and forest management.

Keywords: mortality, hardwood, selection cutting, snag, uneven-aged

Buried wood – or the role of bryophytes in the deadwood cycle of humid boreal forests

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Using triangular line intersect sampling (trenching), large amounts (389±39 m3 ha-1) of buried wood were found in the organic layer of 3 old-growth black spruce (Picea mariana) forests in the high-boreal forests of Labrador. Stand-replacing wildfires consumed the organic layer and killed the previous stands, producing snags, which subsequently fell and became buried by moss, resulting in large amounts of woody debris (WD) buried deep in the current organic layer. The experimental burial of 45 standardized sample logs at various depths in the organic layer showed that burial significantly decreased WD sapwood and heart temperatures, increased WD moisture content, and tended to decrease WD respiration rates (EGM-4, PP Systems). Buried wood samples collected near the bottom of the organic layer of the 3 sites were up to 450 years old (14C measurements), and had been dead for more than 200 years. The decreased respiration rates of buried sample logs and the presence of old yet well-preserved buried wood in forests where most aboveground WD decays or becomes fragmented within ~70 years of tree death indicates drastically reduced decomposition rates following WD burial by moss. Bryophytes are therefore critical in initiating the formation and accumulation of a large and long-lived buried wood carbon pool, potentially relevant to the carbon cycle of many coniferous forest ecosystems in and outside of the boreal biome.

Keywords: buried wood, radiocarbon age, wood respiration, bryophytes, carbon cycle, humid boreal forest

Disturbance history influences downed woody debris respiration

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In boreal forests, disturbances such as stand-replacing fires and clearcut harvesting create large amounts of downed woody debris (DWD), which release considerable amounts of CO_2 to the atmosphere during decomposition. Harvesting and fire differ with respect to DWD characteristics, decomposition environment, and abundance. Differences in DWD respiration rates between stands of different disturbance history can therefore be expected. From July to September 2008, we periodically measured temperatures, moisture content, weight, and respiration of 45 standardized black spruce logs placed in three old-growth (>140 years), three clearcut harvested (3 years prior), and three burned (23 years prior) black spruce stands in Labrador, Canada. Concurrently, soil temperatures, moisture potential, and respiration were measured next to each log. Moisture content was the dominant environmental control of DWD respiration, followed by temperature. Within-log differences in moisture and temperature resulted from drying of the log surface and water transfer from the moss layer to the log. Wood temperatures were higher in disturbed stands compared to old-growth stands. Piece-level DWD respiration rates were highest in harvested stands, while low DWD moisture levels limited respiration in burned stands. Compared to soil respiration, stand-level DWD respiration reached similar (post-fire) or equal (post-harvest) rates. Disturbance-induced changes in temperature and moisture regimes are reflected by DWD respiration rates, and decomposition rates of forest C models should hence be differentiated by disturbance-specific decomposition environment.

Keywords: woody debris respiration, wildfire, clearcut harvesting, disturbance

Mortality and dead wood dynamics following forest tent caterpillar outbreaks in aspen stands: A model for partial cutting?

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Forest tent caterpillar (FTC) is an important insect defoliator in boreal mixedwoods. Vast areas of aspen-dominated forests in eastern and central Canada have recently been subject to dieback and mortality following FTC outbreaks and/or drought. This study evaluated when mortality occurred around a FTC outbreak (1999-2002) in three aspen-dominated stands in Abitibi, Quebec. We also compared patterns of mortality and maintenance of standing dead wood following FTC outbreaks to light low thinning and heavy crown thinning treatments preceding the outbreak (winter 1998-99). To estimate time of death in FTC affected stands, we sampled disks and cross-dated chronologies from dead trees in 2009 with a reference chronology. Snag diameter distributions were calculated for low and high degradation snags (classes 4-6 and 7-8 respectively, according to Imbeau & Desrochers' (2002) classification). In stands affected by FTC, smaller stems died first with 35% and 62% of the dead stems < 17cm DBH dying before or during the outbreak respectively, while 24%, 39% and 37% of dead stems ≥ 17 DBH died before, during and after the FTC outbreak respectively. Stands affected by the FTC maintained higher densities of both high and low degradation snags compared to partially harvested stands, especially in diameter classes over 20cm. However, both partial cut treatments maintained large living aspen stems, thus providing for potential recruitment of large snags in the future. Finally, FTC had more of a low thinning effect, thus showing greater resemblance to the light low thinning treatment.

Keywords: forest tent caterpilar, standing dead wood, partial harvesting, timing of mortality

Insect succession in postfire black spruce forests: a 10-year study

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Fire is the most important natural disturbance affecting the dynamics of black spruce boreal forests. Within the context of wood fibre rarefaction, salvage harvesting of recently fire-killed trees in the boreal forest is a measure that helps to maintain the wood volumes needed to support industrial activities. However, a diverse insect fauna is found in burned trees and needs to be taken into account in order to avoid negative impacts of salvage harvesting on biodiversity. We studied insect succession in black spruce trees that died after a fire that occurred in early June 1999 in the Parc des Grands-Jardins, Quebec, Canada. Four trees were cut yearly from 2000 to 2004, and again in 2009, in each of three burned mature stands; 40-cm boles were then collected and reared for up to four years. In 2005, bole sections were also collected from trees cut in previous years to study insect succession in trees that fell to the ground. Results indicate that snags are rapidly colonized by several species of Cerambycidae and Scolytinae. Snags were heavily used during the first two years after fire but they became poorly used after, except by some species such as Acmaeops pratensis (a red-listed species in Europe) that increased over time. The latter species was still found in snags 10-yrs after fire. Once on the ground, boles were invaded by a variety of insects, predominantly by ants but also by several saproxylic species.

Keywords: insects, fire, black spruce, boreal forest, succession

Interactive effects of moisture, temperature and decomposition stage on respirational carbon loss from coarse woody debris (CWD) of important European tree species

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Coarse woody debris (CWD) is critical for forest ecosystem carbon (C) storage. Since its turnover is mostly driven by mineralization, changes in temperature and precipitation may influence the pools and functions of CWD. Therefore, we analysed the effect of wood temperature and moisture on the C respiration from CWD for Fagus sylvatica, Picea abies and Pinus sylvestris in different stages of decay under controlled conditions. Additionally, we measured CWD respiration over one year in the field for F. sylvatica and P. abies logs and analysed the effect of substrate specific, micro-climatic and environmental variables. The CO2 flux from beech woody debris was about two times higher than that of spruce and pine. Under controlled conditions, wood moisture exerted a stronger influence on respiration than wood temperature. In contrast, temperature was most important in the field observations. Field respiration rates of spruce and beech were similarly temperature sensitive (Q10 3.49 and 3.23). Wood density interacted with temperature to influence the CO2 flux from beech under controlled conditions, and it correlated significantly with CO2 flux from beech and spruce logs in the field. Between 60 and 70% of the whole variation in respiration under controlled conditions and in the field could be explained by stepwise linear regressions. Further, we predicted average monthly temperatures of CWD in the field very accurately from air temperature (r2=0.96), which may be highly relevant for modelling CWD-C dynamics under climate change scenarios.

Keywords: coarse woody debris (CWD), respiration, decomposition, carbon

Habitat and substrate associations of red-listed saproxylic beetles in old growth reserves and managed forests: implications for conservation

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Forestry management in Fennoscandia has become a serious threat to biodiversity, particularly threatened are species depending on coarse woody debris (saproxylics) and old growth forests. Thus, the Swedish environmental goals include the protection of remaining forests with high conservation values as well as increasing the amount of dead wood in the forest landscape. However, the relative importance of protected old growth forest areas is debated and our knowledge of habitat and substrate requirements of threatened saproxylic species is limited. To increase our knowledge, we conducted a large scale field experiments at 10 localities, each consisting of three forest types, old growth forest reserve, mature managed forest and clear-cut, in Northern Sweden. We determined the distribution of red-listed saproxylic beetles on standardised experimental substrates of spruce and birch in managed forests and reserves. During the 2001-2006 year we collected and identified ca 360 000 beetle individuals belonging to more than 930 species and of these there were ca 50 red-listed saproxylic species. Somewhat surprisingly, the abundance and species richness of red-listed species was similar in reserves and mature managed forest but lower in clear-cuts. However, the assemblages differed between the forest types, even between old growth forests and mature managed forests as well as between different dead wood substrates. Some species were clearly confined to older forest whereas others only occurred in clear-cuts. The implication of our results for the conservation of threatened saproxylic species is discussed.

Keywords: dead wood quality, forest reserves, red-listed saproxylics, conservation, biodiversity

Dead wood diversity promotes saproxylic biodiversity

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Saproxylic (wood living) species are threatened due to intensified forest management. Increasing the amount of dead wood in the managed forest landscape is therefore of high priority. However, in many cases only one type of dead wood is produced, e.g. height stumps and it is unlikely that this will be a suitable substrate for all saproxylic species of concern. To determine the relative importance of dead wood diversity we conducted a large scale field experiment at 10 locations, each consisting of three forest types, old growth forest reserve, mature managed forest and a clear-cut, in Northern Sweden. At each location we placed a total of 10 standardized experimental substrates (Birch and Spruce substrates including, high stumps, logs, inoculated with different types of wood fungi, burned or shaded). Emergence traps were used to collect insect emerging from the different dead wood substrates. During 2003-2004 we collected and identified ca 80 000 saproxylic beetle individual belonging to more than 380 species. We found clear evidence that one substrate type is insufficient to maintain saproxylic biodiversity. Many species were more or less confined to one substrate type. However, many of these early successional saproxylic species are surprisingly generalistic with regard to substrate choice. Still our results strongly suggest that it is necessary to provide diversity of substrate types in the managed forest landscape to maintain saproxylic diversity.

Keywords: saproxylic diversity, substrate preferens, snags, logs, inoculated, biodiversity

Use of tree cavities by the northern flying squirrel in the eastern Canadian boreal mixedwood forest

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Tree cavities are used as shelter and breeding nests by numerous avian and mammalian species. In cold environments, tree cavities are often proposed as the best winter nest choice because of the superior protection they offer from precipitation, wind, cold temperatures, and predators. As such, they represent a critical resource that has the potential to limit population size of non-excavating species. The objectives of this study were to assess factors affecting site occupancy in the boreal forest by northern flying squirrels, a secondary user of tree cavities, and to identify which nest type is preferred during the colder days of the autumn-winter period. We trapped flying squirrels twice in 59 aspen-dominated stands in the autumn period to determine site occupancy. A total of 85 individuals were captured on 2880 trap-nights. During the winter, we radio-tracked 26 individuals to 90 diurnal nests in 225 locations. None of the habitat variables considered (cavity availability, woody debris and lateral cover) explained site occupancy. Detectability was influenced negatively by precipitation, and was lower using high traps than low traps. However, uncertainty associated with model-averaged predictions was high. Both females and males used tree cavities (26%), external nests (39%), and ground nests (35%). In cold weather, females preferred ground nests, whereas males preferred external nests. Our results do not support the hypothesis that tree cavities represent a limiting factor to northern flying squirrels in cold environments. Instead, this species seems to be generalist and is opportunistic, using a variety of nest types.

Keywords: northern flying squirrel, boreal mixedwoods, site occupancy, cavity availability, nest web, habitat use

Contribution of Downed Woody Debris to Biomass and Nutrient Pools in Boreal Mixedwoods of Northeastern Ontario

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Harvest-related decreases in the amount of downed woody debris (DWD) in forests may have important implications for stand development and nutrient cycling; however, patterns of nutrient release from decaying DWD are poorly understood. We investigated the importance of DWD relative to other major biomass and nutrient pools in six, second-growth (36-65 year old) boreal mixedwood forest stands near Kapuskasing, Ontario. Nutrient concentrations during decay of balsam fir (*Abies balsamea*) and trembling aspen (*Populus tremuloides*) also were determined. Wood density of trembling aspen and balsam fir DWD decreased approximately exponentially with decay; however, on a per g basis, concentrations of N, P, Ca, and Mg increased with decay class, especially for aspen, whereas concentrations of K decreased. Stands had an average aboveground biomass (live biomass plus forest floor) of 180 T· ha^{-1}, with trees and DWD accounting for 84 and 4% of this quantity, respectively. Nutrient pools of aboveground biomass were: 617 kg·ha^{-1} for N; 55 kg ha^{-1} for P; 1217 kg·ha^{-1} for Ca; 95 kg·ha^{-1} for Mg ; and 321 kg·ha^{-1} for K. Tree biomass dominated the aboveground nutrient pools, with respective DWD contributions being only 3, 2, 3, 4, and 2%. Due to its large mass, soil (including the O and mineral layers) tended to dominate total ecosystem carbon and macronutrient pools, representing 43, 87, 92, and 51% of the respective nutrient pools and 91% of the carbon pool. Within the detritus pool (DWD, litter, and organic soil), soil organic matter dominated by weight (63%) and was even more dominant among macronutrient pools (69-80%). Conversely, although contributing 12% by mass, DWD contributed only 2-8% of macronutrients to this pool. These results suggest that in these closed-canopy, second growth forests, DWD comprises a relatively minor pool of nutrients compared to its contribution to carbon pools. However, the potential value of a diverse array of log species and decay classes is highlighted because of differential nutrient contributions as a function of species and time; for example, the relative high concentration of K in early decay class wood, especially for balsam fir, versus the increasing concentrations of N and P through the decay class sequence.

Keywords: downed woody debris, biomass and nutrient pools, boreal mixedwoods, wood decay

Biodiversity, structure and process: changes in saproxylic beetles, deadwood and decomposition rates following forest harvest

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The effects of forest harvest on biodiversity, forest structure and ecosystem processes are often considered independently in studies of forested ecosystems. However these three components of forested ecosystems do not work independently and especially in deadwood habitats there can be a high degree of interaction. Here, we used a network of partial cutting sites in the black spruce dominated region of north-western Quebec and monitored the response of saproxylic beetles and polypore fungi, the changes in forest structure and woody decomposition rates. We found that any amount of cutting greatly altered the saproxylic beetle assemblages and changed relative dominance of polypore fungi. Furthermore, cutting tended to increase the total amount of deadwood in the short term and change relative representation of different types of fungi. Decomposition rates also progressively increased with harvesting intensity, where total cuts had 50% higher decomposition rates than uncut stands using a stand negative exponential model of wood decay. We concluded that changes in environment caused by forest harvesting increased fungal growth rates and therefore decomposition rates. Increases in fungi also had the effect of increasing fungivore diversity and increased the total number of predators found in the cut stands. The implications of this research is that deadwood habitats will disappear faster in the cut stands threatening the large component of biodiversity which depend on deadwood habitats.

Keywords: biodiversity, saproxylic, decomposition, harvesting, beetles, fungi

Assemblage composition and diversity patterns on created dead wood in a managed forest landscape

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Different functional groups of beetles exhibit different responses to forest management and it is essential that we gain knowledge on these responses to minimize the negative impacts of forestry in boreal ecosystems. In a large-scale field experiment, we placed fresh logs in 27 stands in northern Sweden. We tested how saproxylic beetles and functional groups of beetles were affected by substrate characteristics (shaded, burnt and fungi inoculated logs and snags) in different stand types (clear-cuts, mature managed and old-growth stands). We monitored insects on the experimental logs during five years. In all years, substrate characteristics and stand type affected abundance, species richness and assemblage composition. The effect of stand type was stronger than the effect of substrate for most of the examined groups; the clear-cuts differed from the mature managed and old-growth stands, while few differences were detected between mature managed and old-growth stands. The most important substrate effect was the effect of snags, which differed from lying logs in all stand types and years. During early succession on logs, cambium consumers dominated in abundance and had different assemblages on burnt logs compared with control logs. Shading of logs was important on clear-cuts. The results suggest that in an area with intense forestry, both old-growth forest reserves and the creation of a diversity of suitable substrates in managed forests are needed to conserve functionally intact beetle assemblages.

Keywords: saproxylic beetles, functional groups, assemblage composition, dead wood creation, forest management, habitat preferences

Short-term responses of beetle assemblages to wildfire in a region with more than 100 years of fire suppression

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Suppression of wildfires in boreal landscapes has become widespread and has seriously affected many species. Little is however known about the response of organism assemblages to large wildfires in regions with a long history of effective fire suppression, such as Scandinavia. We studied the short-term effects of a >1600 ha wildfire on saproxylic beetle assemblages in northern Sweden. For two years after fire, beetles were sampled in 12 sites using large window traps, half in old pine forest stands in the burned area and half in similar, but unburned control stands. The entire beetle assemblage and seven subgroups were analyzed: saproxylics, fire favoured, strongly fire favoured, fungivores, predators, cambium consumers and red-listed species. Species composition differed between burned and unburned forests in all groups. Beetle abundance was higher in the burned area for the entire assemblage and for saproxylics, including both groups of fire favoured species, predators and cambium consumers. In contrast, species number was higher only for non-saproxylics, strongly fire favoured species, and cambium consumers. Our results show that wildfire has rapid and strong effects on a wide range of beetles. However, we trapped very few fire dependent beetles, which may suggest a lack of such species in the region, possibly due to >100 years of fire suppression. At the regional scale, the studied wildfire potentially increases the abundance of these beetles after a longer period of reproduction in the burned area.

Keywords: dead wood, saproxylic beetles, wildfire, functional groups, boreal forest, forest management

Harvest of bioenergy wood and effects on wood living insects

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To substitute fossil fuels, new assortments of wood are harvested as bioenergy, assortments formerly retained in the forest. Hitherto the main source in Scandinavia are logging residues: branches, twigs and tops, but over the last years interest has expanded to stumps. Extraction of more wood from the forest infers less habitat for organisms breeding in dead wood. However, the fauna in these types of wood is vaguely known and therefore we asked: Is this wood used by species threatened by forestry? Is it necessary to formulate recommendations to mitigate negative effects on the wood- living insect fauna? Can recommendations be based on tree species and diameter classes? Data was collected by bringing in wood samples to the lab and rearing out insects from them. Two age-classes of wood were investigated- one summer old wood and 4-5 year old wood. We found that both logging residues and stumps, retained on clear cuts, may host many species, including several red-listed. Deciduous wood was richer than coniferous especially for logging residues. Therefore we recommend that spruce can be harvested to a large extent, whereas deciduous wood, especially aspen and oak, should be retained on many areas. Diameter cannot be used for recommendations for logging residues, and probably not for the stumps either.

Keywords: bioenergy wood, insects, species numbers, tree species, diameters, successional stages

Extinction debt among wood fungi in small fragmented boreal forest stands

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Fennoscandian forests have been subject to industrial forestry for more than a century and remaining forests of high natural value are increasingly fragmented and isolated. Population dynamics are slow for some species groups, and during the rapid transformation of the forest landscape the occurrence of species may not be in synchrony with the current landscape and habitat conditions. This poses challenges to evaluating the role of small set asides where a significant extinction debt may be present. Although the theoretical foundation for an extinction debt is well established the amount of empirical data confirming its existence is limited. Based on extensive inventories of naturally fragmented forest patches in comparison with a set of more or less recently isolated fragments in the managed landscape, we evaluated the presence and magnitude of the extinction debt of wood living fungi. The results show clear evidence of a continued loss of species and decreasing population size during the first decades after isolation. Further, the results support the threat status of red-listed species as these dominated among species showing a temporal decline after isolation. Our results provide much needed empirical support for the presence of an extinction debt in small set-asides and emphasize the need to consider long term population trends in designing efficient conservation strategies.

Keywords: dead wood, sweden, fungi, fragmentation, conservation, forest management

The effect of forest management intensity on the diversity of wood-decaying fungi and dead wood decomposition (FunWood)

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Dead wood is decayed by various types of organisms such as insects, bacteria and fungi. Fungi, chiefly Basidiomycota and a few Ascomycota, play a dominant role. We will show the change in dead wood fungal diversity on logs of *Fagus sylvatica, Picea abies* and *Pinus sylvestris* along a forest management intensity gradient in Germany and its correlations with wood decay and ecosystem processes such as nitrogen cycle and organic carbon leaching. Most studies on dead wood decomposition have focused on old growth forests (primeval forests), where large amounts of dead wood are available. However, whether the decomposition patterns in dead wood are altered through patterns in fungal colonization that are related to forest management (intensity, landscape context) has not been investigated so far. We hypothesize that the diversity of wood decaying fungi increases with decreasing forest management intensity. In terms of ecosystem processes we hypothesize that wood decomposition rates as well as the degree to which wood is completely mineralized increase with fungal diversity. An alternative hypothesis to the latter is that in cases where wood decomposition is dominated by a few aggressive fungi e.g. Fomes fomentarius the wood decay rates are accelerated or in the case of *Xylariaceae* such as *Xylaria* spp. or *Ustulina* spp., a substantial part of dead wood is chemically transformed into persistent melanins, which may form a carbon sink in forests.

Keywords: fungal diversity, forest management, Germany, wood decay, dendrochronology, biodiversity exploratoration

Does dead wood leave a footprint in the soil?

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The transport of carbon from coarse woody debris logs (CWD) to the soil as well as to the soil organic carbon (SOC) pools under and beside beech (Fagus sylvatica) CWD in the NP Hainich, Germany were investigated. Drainage water under CWD was analysed for dissolved organic carbon (DOC) and in a paired sampling design soil samples were taken under and beside (control) CWD. Results showed that high DOC fluxes (76 gCm-2y-1) from CWD to the soil exist (control: 4.2 gCm-2y-1). Despite this fact, the SOC pools under CWD did not increase within a timeframe of 30 years. The DOC from CWD showed significantly higher d13C values than the control. These values reflect the isotopic differences between wood vs. litter and roots. With these isotopic differences it was possible to follow the fate of the carbon from CWD to the soil. Down to 10 cm mineral soil depth a significantly higher d13C value was found in the SOC under CWD. The carbon from CWD exchanges within 20 years about 20% of the SOC pool under the CWD without any significant changes to the SOC pool. It is probable that the exchanged carbon is completely mineralised in the soil.

Keywords: carbon cycle, dissolved organic carbon, *Fagus sylvatica*, stable carbon isotopes, soil organic carbon, carbon sequestration

Molecular diversity of saproxylic fungi and wood decay along a forest disturbance gradient

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Saproxylic pioneer fungi play a key role during wood decomposition process by structuring saproxylics communities. This research aims to understand how communities of pionneer fungi exploiting woody debris organize themselves according to deadwood dynamics as modulated by disturbance type and stand composition. This experiment takes place in stands originating from three different fire episodes along a well-documented post-fire succession. In October 2005, we deposited a total of 480 wood blocks, 240 of balsam fir (*Abies balsamea*) and 240 of trembling aspen (*Populus tremuloides*), on the forest floor in three replicates of eight treatments (natural stands, partial cut [six different treatments], and control burned). Blocks were then harvested every six months until January 2008. Using a culture-independent molecular fingerprinting approach, we assessed wood decomposition in relation to pioneer saproxylic fungal diversity and disturbance intensity. Our results underline the differences between trembling aspen and balsam fir wood with respect to factors affecting the diversity and activity of early colonizing fungi in both managed and unmanaged stands. Aspen decomposition proceeded with more efficiency than that of balsam fir as indicated by the strong relationships between time, C:N ratio, wood density, lignin/(lignin + cellulose) ratio and respiration observed for trembling aspen only. Diversity and species richness decreased over time for balsam fir. Although respiration increased with time for both wood species, the increase may result from different processes, increased competition or decomposition, depending on wood species.

Keywords: saproxylic fungi, diversity, decomposition, coarse woody debris, disturbance, boreal forest

Nutrient (N, C, S) concentrations and wood decomposition in windthrow areas in Estonia

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Total concentration of 3 chemical elements (N, C, S) and factors affecting early wood decomposition (wood density changes) were measured in standing, leaning and downed dead wood in two windthrow areas in eastern Estonia, which experienced storms on summers of 2001 and 2002. Samples for chemical analyzes and wood density measurements were taken from Norway spruce (*Picea abies* (L.) Karst.) and birch (*Petula pendula* Roth.) in 2004 and 2008. The wood samples were taken from trees located in totally damaged (TD), partly damaged (PD) and control areas with no damage (ND). Total nitrogen, carbon and sulphur content of oven- dried samples were determined by dry combustion method. Sample volume was determined by water displacement technique. Wood densities after initial period of decomposition were significantly different, depending on tree species, log or snag position, and damage severity. Snags/logs from TD area had a lower density than those from PD area. Annual decomposition rates ranged from 0.78% to 5.57% for spruce and 2.19% to 7.42% for birch. In the case of birch, average nitrogen stores increased in TD areas by 39% and in PD areas by 26%. Average nitrogen stores for spruce decreased in TD areas by 22% and in PD areas by 12%. In birch the average carbon concentration increased 5-6 years after disturbance, while for spruce the concentration stayed stable. Sulphur concentrations increased slightly in both tree species.

Keywords: windthrow, coarse woody debris, damage severity, decomposition

Nest site characteristics of the Okinawa Woodpecker Dendrocopos noguchii in the subtropical evergreen forest “Yambaru”; Consequences of land-use history and pine-wilt disease

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The Okinawa Woodpecker (OW), is the rarest extant woodpecker species, and inhabits only subtropical evergreen forests called “Yambaru” located in the northern part of Okinawa Island, south-western Japan. The breeding range of OW has been known to be restricted to primeval forest in the central mountain range of Yambaru. However, breeding was recognized recently outside of this main range. In this study, we conducted a survey of stand characteristics and land-use history of OW nest sites. We examined the OW nest site history by using 8 aerial photos (1944 ~ 2006) and forest plan maps, and also a vegetation survey around the individual nest trees. According to the land-use history results, the OW nest sites were classified into 4 categories: 1) primeval or mature forest, 2) secondary forest more than ca 40 years after clear-cut, 3) secondary forest more than ca 40 years after abandonment of farmland and 4) pine (*Pinus luchuensis*) plantation or pine mixed forest infected by pine-wilt disease. In the category 1) and 2) forests, OW nested mainly in Castanopsis sieboldii, while in the secondary forest of the category 3), *Melia azedarach* appeared to be the most important nest tree species. OW usually avoids conifer forest, but in this study, we found OW nested on pine snags in pine forests. Infection of pine-wilt disease seems to create temporal nesting habitat for OW.

Keywords: subtropical forest, pine-wilt disease, land-use history, endangered species, Okinawa Woodpecker, nest site

Population trend of the Rosalia longicorn (*Rosalia alpina*) in Switzerland

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Many threatened forest relict species dependent on old trees and dead wood suffer from habitat loss due to logging and wood harvesting. The analysis of historical and current occurrence data (relative sampling) shows a positive trend since 1900 for the populations of the popular saproxylic cerambycid Rosalia alpina in the Swiss forests. Although this species benefited from special conservation efforts and attention in the last years, the tendency started many decades before. This positive trend is ascribed to improved breeding conditions. The larvae of Rosalia longicorn are mainly dependent on old moribund and standing dead beeches that have considerably increased in Swiss forests over the last decades. Furthermore, Swiss forests are getting older and the number of trees with a diameter larger than 80 cm has doubled in the last 20 years. Although, historical data (>20 years back) about dead wood are not available, it can be assumed that with the increase of the forested area, the decrease of forest management intensity and an adapted forestry management, the amount of dead wood in Swiss forests has increased over more than 100 years. Even though quite a long time is necessary for saproxylic species to recover after a period of intensive exploitation and even though other important factors currently show a negative trend (Swiss forests become denser and darker), a primeval forest relict species such as the Rosalia longicorn is shown to be able to recover in surprisingly short time.

Keywords: relative sampling, population trend, *Rosalia alpina*, saproxylic species, Swiss forest, dead wood

Tree-microhabitats in the montane Beech-Fir forests of the Pyrenees (France): Revealing girth thresholds correlated with microhabitat occurrences

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The focus on tree microhabitats as a proxy for taxonomic biodiversity is recommended because biodiversity assessments in forests using bioindicator tools are very expensive and require taxonomic specialists. However, few quantitative data are available for forest managers to apply tree microhabitats as a criteria. We selected 10 montane sub-natural beech-fir forests that had not been logged for more than 100 years to inventory 6 tree microhabitats: carpophores of saproxylic fungi, dendrothelms, cracks, sap flow, cavities and bark loss. We inspected 2183 live trees and 526 snags on 62 plots. Only 0.85 % of the live trees carried carpophores of saproxylic fungi. 78 % of the dendrothelms were found on beech. 89 % of the cracks were observed in fir snags and 68 % of these cases involved bark in the process of peeling. There were 2.1 sap flows per ha and this microhabitat was strictly found on fir. Cavities were the most frequent microhabitat: 57 per ha on average. We found no difference between fir and beech with respect to the microhabitat formed by bark loss. We found one or more girth tree thresholds that correlated to the occurrence of each microhabitat. 81 % of these thresholds were situated above 150 cm of circumference at breast height, which is the logging circumference currently recommended by forest managers for beech and fir. When considering the whole microhabitat set, the most significant girth thresholds were 131, 188, 230 and 280 cm for beech and 312 cm for fir. We suggest conserving several large trees in managed stands.

Keywords: tree-microhabitats, beech, fir, girth thresholds

Deadwood in European forests

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Reporting of volumes of deadwood in the European states has been part of the European Ministerial Forest Process since 1998. The first presentation of deadwood in the report MCPFE/UNECE/FAO 'State of Europe's Forests 2007' revealed a great heterogeneity among countries. Furthermore the issue of 'how much is enough' was raised. At the upcoming Ministerial Conference in 2011 improved deadwood data are expected. Most importantly reporting according following the new scheme of European Forest Types should allow a better analysis. Monitoring of deadwood is also increasingly improved and harmonized in e.g. the National Forest Inventories (NFI) even if the COST action E43 demonstrated that relevant differences in definitions and assessment methods exist across the countries. At the Symposium most recent European figures on deadwood will be presented. Additionally three national 'case studies' on deadwood monitoring and assessment will be presented. Sweden, having the largest forest area of the EU member states, has been monitoring deadwood for decades through the National Forest Inventory. More details will be presented comparing e.g. protected forests with production forests. Some ideas of assessment of deadwood as an indicator on 'favorable conservation status' according to the EU Habitat Directive will also be presented. Ireland, with an ambitious forest policy, relies heavily on forest plantation of exotic tree species. Management measures to increase the amount of deadwood in Irish forests will be discussed. In Italy in a network of old-growth forests deadwood was recently assessed and compared with figures reported by the NFI in order to define suggestions for forest management policies.

Keywords: deadwood, reporting, monitoring

Deadwood as a surrogate for forest biodiversity: Meta-analysis of correlations between deadwood volume and species richness of saproxylic organisms

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Deadwood is an important component of forest ecosystems on which many forest dwelling species depend. Deadwood volume is therefore widely used as an indicator of biodiversity, notably throughout Europe. However, using deadwood as an indicator has mostly been based on boreal references, and published references for temperate forests are scarce. As a result, the magnitude of the relationship between deadwood volume and species richness remains unclear for saproxylic species. We used meta-analysis to study the correlation between deadwood volume and the species richness of saproxylic beetles and fungi relative to several covariables: biome, type of deadwood (log, snag, and stump) and decay class (fresh versus decayed). We showed that the correlation between deadwood volume and species richness of saproxylic organisms was significant but moderate (r=0.31), and that it varied slightly between logs and snags (stumps were an exception) and decay stages. However, we found a strong biome effect: deadwood volume and species richness were more correlated in boreal forests than in temperate forests. This could be attributed both to differences in the history of forest management between biomes and to varying landscape patterns. Finally, we conclude that total deadwood volume is probably not a sufficient indicator of biodiversity, and that landscape variables and other variables such as those tested here should be integrated in deadwood monitoring. In addition, further research is needed in forests to better assess the relationship between deadwood and biodiversity in order to build indicators adapted to different biome contexts.

Keywords: deadwood, species richness, biome, meta-analysis, decay stage, deadwood type

Time-since-death, decay classes and decay progression in beech and silver fir forests in the central Apennines (Italy)

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We investigated the relationship between time-since-death and morphological characteristics of *Abies alba* Mill. and *Fagus sylvatica* L. stumps in two forest stands in the central Apennines (Italy). At each site, living trees were selected and increment cores collected to build master ring-width chronologies. For both sites, cross-sections were collected from stumps. Samples were assigned to visually discernible decay classes, and their death date dendrochronologically determined. Moreover, in order to assess changes in chemical variables, cellulose, lignin, C and N content and C:N ratio were analysed during decay processes in relation to the year since death of trees and decay classes assigned in the field. Analysis of the time-since-death of the stumps suggests that the two species have similar decay rates, although A. alba past faster from class 2 to class 3. However, this study revealed a continuum of decay classes, and showed a high variability in the transition rate from one class to another. Results show how C:N ratio decreased over decades due to an increase of N. On the contrary, the C concentration in stumps remained substantially constant throughout the years. Again, lignin content remained stable while cellulose content decreased. This information helps to improve our understanding of terrestrial nutrient cycles in a Mediterranean-type mountain environment and to clarify the role of forest ecosystems, and particularly of deadwood, in carbon sequestration.

Keywords: deadwood, dendrochronology, decay progression, C:N ratio, lignin, cellulose

Boreal small mammal, fungi, and insect communities as a function of variation in downed woody debris quantity and quality

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Effects of forest management on downed woody debris (DWD) quality and quantity have the potential to affect the biota of the boreal forest. We used live-trapping of small mammals, fruiting body and DNA-based surveys of fungi on spruce logs, and insect emergence trapping of soil and spruce and aspen logs to study three forest types in boreal northeastern Ontario: mechanized-logged forests 30-40 years old, horse-logged forests 45-65 years old, and unlogged forests. Neighbourhood-scale modeling indicated that in spring, red backed voles were associated with trap stations that had abundant late decay DWD, which was most evident at sites in which this habitat element was scarce (<0.8% projected ground cover), especially horse-logged grids. Fungal sampling revealed strong effects due to sampling method, with 304 species from DNA-based sampling of 60 logs, but only 116 species from fruiting body samples of 150 logs. In both samples, wood decay type was the strongest source of variation (late decay wood had 1.8 times more species than early decay wood). Some members of the Polyporale were most abundant in unlogged sites. Insect sampling also showed strong decay-stage effects. Forest type effects for scelionid parasitic wasps may have been due to less coniferous, late decay DWD in mechanized-logged grids. Preliminary results are presented from studies in which DWD supplies are being actively manipulated.

Keywords: downed wood, forest management, small mammals, insects, fungi

Wood decay rates reconsidered: contrasting density and volume depletion

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The abundance, structure, and function of down woody debris (DWD) change continuously as a consequence of tree mortality (DWD additions) and wood decay (losses). In order to model DWD biomass depletions through time, prior studies of decay rates have focused on reductions in wood density. However, this focus overlooks volume reduction of the log itself, a critical metric for modeling structural heterogeneity and habitat diversity through time. Using a number of long-term US Forest Service studies in northern Minnesota, logs of known size, mortality date and cause of death were re-located and sampled to construct a chronosequence (1941 - 2010) of wood densities and log volumes for aspen (*Populus tremuloides*) and red pine (*Pinus resinosa*). Log diameters were measured parallel and perpendicular to the forest floor at breast height to calculate change in volume, and cross-sectional samples were returned to the laboratory to determine density. Field measurements show little volume reduction for the first 10 – 20 years after tree death. This plateau is followed by progressive collapse over subsequent decades. These volume-reduction results suggest decay patterns markedly different from existing models used to describe DWD density reduction, a conclusion that will be confirmed by analyzing density values from these same logs. Preliminary data suggest that modeling DWD depletion based on density reduction curves alone is likely to underestimate deadwood abundance, leading to inaccurate representations of fuel loads, carbon storage, and habitat availability.

Keywords: decay rates, decomposition, down woody debris, *Pinus resinosa*, *Populus tremuloides*

Debris down under: coarse woody debris loads in the cool temperate forests of Tasmania, Australia

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Tasmania is Australia's southernmost state, and much of the island experiences a cool temperate climate. Its native forests occupy a range of altitudes and occur under a range of rainfall regimes, and vary from dry open eucalypt woodland to dense rainforest. Non-stand-replacing wildfires are the predominant natural disturbance agent in most forest types, and result in mixed-age stands in which coarse woody debris (CWD) loads are highly variable in space and time. This variability has defied past attempts to evaluate CWD loads across the state. However, through a combination of experimental studies and inventory data, we have for the first time attempted to determine CWD loads across the spectrum of forest types present in Tasmanian state forests, including those managed for timber. While CWD is scarce in some forest types, typical loads in lowland wet eucalypt forest are exceptionally high by international standards, rivalling those of the Pacific Northwest. Our studies demonstrate the significant role that coarse woody debris is likely to play in both forest ecology and carbon cycling in Tasmania.

Keywords: inventory, coarse woody debris, wildfire, Tasmania

Deadwood recruitment and its spatial distribution in unmanaged and selection harvested stands of a mixed forest in northern Japan

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It's important to examine not only the amount of deadwood but also how they are spatially distributed in natural forests, and to evaluate effects of management on them. The objective of this study is to compare deadwood recruitment and its spatial distribution in unmanaged and harvested (single-tree selection cutting) stands of a fir-dominated mixed forest in northern Hokkaido, Japan. Tree inventory datasets, based on an all tree census (>= 12.5 cm in DBH) at approximately 10-year intervals, have been recorded over 30 years in an unmanaged stand (5.4 ha) and a harvested stand (6.7 ha). All trees were stem-mapped with individual identification in these stands. Spatial distribution patterns of deadwood were evaluated with Ripley's L function. The amount of deadwood recruitment during the study period in the unmanaged stand was higher than that in the harvested stand. In terms of size distribution, small trees (DBH =< 20 cm) in the harvested stand had higher mortality than that in the unmanaged stand. On the other hand, the supply of larger dead trees (DBH >=25 cm) was greater in the unmanaged stand. The spatial patterns of deadwood recruitment in the unmanaged stand exhibited a clumped distribution at scales between 20-60 m throughout the study period, while that in the harvested stand tended to shift to random distribution at scales larger than 20 m. These results suggest that tree harvesting has altered the spatial pattern of deadwood recruitment and reduced structural complexity of the harvested stand.

Keywords: spatial distribution, size distribution, structural complexity, large-scale and long-term plot study, natural conifer-broadleaved mixed forest, single-tree selection cutting

Reproductive trade-offs by red-breasted nuthatch (*Sitta canadensis*) imposed by a community-wide resource pulse of mountain pine bark beetles (*Dendroctonus ponderosae*) in interior British Columbia

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Large-scale forest insect outbreaks can result in immediate increases in food availability, and lagged increases in the availability of dead wood for insectivorous bird communities. Dead and dying trees provide a critical nesting resource for cavity-nesting communities that comprise many species of nest cavity producers, consumers, and predators. Thus forest insect outbreaks can ameliorate food and nest-site constraints, but community-wide increases in population densities may result in increases in competition and predation. We examined how a community-wide food pulse of mountain pine bark beetles (*Dendroctonus ponderosae*) influenced fecundity, competition for cavities, and nest predation for a bark insectivorous cavity-nester, red-breasted nuthatch (*Sitta canadensis*), at 30 sites in interior British Columbia, during 1995-2009. We show that nuthatch populations experienced increased reproductive output at sites with high bark beetle abundance. However, higher densities of competitors and predators at these sites led to increased competition for cavities, and increased nest predation rates. The result that nuthatches traded off lower competition and nest predation risk for higher food availability during the beetle outbreak suggests that retention of dead and dying cavity-bearing trees may be especially important during insect outbreaks for long-term maintenance of cavity-nesting communities.

Keywords: cavity-nesting birds, community ecology, disturbance, insect outbreak, resource pulse

Ecological characteristics of mushroom mite assemblage in temperate deciduous forests

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Wild mushrooms have important functions such as decomposing dead wood and providing habitat and nutrition for invertebrates. By considering mushrooms as invertebrate habitats, we can address ecological questions such as: 1) effects of habitat diversity (mushroom species richness) for inhabitants (invertebrates), 2) importance of connectivity of habitats in conservation of biodiversity (mushrooms are fragmented resources for invertebrates), and 3) a surrogate indicator of forest biodiversity. We collected mites from wild mushrooms to address these questions. Mushroom species richness was significantly correlated with mite diversity in different seasons in an old growth forest (GLM, $p = 0.0198$). Both mushroom and mite species numbers increased with forest stand age probably because the amount of resources for mushrooms including dead branches and larger dead wood increased. Some mites were collected only from mushroom fruiting bodies but not from the soil or litter around the mushrooms. Mites tended to inhabit fruiting bodies lasting for a long while (e.g., mushroom species except for Agaricales and Phallales mushrooms), generally growing on dead wood and use insects living in mushrooms and/or on dead wood for their dispersal. Therefore, biomass of dead wood could be a surrogate indicator of diversity of both decomposers and organisms associated with the decomposers.

Keywords: biodiversity, forest succession, insect, patchy habitats, phorecy, species interactions

Decomposition of above and belowground deadwood in managed Sitka spruce forests in Ireland

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In Ireland, Sitka spruce (*Picea sitchensis* (Bong.) Carr.) accounts for 52.3% of the forest estate. The decomposition and residence time of above and belowground deadwood in managed P. sitchensis forests has management implications for carbon storage, soil strength, belowground habitat, biodiversity and nutrient dynamics. This study determined the decay class density (DCd), decay rates (k), carbon fraction, carbon-nitrogen (C-N) ratio and residence time (95% decomposition) of logs, stumps and roots created from thinning. The roots were excavated and categorized into small (2-10mm), medium (10-50mm) and large (>50mm) diameter classes. The deadwood was classified into DCs, bulk density determined by volume displacement, and C-N analysis was performed on representative samples. Density and deadwood-age (ranging from fresh-17 years) were used to create single-exponential decay curves for logs, stumps and roots. The residence time was estimated using the density decay constant of the deadwood. There were significant differences ($p>0.05$) in the DCd and C-N ratio of all samples, but no difference for carbon fraction (ranging from 46-48%). The DCd and C-N ratio declined as decomposition progressed. The k was highest for logs (0.0601/yr) and lowest for small roots (0.0303/yr). The residence time was estimated at 50, 63, 99, 67 and 93 years for logs, stumps, and roots (small, medium and large), respectively. The 10-year IPCC-default decay period would appear to be an overestimation and could be increased substantially.

Keywords: residence time, decomposition rate k, aboveground, belowground, density decay curves, Sitka spruce

Restoration fire and wood-inhabiting fungi in a Swedish *Pinus sylvestris* forest

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A growing awareness of the negative consequences of efficient fire prevention in boreal Fennoscandia has resulted in an increasing use of fire as a restoration method. The primary purpose of restoration fire is to recreate features of natural forests that have been lost during long periods of fire suppression. We used the occurrence of fruiting bodies from wood-inhabiting fungi to assess the conservation value of and gain ecological information about restoration fire in a *Pinus sylvestris* dominated forest. The general pattern for the majority of the species was a drastic decline during the first two years after the restoration fire. However, our results clearly demonstrate that most of the species that declined during the first years after the fire rebounded after four years and were frequently found on charred wood. Species that increased after the fire and often occurred on charred logs were: *Antrodia sinuosa*, *Botryobasidium obtusisporum*, *Galzinia incrustans*, *Phlebia subserialis* and *Tomentella* spp. In addition, three threatened, red-listed and fire-favored species were also found on heavily charred logs: *Antrodia primaeva*, *Dichomitus squalens* and *Gloeophyllum carbonarium*. Our results indicate that fire disturbance creates a unique type of dead wood important for fungal species richness. The results also support the use of restoration fires in maintaining forest biodiversity.

Keywords: restoration fire, prescribed fire, disturbance, biodiversity, dead wood, wood-inhabiting fungi

Influence of tree characteristics and forest management on tree microhabitats

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Higher densities of tree microhabitats in unmanaged forests may explain biodiversity differences with managed forests. To better understand the determinants of this potential biodiversity indicator, we studied the influence of tree characteristics on a set of tree microhabitats (cavities, cracks, bark features) on 75 plots in managed and unmanaged French forests. We hypothesized that the number of different microhabitat types per tree and the occurrence of a given microhabitat type on a tree would be higher in unmanaged than in managed forests, and that this difference could be linked to individual tree characteristics: diameter, vitality (living versus deadwood) and species. We show that unmanaged forests contained more trees likely to host microhabitats (large trees, snags) at the stand level. However, at the tree level, forest management did not influence microhabitats; only tree characteristics did: large trees and snags contained more microhabitats. The number and occurrence of microhabitats also varied with tree species: oaks and beech generally hosted more microhabitats, but occurrence of certain types of microhabitats was higher on fir and spruce. We conclude that, even though microhabitats are not equally distributed between managed and unmanaged forests, two trees with similar characteristics in similar site conditions have the same number and probability of occurrence of microhabitats, whatever the management type. In order to preserve biodiversity, foresters could reproduce unmanaged forest features in managed forests through the conservation of specific tree types (veteran trees, snags). Tree microhabitats could also be more often targeted in sustainable forest management monitoring.

Keywords: tree microhabitats, management, snags, tree species

Diversity of bryophytes in relation to available coarse woody debris: does it differ between a post-fire and a post-clearcut forest succession?

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In the boreal forest, numerous bryophyte species are associated with downed logs and stumps as substrate but also for the fine scale humidity and light conditions they create. Managed forests differ from natural forests in the availability of dead wood as well as in the heterogeneity of available microhabitats for bryophyte colonisation. This study compared the amount of available coarse woody debris (CWD) in function of decay class and diameter in a post-fire and a post-clearcut forest succession. Secondly, the diversity of bryophytes was related to CWD amount by decay class, disturbance type and time. The study area is located in the North Shore region of the province of Quebec, Canada, in the balsam fir -white birch and spruce-moss forest domains. Eighteen sites, nine after fire and nine after clearcut, ranging in age from 20 to 80 years post-disturbance were sampled. All CWD in a 400 m2 circular plot, one per site, was measured and categorized as belonging to one of five decay classes. Bryophytes were collected within 20 subplots of 1 m2 and their associated substrates were noted. CWD volume is predicted to be higher in the post-fire chronosequence, and they will support a more diverse and abundant epixylic bryophyte community. However, as bryophytes are dispersal limited, time as well as microhabitat availability is predicted to be an important factor in determining bryophyte colonisation on CWD.

Keywords: bryophytes, diversity, epixylic, coarse woody debris, clearcut, boreal forest

Climate change mitigation: Potential effects of future plantation management on beetles associated with deadwood

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A major component of proposed climate change mitigation strategies is the greater use of wood products as a feedstock for bioenergy. Ultimately, increased land use intensity, e.g., stump removal and complete tree harvesting, may be detrimental to biodiversity. We tested the impact of increasing harvest intensity and clearfell age on saproxylic beetle diversity at a landscape scale. Clearfell age was included to assess whether those habitats acted as ecological traps whereby saproxylic beetles were destroyed during site preparation for replanting. The study was undertaken in *Pinus pinaster* forests in the Landes region of France. Beetle communities were sampled by flight intercept trapping in multiple replicates of model landscapes (radius of 3km) that had differing proportions of recent clearfell, young regenerating and mature stands. Assemblages of saproxylic beetles species in clearfells were distinct from assemblages in mature stands. This may reflect those habitats provide a large amount of specific resource (sun-exposed woody debris and stumps) compared to mature stands. The cumulative number of species was significantly higher in clearfell compared to recently planted stands, suggesting that clearfells may represent ecological traps when deadwood is destroyed prior to the emergence of saproxylic species. The degree of fragmentation of mature forest had a significant effect on the composition of saproxylic beetle assemblages. Furthermore, the species richness of saproxylophagous species in mature stand was significantly higher in landscapes containing the lowest proportion of open habitats. The latter may therefore act as a barrier to dispersion for some forest specific species.

Keywords: saproxylic beetle, clearfell, landscape ecology, forestry intensification

Accounting for dead wood (debris and snags) characteristics and quantity in managed stands: a comparison of selection cut and 2 diameter cuts in Sugar maple/Yellow birch stands of Témiscamingue

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Large woody debris provides many ecological services, forming high quality substrate for the establishment and support of multiple species. In unmanaged forests, dead wood is continuously recruited through the mortality dynamic of old and less vigorous trees. In the deciduous temperate forest, diameter limit cut (DLC) or selection cutting (SC) are often used to manage stands. In harvested stands under such partial cutting systems, large (DLC) or less vigorous trees (SC) are culled, which can limit the recruitment and quality (size and decay state) of dead pieces. This study aims at documenting the characteristics (size and decay state) and the abundance (volume and density) of dead wood (downed woody debris (DWD) and snags) in Sugar Maple/Yellow Birch stands of Témiscamingue, south-western Québec, harvested using diameter limit cut in 1980 (DLC80, selective cut) and in 1990 (DLC90, non-selective cut) and selection cut in 1990 (SC90). DWD and snags from 15 stands (5 stands/treatment, 4 sites/stands) were sampled using prism sweep, noting diameter, decay state and length. Our results show that volumes of DWD (CDL80, 57.74, CDL90, 69.3, CJ90, 56.4 m3/ha) and snags (CDL80, 15.8, CDL90, 17.9, CJ90, 23.9 m3/ha) are similar among the treatments and all lower than what was observed in unmanaged forests of this type in the literature. Snag abundance is significantly higher in SC90 (26.8/ha) than DLC80 (6.8/ha). This is explained by significantly higher snag mean diameter in DLC80 (436 mm) compared to SC90 (318 mm). We also observe significantly more decayed DWD in SC90 than DLC90, and more decayed snags in DLC (80&90) than in SC90. These results suggest that these two silvicultural treatments may impede dead wood recruitment and have different effects on dead wood quality and repartition.

Keywords: coarse woody debris, snags, selection cut, diameter cut, forest management, post harvest dynamics

Restoring boreal ecosystems using coarse woody debris: an application for oil and gas operators

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Bridging the gap between science and management is a difficult task, but it's critical that we find ways to successfully do so. In this presentation we will discuss an innovative example that seeks to develop a woody debris field guide for use in restoration projects related to the oil and gas industry in Alberta, Canada. The energy sector in Alberta has been operating on the Boreal landscape for a number of years and has a significant impact on forest resources. Traditionally, disturbances such as seismic lines have persisted for several decades and have failed to recover back to functional forests. Companies now recognize the long-term impact of such disturbances and are seeking innovative ways to restore these ecosystems. Through the use of a literature review, natural analogue curves and our existing knowledge of forest management, we developed recommendations for the use of woody debris in the restoration of these seismic lines. This project not only provides value to the scientific community through performing a review on woody debris with respect to restoration, but also to the practitioner community in the form of a highly visual field guide to implement these scientific concepts on the ground. We will discuss the results from the analysis, and the knowledge exchange process applied to this project.

Keywords: restoration ecology, knowledge exchange, oil and gas, debris management

Metapopulation dynamics and conservation of a beetle, *Osmoderma eremita*, living in hollow trees in Europe

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Osmoderma eremita is a beetle species associated with hollow trees, which has been given the highest priority according to the European Union's Habitat Directive. In managed forests, trees are cut down before they become old enough, and therefore today the species occurs mainly in old-fashioned agricultural landscapes. Based on capture-recapture and telemetric studies, we have estimated that only 15 % of adult beetles leave their natal tree for another tree. This, together with the outcome from studies on spatial occurrence patterns and population dynamics, suggest that *O. eremita* individuals in each tree may be described as a local population that is fairly independent from the populations in neighbouring trees. Individuals in a stand of trees together form a metapopulation, connected by dispersal between trees. A population viability analysis based on the present knowledge about the species' population dynamics suggested that many *O. eremita* populations in small stands will go extinct, even if the habitat quality of these stands are assumed to remain constant. However, the extinctions may take place in several decades or even a few centuries. Larger aggregations of suitable trees are necessary to provide long-term viability of *O. eremita* populations. Therefore, priority should be given to maintaining the largest sites, or to increase size and connectivity of smaller localities with potential for relatively rapid restoration.

Keywords: metapopulation, beetle, hollow tree, spatial occurrence patterns, population viability analysis, dispersal

Modeling dead wood dynamics to predict effects of biomass harvesting for energy production

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In Sweden, stumps and fine woody debris (FWD) left after clear cutting are increasingly being extracted for bioenergy purposes. We have estimated how extraction of FWD and stump harvest effects habitat availability for about 600 species of wood- and bark-inhabiting basidiomycetes, beetles and lichens in Sweden using Norway spruce (the most abundant tree species in Sweden) as their primary substrate. We combined modeling of (i) the amount of various types of woody debris available throughout a forest rotation in managed forests with (ii) a classification of each species' associations with different types of wood. The modeling of woody debris was done by equations that describe forest growth, tree mortality, natural decay of dead wood, and destruction and removal of dead wood during forestry operations. We found that extraction of FWD generated a 35–45% reduction in aboveground FWD and a more than 20% decline in the potential amount of substrate for about 50% of the species. The current situation in Sweden with extraction of 70% of Norway spruce FWD on 50% of the clear cuts probably constitutes a minor contribution to the regional extinction risks. Stump harvest has a stronger effect. The volume of dead wood removed per forest area is smaller in comparison with when FWD is extracted, but for Norway spruce, stumps constitute an important substrate for a larger number of species than FWD.

Keywords: bioenergy, computer simulation, extraction of fine woody debris, dead wood dynamics, stump harvest, habitat requirements

Effects of intensified forestry on the landscape-scale extinction risk of dead-wood dependent species

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In the future, a significant proportion of northern forests may become intensively managed through the planting of monospecific stands of native or introduced trees, and the use of multiple silvicultural treatments such as forest fertilization. Such an intensification of management in selected parts of the landscape is suggested by different zoning models, for example the TRIAD approach, which is under evaluation in some regions of North America. In this study, we predicted landscape-scale extinction risks of five hypothetical model insect species dependent on fresh dead wood from Norway spruce (*Picea abies*), by simulating colonizations and local extinctions in forest stands. Intensified forestry applied to 50 % of the spruce stands led to strongly increased extinction risks of all species during the following 150 years. For one species – the sun-exposure specialist – there were strong effects already after 50 years. The negative effects of intensive plantation forestry could be compensated for by taking greater biodiversity conservation measures in other managed forests or by setting aside more forests. This is consistent with the TRIAD model, which is according to our analyses an effective way to decrease extinction risks, especially for the short-dispersing species and the species associated with closed forest. A zoning of forest land into intensive forestry, conventional forestry, and set asides seems to be better at combining increased timber production and maintenance of biodiversity in comparison to landscapes where all production forests are managed in the same way.

Keywords: intensive plantation forestry, landscape scale, saproxylic insects, simulation study

Spatial occurrence patterns and habitat requirements of a threatened beetle, *Upis ceramboides*, in a managed boreal forest landscape

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Since forest fires are today scarce in Fennoscandia, sun-exposed dead wood on clear-cuts can be important for saproxylic species, adapted to burned forest habitats. We have investigated occurrence patterns and habitat requirements of a threatened beetle, *Upis ceramboides*, in repeated surveys 2003-2004 and 2010, in a managed boreal forest landscape in Sweden. The species has gone regionally extinct from southern Sweden. The studied population is currently the southernmost and rather isolated from the larger occurrence area in the north. *U. ceramboides* requires sun-exposed, moderately-decayed birch logs for larval development and appears to have a higher frequency of occurrence in dead wood items situated in parts of clear-cuts with highest density of suitable logs. Occurrence of the species per clear-cut is strongly dependent on amount of dead birch wood. Even time since clear-cutting is important, as *U. ceramboides* was found mostly on six to eleven year old clear-cuts. Between 2004 and 2010, we observed a clear decline in occurrence of *U. ceramboides* – from 30% to 4% of all clear-cuts. A possible factor causing the decline is habitat degradation, if the species respond with a time lag to decreasing amounts and quality of dead wood, or decreasing proportion of deciduous trees in the managed forest stands. Even changes in competitive interactions with other species, as a consequence of climate change, are plausible and could be studied further in the future.

Keywords: saproxylic insects, conservation, species decline, clear-cuts, dead wood

Response of saprophagous wood-boring beetles (Coleoptera: Cerambycidae) to severe habitat loss due to logging in aspen- and spruce-dominated landscapes

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Regional persistence of saprophagous wood-boring beetles (Coleoptera: Cerambycidae) depend on spatial and temporal connectivity between potential egg-laying hosts, i.e., standing dead trees of various decay states. Logging significantly reduces the proportion of late-seral stands in managed boreal landscapes, which results in a decreased availability of standing dead wood. As a result, dependant species may have their abundance reduced or become locally extirpated, potentially affecting the ecosystem processes/services in which they take part. We evaluated the impact of habitat loss on saprophagous cerambycid beetles in two highly fragmented landscapes under different dynamics, the first aspen-dominated, the second spruce-dominated. We expected different responses from the two landscapes, first because species associated with aspen generally uses more decayed wood, second because species associated with boreal coniferous-dominated landscapes are expected to be better adapted to large-scale disturbance, thus of higher dispersal potential. Sixty aspen and 90 spruce snags were dissected for beetle larvae. Species occurrence patterns were related to percentage of residual cover at species-specific spatial scales, identified using iterative regressions done on spatially independent snags. Our results show that some saprophagous wood-borers do react negatively to habitat loss, but that within a relatively homogenous group the response can vary significantly between species. They also show that the spatial scale at which species respond vary significantly with the species life history. Saprophagous wood-borers should be considered potentially sensitive to habitat loss, and their response to fragmentation remains to be evaluated on a longer time frame.

Keywords: saproxylic insects, forest management, dead standing trees, biodiversity, fragmentation

The hidden and unknown biodiversity of dead wood: Saproxylic Collembola in forests of Northern Hemisphere

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Thousands of arthropod species in forests use different forms of coarse woody debris. Many of them are ‘saproxylic’ forms that depend, during some parts of their life, on decaying wood, or presence of other saproxylic organisms. Saproxylic species are one of the important components of natural forests, play important roles in nutrient recycling and initial stages of decomposition. In spite of these facts many groups of dead wood -dependent invertebrates, especially microarthropods, have been little studied. Among them springtails are one of the most diverse, widespread and abundant. Recent investigations suggest that soil and litter springtails gain in importance in decomposition processes. Unfortunately, the knowledge of springtails associated with CWD is very scattered. Saproxylic springtails were investigated in North America (Oregon, H.J.Andrews Experimental Forest) and Europe (Poland, Carpathians), in fragments of ancient old-growth forests with high amount and diversity of CWD. This study allowed to investigate species richness of Collembola associated with CWD, and asses number of saproxylic springtails depending on presence of decaying wood and number of species facultatively utilizing logs. Saproxylic Collembola restricted to CWD are characterized by distinct features: absence of body pigment, strong reduction of eyes and jumping organ, relatively short antennae and legs, often dorso-ventrally flattened body shape. Some interesting taxa and the most important features of the springtail wood-dependent community: the proportion of number of species belonging to different families, life-forms and feeding habits, are presented. Additionally, description of new saproxylic springtail species is provided.

Keywords: springtails, North America, new species, saproxylic species, Europe, diversity of springtail wood-dependent community

Deadwood and fine litter dynamics following complete and partial harvesting

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Forest ecosystems play an important role in the global carbon cycle. It is expected that a shift from a single even-aged management approach towards an approach based on varying silvicultural treatments may have implications for forest C balance. Our objective was to compare the effects of harvesting prescriptions on finelitter and coarse woody debris (CWD) dynamics. The study was set in the SAFE Project, an experiment within the Lake Duparquet Research and Teaching Forest that tests an ecosystem management model based on natural dynamics. This project includes different harvesting prescriptions in three stands (aspen, post-budworm and mixed-aspen stands). At various intervals after harvesting, the following were assessed: leaf litterfall by means of litter traps; volume of CWD by triangular-transect method, finelitter and wood decomposition rates by litterbags experiment. In all stands, litterfall decreased after harvesting, reflecting residual basal area, whereas the amount of CWD, mainly small fresh debris, increased. Differences between treatments decreased with time. After 8 years, litterfall and amount of CWD showed little difference between partial harvesting and control. Treatments had no significant effect on rates of decomposition of wood blocks. However, mass losses of leaf litterbags were slightly lower in clearcut of aspen and post-budworm stands. In future, carbon pools in soils will be estimated and compared with differences between carbon inputs by litterfall and CWD recruitment and carbon outputs by decomposition in order to establish a model of carbon dynamics in boreal forest in a context of ecosystem management.

Keywords: coarse woody debris, fine litter, carbon cycle, boreal forest, ecosystem management

Past and present state of dead wood and senescent trees in the Sonian Forest (Belgium), a woodland of great importance to kings and emperors, and old-growth biodiversity

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Forests in Belgium have been scarce and intensively managed for centuries, with senescent and dead trees virtually absent. Sonian Forest, a 5000 ha forest area at the verge of Brussels, was for more than 800 years privileged to dukes, kings and Habsburg Emperors, and was of high economic and strategic, but also recreational value to them. Based on historic archive documents and extensive inventories, past and current state of overmature trees and dead wood are described. Special attention is given to an area of strict reserve that has been left unmanaged for over 25 years. In addition, specific inventories of old-growth related biodiversity (saproxylic beetles and fungi) were performed. The results show that aesthetic aspects of senescent trees played an important role in past management. At present the number and density of old trees, especially beech trees, are extraordinary high. Amounts of dead wood have been extremely low, and still are quite low with less than 10 m³/ha on average. However, in the unmanaged area, amounts have quickly increased to over 130 m³/ha, especially due to heavy windstorm events. Finally, some preliminary results from fungi and beetle inventories confirm the high potential for biodiversity that could be derived from the specific history and current state of the site : the forest proves to be one of the most important hotspot-sites for old-growth related biodiversity in the Low Countries.

Keywords: senescent trees, dead wood dynamics, forest history, saproxylic beetles, wood-decaying fungi

Deadwood cycling in old-growth temperate forests: what are the differences between diverse forest types?

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As a result of 35 years research of old-growth temperate forests we present the differences in deadwood volume, structure and decomposition rate between floodplain hardwood and mountain fir-beech forest stands. The objectives of the study were i) to quantify individual forest type cycling and ii) to evaluate the differences between CWD cycling in the two forest types. Both sites have been left to spontaneous development since the 1930s. From 1973 to 2007 three repeated measurements of standing and lying, living and dead trees (DBH ≥ 10 cm) were performed on the whole area (22+21 ha). The patterns of wood cycling were described and plotted in the form of a flow chart. Specifically the differences in rate of woody biomass cycling and the changes in dead/live volume ratio in time were compared between both forest types. Although the two sites differ significantly in natural conditions and tree species composition, the total volume of live and dead trees reached similar values. However, the rates of living tree woody biomass and CWD cycling differed markedly. The rate in alluvial hardwood forest exhibited a distinctly higher value compared to the cycling rate in mountain fir-beech forest. Over 35 years the dead/live volume ratio in alluvial hardwood forest varied little: it ranged from 0.17 to 0.26. The ratio in the mountain fir-beech forest exhibited more dynamic change: it increased from 0.25 to 0.62.

Keywords: deadwood cycling, temperate old-growth forest, deadwood structure, decomposition rate

Saproxylic beetle communities of trembling aspen deadwood

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Deadwood is a critical component of forest ecosystems, particularly as habitat for hyperdiverse saproxylic (i.e. deadwood-dependent) communities. Saproxylic beetles comprise a large proportion of forest biodiversity and have received growing attention as many species have become threatened in intensively managed boreal forests of Fennoscandinavia. However, less is known about this fauna for other areas, including North America. We sampled saproxylic beetles from targeted deadwood habitats in mature deciduous stands of the boreal mixedwood forest in northwest Alberta, Canada, using emergence traps, window traps, rearing drums, extraction funnels and destructive sampling. We assessed beetle assemblages from a wide array of deadwood habitats, ranging from declining, intact trees to nearly humified wood on the forest floor and examined habitat associations. We collected 229 saproxylic beetle species, including 5 new species to science. The saproxylic beetle community varied greatly between deadwood habitat types. Position, decay class, and diameter influenced species composition and richness. Numerous species have a strong affinity for a particular decay class and some species were indicators of large diameter deadwood. Forest management schemes should aim to maintain critical deadwood habitats over time, including the full range of decay stages of both standing and fallen deadwood, particularly large diameter wood. Effective conservation of forest biodiversity will require further understanding of the saproxylic beetle fauna, taxonomy, habitat preferences, and responses to harvesting.

Keywords: insect biodiversity, saproxylic beetles, habitat associations, community ecology, deadwood habitat

Post-harvest recovery of coarse woody material and its influence of litter dwelling arthropods

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Recovery of residual biomass following forest harvesting has been proposed as a viable means of obtaining additional fiber for multiple uses. Here we report on the initial responses of leaf litter invertebrates [spiders and carabid beetles] from a series of experimental manipulations of deadwood where residual coarse woody material (CWM) and branches were removed following clear cut and partial cut harvesting in jack pine stands in western Québec. These experiments were put in place in 2008-2009, north of LaSarre, QC and in the Lac Duparquet Research and Teaching Forest. We compared changes in overall insect composition to changes in residual volumes of CWM following experimental removals and examined changes in abundance and sex ratios of individual species. Initial comparisons of beetle and spider communities in LaSarre following biomass recovery in clearcut stands show few differences in compositional changes when compared to clear cut sites without additional biomass recovery. However, individual species such as Agonum retractum did show significant declines as a result of biomass harvesting. We also link arthropod responses from biomass removal studies to a series of partial thinning trials meant to augment CWM as a means of deadwood restoration.

Keywords: arthropods, coarse woody material (CWM), biomass harvesting, partial cutting, clear cutting

Estimating species loss of saproxylic insects under scenarios of reduced coarse woody material (CWM) in eastern boreal mixedwood forests

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Increased exploitation of forests and residual biomass has the potential to reduce biodiversity particularly of saproxylic organisms. We compare incidence-based species accumulation curves based on saproxylic flies collected using in situ emergence cages in 2006 and 2007 under two biomass harvesting scenarios. In these scenarios volume-based biomass targets would be achieved by either 1) selective removal of the largest individual pieces of coarse woody material (CWM) or alternatively 2) selective removal of smaller pieces of CWM with preferential retention of larger pieces of CWM with presumably greater conservation value. We then extrapolated a species accumulation curve to estimate thresholds of potential species loss as a function of CWM volume left within a forest stand using binomial mixing. More species would be maintained under the scenario that selectively targets larger individual pieces of CWM because of extremely large species turnover between individual sample logs and little relation between species richness and diameter of CWM. Given these circumstances, the number of individual pieces of CWM present in a stand may be more important in determining species richness than total volume of CWM for flies. When the species accumulation curve was extrapolated to stand-level volumes, species richness began to decline when CWM volumes were reduced below 40 m3/ha. We suggest that intensive management strategies aimed at recovering additional woody biomass should not exploit CWM volumes below these thresholds without mitigative measures if maintaining biodiversity is an objective.

Keywords: coarse woody debris, saproxylic biodiversity, Diptera, biomass harvesting

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The authors of each abstract are solely responsible for the content.

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Patterns of lignin degradation and oxidative enzyme activities on dead wood as a function of decay stage and fungal colonisation

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Dead wood, also referred to as coarse woody debris (CWD), is decayed by various types of organisms such as insects, bacteria and notably by fungi. Among the latter, chiefly Basidiomycota (white- and brown-rot fungi) and a few Ascomycota (soft-rot fungi) are the main wood decomposers. To accomplish lignocellulose degradation, they actively secrete different sets of oxidative and hydrolytic biocatalysts (peroxidases, laccases, polysaccharide hydrolases). Here, we report on the variability of lignin degradation and the presence of oxidative enzyme activities in dead wood in relation to fungal diversity along a forest management intensity gradient. We selected around 200 CWD logs of three tree species (Fagus sylvatica, Picea abies and Pinus sylvestris) of different decay stages and diameter in the German Biodiversity Exploratories (Schorfheide-Chorin, Hainich-Dün and Schwäbische Alb). Nine plots are in each Exploratory and represent different management intensities (unmanaged, age -class forest and selection forest). We collected representative samples (up to seven) from each log and analysed them for Klason lignin and water-soluble, lignin-borne fragments with aromatic properties (UV absorption band at 280 nm). In addition, activities of the key enzyme of lignolysis, manganese peroxidase, as well as of manganese-independent peroxidases and laccase were measured. We focus on the question: How do the contents of lignin and water-soluble aromatic CWD fragments as well as the activities of peroxidases and laccase in CWD vary with colonization patterns of wood-decaying fungi and with decay stage?

Keywords: wood decomposing fungi, oxidative enzyme activities (peroxidases, laccases), lignin degradation, Klason lignin, water-soluble lignin-borne fragments

Impact of partial cuts on xylophagous insect activity in the balsam fir-white birch domain

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To ensure an integrated management of natural resources, alternative silvicultural methods have been developed and their use has increased in recent years in Québec's forests. In this context, partial cutting aims at harvesting a predetermined percentage of wood. This method lowers the age of forest stands and opens up the canopy, leading to changes in the ecosystem. In addition, these treatments may impose additional stress to residual trees, a phenomenon known as "thinning shock", making trees more vulnerable to xylophagous insects (e.g. *Cerambycidae*, *Scolytinae*). The objective of this project is to quantify the abundance and evaluate attack rates of xylophagous insects on residual trees the year following a partial cut using recently cut logs. At the Montmorency experimental forest, near Québec City (Québec, Canada), we exposed freshly cut logs (2m in length) from three different species representative of the tree flora (balsam fir, white spruce, paper birch). The logs were placed in experimental plots characterized by a gradient of partial cuts (i.e. 0%, 25%, 40%). Xylophagous insect species specialized in trees that have reached a specific decaying state (e.g. stressed, moribund, recently dead), and consequently the composition of insect assemblages can provide reliable indications of the state of the forest stand. Bark peeling the logs allows us to determine the relative abundance and attack rates of xylophagous insects in relation to tree species and level of thinning. Preliminary results will be discussed.

Keywords: xylophagous insect, management, partial cut, logs

A test for rapid assessment of saproxylic beetle biodiversity using subsets of "monitoring species"

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Saproxylic beetles have been frequently proposed to evaluate the conservation status of temperate forest. Due to their high species richness and the lack of comprehensive literature in Europe, many beetle species can only be determined by a few experts, which makes biodiversity surveys expensive and time consuming. Therefore, there is a need to develop simple and reliable rapid-assessment techniques for biodiversity surveys to be cost-effective. Our study aimed at assessing the potential for different subsets of taxa to serve as surrogates for biodiversity assessment, and as indicators for biodiversity monitoring. Could large-scale diversity studies be financially restricted to a subset of species that mirror the diversity pattern of the entire community? We built a large scale compiled dataset (ca 80 elementary datasets, 650 plots, 1400 traps, 1000 beetle species) from biodiversity surveys or ecological studies in France and in Belgium, covering a wide range of environmental conditions (latitude, altitude, forest type…). We figured out the number of species in different predefined subsets of pragmatic species (easy-to-identify species, monitoring species defined by crossing ecological requirements, rarity and "identifiability", red-listed species, individual families and their combinations, faunal subsets derived by aggregating the beetle fauna at higher taxonomic levels (number of genera, number of families)). Over our large forest and geographical gradient, and three nested spatial scales, we analyzed the performance of surrogates using the correlation between the number of species in subsets and in the global assemblage.

Keywords: saproxylic beetles, species subsets, biodiversity surrogates, biodiversity survey, monitoring species, biodiversity indicators

Spatial segregation of three longhorned beetles in burned trees of the boreal forest

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In a context of timber's scarcity, post-fire salvage logging is increasingly used to maintain wood volumes needed to support industrial activities. However, if salvage logging is delayed, damage caused by woodborers in recently burned stems may cause considerable economic losses. In this study, we examined the spatial segregation of three major Cerambycid species, *Monochamus scuetellatus scutellatus* Say (whitespotted sawyer), *Acmaeops proteus proteus* Kirby and *Arhopalus foveicollis* Haldeman, in jack pine and black spruce trees across different burn severity (low, moderate & high) in three 2009 burns of northern boreal forest. Four trees with a diameter at breast height ranging between 15 and 20 cm were cut for each treatment (tree species × burn severity) and 30cm logs were collected at different heights along the stem of each tree. Overall, 504 logs were collected and brought to the laboratory where they have been debarked and larvae collected. Result shows that *A. foveicollis* is only present in the lowest log and mainly in lightly burned jack pine, while *A. p. proteus* is found all along the stem in all treatments. The abundance of *M. s. scutellatus* is higher on black spruce and on lightly burned trees. Its abundance decreases from the stump towards the top on spruce while it remains rather constant on pine trees. These estimates of longhorned beetle densities will help to improve salvage logging by directing operations where damages are lower.

Keywords: salvage logging, cerambycidae, boreal forest, forest fires, spatial segregation, longhorned larvae

Increased heat resistance found in mycelia from wood fungi prevalent on fire-affected substrates: a possible adaptation to forest fire?

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For a long time, forest fires have been the major stand-replacing/modifying disturbance in boreal forests. To adapt to fire disturbance, different strategies have evolved. This study focuses on wood fungi, and one of several possibilities for adaptation to forest fire: increased heat resistance in the mycelia. Sixteen species of wood fungi were selected and sorted a priori according to their prevalence on fire-affected substrates. These were isolated and re-inoculated on fresh wood before testing. Experiments were done in a series where the mycelia were exposed to 100, 140, 180, 220°C for 5, 10, 15, 20, min. A clear difference was found. The group containing species associated with fire-affected substrates had a much higher survival rate over all combinations of time and temperature compared to species with a more general ecology. Thus, these data show increased heat resistance in mycelia from species possibly adapted to forest fire. Such adaptations would have major impacts on the ecology and population dynamics of wood fungi, as well as implications for best practices in prescribed restoration burning events.

Keywords: wood fungi, restoration fire, heat resistance, adaptation, dead wood

Managing an old plantation of lapsed pollard trees to preserve the endangered beetle *Rosalia alpina* (Insecta: *Coleoptera*)

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Several saproxylic species are endangered because big mature trees have become scarce in most temperate forests as a consequence of traditional timber exploitation. This fact is exemplified by *Rosalia alpina* in the province of Gipuzkoa (Northern Spain), where in absence of alternative natural old big beechs, the species is almost confined to pollard beech woodlands, as occurs in other European regions. In Gipuzkoa, exploitation of pollard trees ceased five to seven decades ago. A large representation of old pollard trees still remains because their lack of timber value saved them from felling. This particular habitat runs the risk of dissapearing because pollard plantations contain trees mostly of the same generation, and lapsed pollards are mechanically unstable. Therefore all of them could collapse in a relatively short ecological time scale. To check what kind of pruning will extend the life of trees, three different re-pollarding techniques have been planned in 3 ha of the gipuzkoano woodland of Artaso. The population of Rosalia alpina has been censused in the summer. Both, pollard trees´and Rosalia alpina´s response, will be monitored. To date, 90 trees have been re-pollarded following two different techniques, and 31 individuals of Rosalia alpina have been registered. As more experimental strategies will be applied in the future, the plan described in this contribution is open to discussion with the assistants of the symposium to improve it next years.

Keywords: pollard trees, *Rosalia alpina*, beech trees, saproxylic

Diptera diversity associated with debris resulting from thinning and clearfell activity in commercial Sitka spruce plantations in Ireland paying particular attention to the *Mycetophilidae, Keroplatidae*, *Bolitophilidae* and *Diadocidiidae* (Diptera: Sciaroide)

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Destruction of global ecosystem functioning, biodiversity and ecosystem services is occurring at an alarming rate. This damage is most evident in highly speciose ecosystems that are typically the focus of conservation concern. Forests, in particular, house a suite of species due to the heterogeneity of their composition in terms of, habitat, microclimates and resource availability. In managed forests, habitat heterogeneity is often reduced due to successional felling. A current trend of deadwood extraction for use as biofuel is further pressuring these ecosystems, and specifically at risk are saproxylic arthropods due to their reliance on it. This study aimed to examine the dipterous fauna utilizing felling and thinning debris in commercial Sitka spruce plantations in Ireland. This habitat is particularly important in preserving species that may be lost due to forestry management operations. Using Standard Emergence Traps (S.E.Ts), we compared woody debris resulting from clearfell processes to debris from systematic thinning of stands. We examined the abundance and species richness of *Mycetophilidae*, *Keroplatidae*, *Bolitophilidae* and *Diadocidiidae* (Diptera: Sciaroidea) to test the null hypothesis that there is no difference between clearfell and thinning debris. We also investigated whether the assemblages in the debris consisted mainly of saproxylic species. Preliminary results suggest that there is a sustained fungus gnat population in thinning debris, probably feeding on the ascomycetes breaking down the woody debris. Approximately 80 species have been catalogued with potentially 5 new species to Ireland.

Keywords: emergence trapping, thinning debris, brash, Diptera, fungus gnats, *Mycetophilidae*, *Keroplatidae*, *Bolitophilidae, Diadocidiidae* (Diptera: *Sciaroidea*)

Monitoring French forest reserves to better understand deadwood dynamics

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Although the importance of deadwood for the conservation of forest dwelling species is now well-established by scientists and increasingly acknowledged by policy makers, the natural dynamics of deadwood in temperate Western European forests remains poorly known. To fill this gap, a long-term monitoring scheme has been implemented in the French forest reserves (National Nature Reserves and Strict Biological Reserves). By precisely monitoring (on average on a 10-year time scale) the flows of living biomass and deadwood, this protocol provides information on the distribution, origin, and ultimately (after the second and later measurements) on the turnover and equilibrium state (at the large spatial scale of the forest mosaic for any given forest stand) of deadwood. Furthermore, the use of permanent plots enables a spatial and temporal monitoring of stand dynamics and helps us to assess the “state of conservation” of any given stand or forest. Since its launch in 2005, 67 forest reserves have been implemented, covering all main forest stands and constituting to date a database of more than 4000 permanent plots at the national scale.

Keywords: deadwood dynamics, monitoring protocol, french forest reserves, state of conservation, national scale

Predicting dead wood volume at landscape scales using airborne-LiDAR delineated gaps in an unmanaged old growth temperate deciduous forest

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Traditionally, dead wood volume has been assessed using field sampling techniques. These inventories present high variability and provide low precision for assessing large areas. When quantifying carbon becomes a stake for ecological market equities, being able to upscale dead volume becomes an important issue. This study aims at testing the ability to predict dead wood volume at large scale using remote sensing. We tested the assumption that most dead wood found in the deciduous temperate mature forest would be associated with an opening in the canopy using a map of 164 gaps delineated from a Canopy Height Model (CHM) derived from airborne LiDAR data collected over three unmanaged old-growth temperate deciduous forest landscapes (1 km^2) in Outaouais, Québec. We then put into the relationship gap characteristics (size and ledge height) and the basal area and the number of dead wood pieces (snag and coarse woody debris (CWD)) in the gap and its surroundings (4 m). Our results show that dead wood pieces are not randomly distributed but closer to LiDAR-detected gaps; this relationship improves as the dead wood piece size increases. We successfully developed a relationship ($P<0.001$) to predict dead wood as a function of gap size, although the relationship was not as strong as expected (basal area: $R^2=0.30$ and number of pieces: $R^2=0.37$). Gap ledge height did not improve the model neither did predicting the mean size of the dead wood pieces. Combined with field sampling, our model may provide a promising solution for large scale dead wood volume inventory.

Keywords: line intersect sampling, carbon pool assessment, canopy height model, abiotic gaps

Assessment and modelling of dead wood dynamics in Swiss Nature Forest Reserves

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Coarse woody debris (CWD) is now recognized as a key structural element of forests and as an indicator of ecologically sustainable forest management. It is particularly important for biodiversity and carbon balance, especially sequestration. Currently increasing efforts are made to manage CWD as a habitat component and a carbon store in Swiss (and European) forest ecosystems. For this a basic understanding of patterns and rates of dead wood decomposition in different forests is crucial. The decomposition rate of CWD is mainly dependent on climatic (wood temperature, wood moisture) and substrate specific (tree species, decay stage, diameter) variables. Here, we analysed the influence of these factors and assessed the decomposition rate of Fagus sylvatica, Picea abies and Abies alba in three diameter classes (10-20 cm, 20-40 cm, >40 cm) along a climatic/altitudinal gradient (temperature, precipitation) and with a constructed chronosequence based on the different decay stages (and –ages) in Swiss nature forest reserves. Volume and mass loss of individual trees as well as decay stage (in 4 decay classes) were assessed based on type and year of origin in long-term permanent inventory plots. Earliest plots were established in the 1960s and were remeasured on average every 10 years since. In combination with the assessment of CWD pools (quantity and quality), recruitment rates from live trees, and fall rates of standing dead trees CWD dynamics in Swiss natural forests could be modelled.

Keywords: coarse woody debris (CWD), decomposition, modelling

Variations in decay states and vegetation capability of deadwoods in a natural mixed forest in Japan

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We investigated decay states and vegetation capability of dead woods in natural mixed forests in northern Japan. We surveyed 192 cut-stumps, consisting of 13 tree species (mainly *Abies sachalinensis, Quercus crispula, Acer mono, Betula ermanii*), recorded in a selection-cut stand established in 1970. To evaluate decay states of these stumps, we measured visual decay class (5 classes) and surface hardness. In addition, we determined water contents, wood density and CN contents of the sampled cores. The vegetation established on the stumps were also recorded. The mean decay class of the stumps supplied 5 and 35 years ago was respectively 1.20 (0.53, SD) and 4.57 (0.54). However, decay states were highly variable among stumps. In terms of wood density, some species showed no clear decline trend across the years; when species were taking together, the sapwood density of 5-year-old and 35-year-old stumps was 0.35 (0.10) and 0.34 (0.07) g/cm3, respectively. Regarding vegetation, 37 % of the stumps harbored canopy-species seedlings, 75 % of which (177 seedlings) were *B. ermanii*. The vegetation cover was highest on decay class 3 (43 % (27)), but there was again considerable variation among stumps. Results examining the effect of stump species and surrounding environmental conditions on the variations found both in decay states and established vegetation will also be presented.

Keywords: decay, vegetation, cut stump, mixed forest

Measuring wood decay and models of woody decomposition

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Numerous methods are employed for measuring wood decay and several models have been proposed to generalize woody decomposition. The most obvious method of measuring wood decay is a time series that follows pieces of wood through the decomposition process. Others have used a log chronosequence approach finding logs of different ages in similar stands and infer decomposition rates. Decomposition rates can also be estimated using a chronosequence of stands of different ages and can be combined with the time-series approach, known as the decomposition-vector method, to estimate decomposition rates. With all these approaches it becomes important to use a model that properly reflects both the data and the process of woody decomposition. The negative exponential model is the most common model, however several other models exist that have received less attention, including lag time models, double exponential models and polynomial models. Here we combine common methods of measuring decomposition in black spruce dominated forests with a 10 year time series across a 700 year chronosequence and resample two years apart. We then compared decomposition models and discuss the relative implications. Preliminary results suggest that a lag time model with a two year lag best fits the data. The implication of this model is that decay rates are actually much higher than what is found using the standard negative exponential model.

Keywords: decomposition, models, chronosequence

Impact of salvage logging on saproxylic beetles living in black spruce stumps: response of cerambycids

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Boreal forest occupies 72% of the Quebec forest territory and the exploitation of the wood represents an important economic activity. Natural disturbances such as forest fires threaten this economy, even if contributing to renewal of the ecosystems. To maintain constant wood supplies, the forest industry salvages more burned trees than ever before. The objective of this project is to characterize the ecological value of burned woody matter left after salvage, such as stumps, residual snags and down dead wood, for saproxylics beetles through time along a chronosequence of 15 years postfire. 120 trunk window traps, as a device to trap beetles, were installed in burns that prevailed in 1995, 2003, 2005, 2007, 2009 and 2010. Salvage operations were conducted in all studied burns, except those of 2009 and 2010. Sampling was done during the summer of 2010, from which more than 1 000 cerambycids were identified and distributed in 19 species. Our results show lower abundance of cerambycids in the salvaged sites from recent fires (2007) when compared to residual sites. However, no difference was observed in other postfire years. The uniformity of the environmental variables could explain parts of these results. Thus, further analyses are needed to assess the main variables affecting cerambycid distribution in postfire habitat.

Keywords: saproxylic, *Cerambycidae*, woody debris, stumps, salvage logging, fire succession

The effect of forest management intensity on the diversity of wood-decaying fungi - including the "hidden" diversity

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Dead wood is decayed by various types of organisms such as insects, bacteria and fungi. Fungi, chiefly Basidiomycota and a few Ascomycota, play a dominant role. We will show the change in dead wood fungal diversity along a forest management intensity gradient. We hypothesize that the diversity of wood decaying fungi increases with decreasing forest management intensity. Our results are based on a two year study on sites of different management intensities on three different locations in Germany. The study was carried out using logs of three tree species (*Fagus sylvatica, Picea abies,* and *Pinus sylvestris*). In addition to the 2 year fungal sporocarp monitoring we also analyzed dead wood samples using molecular methods (DNA, ARISA profiles) in order to get a view on the “hidden” diversity of fungi in dead wood logs. The comparison of these methods shows an unexpectedly low number of species which are found with both methods. We discuss the reasons for these findings and implications for monitoring fungal biodiversity in dead wood logs.

Keywords: fungal diversity, forest management intensity, sporocarps, DNA, ARISA, monitoring, biodiversity exploratories

Plasticity in growth, biomass partitioning and root architecture of yellow birch seedlings growing on decaying wood: ecological implications

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Decaying wood is a well-known microsite for the germination and establishment of small seeded trees such as yellow birch. In managed temperate deciduous forests of north-eastern America, where decaying wood is rare, forest managers routinely use scarification to expose some mineral soil to facilitate yellow birch regeneration. However, many casual observations made over the years suggest that yellow birch do not do as well on mineral soil as on decaying wood. The possible causes are not known, but we hypothesised that many root traits important for yellow birch growth and survival are improved in decaying wood compared to mineral soil, which would then improve their efficiency for gap filling. To verify our main hypothesis, we sampled seedlings growing on three different types of seedbeds (mineral soil, decaying wood and decaying wood colonised by mosses). We destructively sampled 90 seedlings for each seedbed on 6 and 14 year-old selection cuts. We measured many traits associated with growth, biomass partitioning, root architecture and survivorship of the seedlings. Our preliminary results indicate that decaying wood provides better growing conditions than mineral soil for many of the traits that we measured, and that these conditions were not associated with better light environment. Consequently, we emphasize that (i) decaying wood is playing a key role in the natural regeneration processes of the mid-shade tolerant tree species yellow birch and that (ii) this role should be integrated in the silvicultural and management practices of this species.

Keywords: *Betula alleghaniensis*, biomass partitioning, root architecture, shade tolerance, tree regeneration, seedbed

Saproxylic beetles in harvesting residues in temperate forests – effects of tree species, diameter, decay class and felling type

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Converting fossil-based energy systems into carbon-neutral systems is an essential strategy to reach targets set by the Kyoto Protocol. For nations with a forestry industry, bioenergy based on logging residues or slash harvesting has a huge potential for development. However, forest fuel harvesting may have ecological consequences, notably for saproxylic biodiversity. Indeed, it reduces the volume of deadwood and is likely to alter the deadwood profile. However the consequences of such harvesting on biotic assemblages in temperate forests remains poorly documented. We compared the species richness and composition of saproxylic beetle assemblages among different types of logging residues. We asked if logging residues have a beetle fauna of conservation interest. Samples of logging residues were collected in 60 cutting areas, located in 12 forests from northern and south-eastern France. Our sampling design crossed four main factors describing deadwood type or environmental conditions: tree species (*Quercus sp, Fagus sp, Carpinus sp, Picea abies*), diameter class (5cm, 10 cm), age class (1 year after logging, more than 5 years after logging) and stand conditions. Four felling types were studied: young improvement cutting, mature improvement cutting, regeneration cut and coppice cutting. On the basis of previous boreal results, we hypothesized that tree species and diameter are the most important variables structuring saproxylic biodiversity. Our results will lead us to discuss the role of slash retention in maintaining the saproxylic biodiversity in temperate forests.

Keywords: biodiversity, logging residues, forest fuel, *Coleoptera*, saproxylic

Stages of white spruce log decomposition and saproxylic beetle diversity

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Increasing attention is being paid to deadwood because it is an important ecological resource providing unique structural characteristics that are critical habitats for various organisms. Many studies have proved how forestry practices such as clear-cutting and salvage logging negatively affect saproxylic organisms (i.e., organisms that depend on dead or dying wood during some part of their life cycle). Nevertheless, there is little specific information about hyper-diverse saproxylic organisms in North America, especially beetles that relates to changes in community composition to different stages of deadwood decomposition. Such information is crucial for conserving biodiversity in the context of sustainable forest management because many different species including rare and threatened species occur throughout the range of decomposition stages. During 2009-2010, a total of fifty four white spruce logs ranging from decay class 1 to 6 were cut to provide bolts c. 60 cm in length and moved to rearing cages and held in forest near the EMEND camp in NW Alberta. Saproxylic beetles were sampled six times during the summer to provide specific information about the assemblages using white spruce downed deadwood ranging over a 'successional' sequence from freshly dead to well decayed.

Keywords: saproxylic beetles, white spruce, coarse woody debris, forest management, biodiversity, Canada

Deadwood in close to old-growth forest stands under Mediterranean conditions in the Italian peninsula

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This study provides some results to identify the distinctive traits of old-growth forests in the Mediterranean ecoregion. Deadwood occurrence is investigated in some forest areas that have developed in absence of anthropogenic disturbance over the past decades. Eleven study sites across the Italian peninsula were selected and records of deadwood were carried out in 1-ha size plots. Deadwood volume, types and decay stages were inventoried. The amounts of deadwood indicate a large variability among the investigated forests: the total volume ranged between 2 and 143 m^3 ha-1, with an average of 60 m^3ha-1. Lying deadwood is the most abundant component, due to the natural mortality occurring in the stands in relation to the processes established in the last decades. On the contrary, stumps are the less represented type of deadwood in almost all the study areas. All the decay classes are present in each study site. The amount of deadwood in Southern Europe, even if lower than that reported for North and Central European countries, could have a different meaning due to the faster decay rate occurring in Mediterranean forest ecosystems. For this reason, old-growth features and the characteristics of each indicator should be framed and referred to well-defined climatic and biogeographic contexts. Under the conditions here investigated, three main deadwood features characterize forest stands close to old-growth: a ratio of dead to living wood not lower than 10%; lying deadwood much more abundant than the standing one; large range of deadwood size and decay classes across all the deadwood components.

Keywords: deadwood occurrence, unharvested Mediterranean forests, sustainable forest management, forest inventory, Italian peninsula

Competition, species interaction and aging control tree mortality in boreal forests

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Tree mortality is one of the central foci in forest ecology as tree mortality alters forest structure and composition. Metabolic ecology theory is proposed to predict tree mortality in equilibrium in tropical forests. In un-equilibrium forests, previous studies have focused on the influence of resource competition on the mortality of juvenile trees, or at one stage of stand development. Using long-term permanent sampling plots data that covered a wide range of tree sizes and stand conditions, we examined the effects of competition, species interaction, and aging on individual tree mortality in un-equilibrium boreal forests. We used boosted regression tree models to partition the influence of relative basal area, stand basal area, the ratio of focal species to stand basal area, and stand age on mortality for four common boreal species. We found that relative basal area had the strongest influence on mortality, and sensitivity of size-dependent mortality decreased from shade-intolerant to shade-tolerant species. With increasing stand basal area, mortality increased for *Pinus banksiana*, *Populus tremuloides*, and *Picea mariana*, but decreased for *Betula papyrifera*. Mortality increased with increase of intra-specific neighbours in the stands for *Populus tremuloides*, *Betula papyrifera* and *Picea mariana*, but decreased for *Pinus banksiana*. Mortality also increased with stand age for all species. Our results show in un-equilibrium boreal forests, tree mortality is driven by resource competition, species interactions, and species longevity, and influences of these mechanisms differ with species' shade tolerance trait.

Keywords: Un-equilibrium forests, competition, size-dependent, intra-specific interaction, species longevity, boosted regression trees

Forest biomass extraction in boreal forests: impacts on soil nutrient status and tree growth

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Increased harvesting of forest biomass may reduce site nutrient reserves and tree growth. Our study was conducted in the boreal forest of northwestern Quebec and investigated soil nutrient status and growth and nutrition of forest regeneration following stem-only (SO) and whole tree harvesting (WTH) on sites of contrasting fertility. The study area covered three types of surfacial deposits (glaciolacustrine clays, tills and fluvioglacial sands) and three species (black spruce, jack pine and aspen). Soil sampling, growth measurements and leaf collection were performed on 117 sites that were harvested 7 to 14 years prior to the study. Whole-tree harvesting reduced forest floor dry weight and N content compared to SO harvesting. Contrary to our hypothesis, forest floor and mineral soil base cation concentrations were higher following WTH. This result may be partly explained by the abundant regeneration of trembling aspen on WTH sites as aspen leaf litter is known to increase upper soil nutrient content. Compositional nutrient diagnostic (CND) ratios, computed using foliar concentrations, were negatively affected by WTH on clay and sand sites but not on tills. However, growth of jack pine and black spruce was reduced by WTH on till sites. Because regional till is coarse-textured and generally located on upper slopes where its depth is limited, WTH could make these difficult growing conditions worse. Harvesting intensity interacts with soil fertility, vegetation and site conditions to create complex patterns of ecosystem response to whole-tree harvesting.

Keywords: forest biomass, soil fertility, nutrition, growth

"Into the wild": when ecological and sociological perceptions of forest naturalness converge

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Naturalness is widely used to assess the conservation value of forest ecosystems. As this concept encompasses ecological as well as sociological aspects, we adopted an inter-disciplinary approach to study naturalness in two french forests (one managed and one unmanaged). The aim was to know whether differences between the two forests assessed through measured ecological indicators, including stand characteristics, and public perception converged. We translated scientific language into more easily accessible terms, then interviewed 30 visitors in each forest. Many ecological and sociological perceptions did converge, notably in terms of criteria of composition, structure and function. However, more specifically, some scientific terms could not be fully transposed and some indicators of naturalness diverged between scientists and general public. The general public seems to be able to differentiate between degrees of naturalness, but studies as the one conducted here need also more influence of sociology on ecology to be fully interdisciplinary. Involving the general public in forest conservation issues could enhance understanding and avoid potential conflict.

Keywords: naturalness, sociological perception, conservation value, unmanaged forest, forest management

Landscape driven effects of saproxylic invertebrates on wood decomposition in a New Zealand production forest

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Saproxylic invertebrates are dependent on dead wood to complete their life-cycle. This dependency is either direct, as a feeding resource, or indirect as a source of habitat or food. They play key roles in important ecosystem processes such as decomposition and nutrient cycling. We are assessing how landscape context, proportion of native habitat in the surrounding landscape and edge gradients influence saproxylic beetle communities and subsequent decomposition of *Pinus radiata*. We combined two different sampling methodologies across nine replicated habitat gradients from native forest fragments into the adjacent plantation forest: 1) *P. radiata* log billets as passive traps for saproxylic invertebrates to measure decomposition, and 2) flight intercept trapping. A second component of the study was to assess host specificity and colonisation preferences of saproxylic invertebrates. Timber billets of three native tree species (*Schefflera digitata, Melicytus ramiflorus* and *Aristotelia serrata*) were placed alongside selected *P. radiata* billets. The edge response associated with native timber resources will be compared to determine if there is any interaction between edge gradient effects and colonisation preferences. For example, host specificity towards native timber, may result in some species only being found living in, and close to, native fragments, not in pine forest. A third component of the study is to determine how saproxylic invertebrate communities change with the age of the timber resource. To do this we used a chronosequence approach and collected *P. radiata* timber of a known age in the forest and sampled invertebrate community composition using emergence chambers.

Keywords: coarse woody debris, saproxylic, edge effects, fragmentation, decomposition, *Pinus radiata*

Host compatibility of eastern Canadian bark- and wood-boring insects for three European trees: Norway maple, Norway spruce, and Scots pine

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The international exchange of goods and materials is a major contributor to the introduction of invasive species. Wood packing materials, such as wood pallets, are important vectors for many bark- and wood-boring insect larvae. Notable examples of invasive insects possibly introduced through pallets are the Asian longhorn beetle and the Emerald ash borer. Once they are established and become invasive, these insects can decimate tree populations in plantations and in urban or natural areas. Before an exotic insect can establish a population, however, it must find a suitable host tree to complete its life-cycle. Many papers study the compatibility of already invasive insects with tree species in their new ranges. The current study will test a more pre-emptive approach. Our aim is to (1) create a preliminary (if incomplete) list of Nearctic xylophages from eastern Canada that could potentially establish themselves in European trees and to (2) find common life-traits among these species that could help predict what other North American species have that same potential. Most xylophagous insects are attracted to weak, dying or dead trees. Cut logs from sugar maple, black and white spruce, and jack pine will be placed in stands dominated by their respective species alongside Norway maple, Norway spruce, and Scots pine for periods of approximately two months. We will then compare species richness and abundance in both the North American and European logs. Preliminary results will be available by spring 2011 and at the conference.

Keywords: host compatibility, invasive insects, xylophagous insects

Developing natural analogues for coarse woody materials for use in restoration of boreal ecosystems

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The energy sector in Alberta has been operating on the Boreal landscape for a number of years. Several different features including well sites, pipelines and seismic lines have become commonplace on the boreal landscape. Fires have continued to operate on this boreal landscape as well. Past practices and Government policy have dictated a neat and tidy approach to managing coarse woody materials. Concerns from fire managers have dictated removal of excess woody debris. In response to this, much of the woody debris has been piled and burned or mulched in order to meet the current regulations. At the same time, many other papers have documented the importance of coarse woody materials in forests. Through this research project we established natural analogues for woody materials based on Natural Subregions in Alberta, Canada. We used forest industry volume sampling data as well as data from the Alberta Bio Monitoring Program to establish background woody debris levels in forests, and these levels were associated with different forest attributes and combinations of forest attributes. The research deliverable is a set of woody debris analogues tied to Natural Subregion. This information will also be used to establish woody debris levels for restoration of sites created by the oil and gas sector. Best management practices will be developed based on these levels and will be used to inform Government policy on managing woody debris in future energy sector programs.

Keywords: natural analogues, government policy, knowledge exchange, debris management, oil and gas

Downed deadwood: nurse logs for whom in the eastern boreal mixedwood?

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Coarse woody debris (CWD) has been recognized as a favourable substrate for germination and growth of regeneration in many forest ecosystems, a quality that has earned it the term "nurse logs". CWD presence can therefore influence forest composition and dynamics. In this study, we took advantage of a mast year in 2006 to compare the establishment and survival of seedlings of five tree species on downed logs and on the forest floor in the eastern boreal mixedwood forest. Seedling surveys were conducted in the fall 2007 and the spring and fall of 2008 in three stand types representing different successional stages: aspen; mixed aspen-fir-spruce; and post-spruce budworm fir-spruce-cedar-birch. Each log was paired with an adjacent equivalent area of forest floor. The following characteristics were measured on each log: decomposition stage, hardness, density, moisture and C:N ratio. Other characteristics measured on logs and on the forest floor included percentage of herbaceous, litter, and moss cover, and thickness of moss and leaves. Data were analyzed using logistic regressions. Probability of seedling establishment increased with wood moisture content and decreased with hardness (of logs), whereas probability of survival decreased with hardwood basal area in stands. Our results show that species that produce small seeds, such as white birch and spruce, established preferentially on dead wood, while fir established more frequently on the forest floor. Relatively open stands with high volumes of downed wood provide best conditions for seedling establishment of spruce and birch.

Keywords: coarse woody debris, regeneration, boreal mixedwood, seedlings

Insights about saproxylic biodiversity living in old-growth forests of the French Pyrenees

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To preserve saproxylic species, forest managers need deadwood standards. Ancient forests may provide relevant data about deadwood and associated species assemblages as they haven't undergone any human intervention for several decades. The aim of our study was i) to improve our knowledge of saproxylic biodiversity in ancient forests and ii) to explore the co-variation of species richness and assemblage composition of several saproxylic groups and their relationships with deadwood attributes. We sampled Fungi, Beetles, Syrphids and Bryophytes during two years (2008 and 2009) in 10 old-growth forests in the French Pyrenees : 2 beech forests, 4 mixed beech-fir forests , 3 fir forests and 1 pine forest. Cortical Lichens and vascular plants have been inventoried as they are considered to be good indicators of ancient forests. Stand characteristics and deadwood attributes have also been assessed. Despite the gradient of deadwood volume (from 20 to 230 m3/ha), no significant effect of this variable has been observed on species richness or on composition of saproxylic assemblages. By contrast, the quality of deadwood (i.e. diversity of types of deadwood) had a significant effect on composition of beetle and syrphid assemblages. Furthermore, no pattern of co-variation among taxa has been observed. Those preliminary results i) confirm the importance of deadwood quality for the conservation of saproxylic species and ii) suggest that multi-taxonomic approach are necessary if we want to established deadwood standards.

Keywords: ancient forests, multi-taxa approach, deadwood quality

Comparison of three insect trap types to survey saproxylic beetles in hollow trees

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Old hollow trees are an important habitat for many saproxylic species. Many endangered and rare insects are specialized on tree hollows and live in the walls of the hollow or in wood mold in the bottom of the hollow. Therefore, it is important to develop suitable sampling methods to study this fauna more precisely. In this study, we compare the species richness and assemblage structure of Coleoptera caught with three trap types in hollow trees. Window, aluminum foil and pitfall traps were placed inside hollow linden, maple, oak and elm trees. Altogether 15 live standing hollow trees were chosen for the study. Insects were sampled from June to September in 2006 in five urban parks located in Helsinki metropolitan area, Finland. A total of 1011 Coleoptera individuals and 117 species are identified so far, of which 867 individuals and 78 species were saproxylic. Species assemblages caught with window and aluminum foil traps were more similar to each other than with pitfall traps, which caught more species living in wood mold. Pitfall traps also caught on average less saproxylic individuals out of total beetle individuals (57%) than window (90%) and aluminum foil (95%) traps. Used trap type affected the Coleoptera species assemblage caught in hollow trees. It is important to choose the appropriate trap type for studies, and to use more than one trap type to ensure detecting as many of the species present as possible.

Keywords: saproxylic beetles, hollow trees, window trap, pitfall trap, aluminium foil trap, species assemblage

Effects of removing logging residues as a source of bioenergy on soil conditions and tree growth

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In Quebec, intensive harvesting of forest biomass represents one of the most promising sources of bioenergy. However, removal of logging residues could affect soil productivity and stand regeneration depending on site sensitivity and physiological characteristics of the regenerating species. Following harvesting, three species were planted in each of four sites across the province of Quebec. Species range from the fast-growing hybrid poplar to the less nutrient-demanding black spruce, and sites represent a gradient of climatic and edaphic conditions. Each species was exposed to eight treatments contrasting the influence of the removal of logging residues on microclimate, vegetative competition, and soil nutrients. The corresponding physiological responses of planted trees regarding tree nutrition, water stress, and growth, will be compared between species and sites. The goal is to work towards the development of guidelines for the quantity of logging residues that can be harvested depending on species and site, without affecting soil fertility and growth potential.

Keywords: forest biomass, intensive harvesting, growth potential, soil fertility

Susceptibility of upland black spruce trees to mortality induced by Armillaria root disease in the boreal plains of western Manitoba, Canada

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Armillaria spp. are a complex of fungal root and butt-rot pathogens affecting populations of upland black spruce (*Picea mariana* (Mill.) B.S.P.). In Manitoba, Duck Mountain Provincial Forest (DMPF) and Porcupine Provincial Forest (PPF) contain extensive Armillaria root disease infestation. In the Clearwater Creek operating area of DMPF, mortality and growth loss due to Armillaria root disease resulted in a volume loss of 74 m^3 per ha within infested areas. In 2007-2008, dead and living trees in 6 infection centres per region were sampled for growth and mortality analyses. In 2009, a subset of 10 infected dead and 10 uninfected living trees from two sites per region were selected for stem analysis. The objectives were 1) to assess whether tree mortality was synchronous among locations, and 2) to assess if Armillaria had an impact on growth by comparing live trees and those that have died. The onset of mortality in affected stands occurred quasi-synchronously across the sampling regions i.e. at an average of 96 and 99 years. Testing of incremental growth ratios indicated that infected trees experienced a sustained decline in basal area and volume increment 5-15 years prior to death, as compared to uninfected trees. Infected trees also reached half of their total height and volume at a significantly younger age than uninfected trees and it is speculated that increased vigour and larger root systems may have predisposed them for infection.

Keywords: *Picea mariana*, root disease, stand dynamics, dendroecology, age at mortality, growth reduction

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