Annual Meeting of the International Research Network on Cold Forests

IRN Forêts Froides

November 2–4, 2020
Online

Foreword

Dear colleagues, chers collègues,

You will find attached the program and contributions of the members of the International Research Network (IRN) on Cold Forests. We will listen to circa thirty presentations, on five themes, and will conclude with constructive discussions to produce common contributions on hot topics for cold forests. For network newcomers, and curious colleagues, you will find the history of the network on the dedicated website.

Vous trouverez ci joints le programme et les contributions des membres du groupe de recherche international sur les forêts froides. Nous entendrons une trentaine de présentations, sur cinq thèmes, et conclurons par des discussions constructives en vue de contributions communes. Pour les nouveaux arrivants dans le réseau, et les oreilles curieuses, vous trouverez l'historique du réseau sur le site web dédié.

We wish you a wonderful meeting!
Bonnes rencontres !

The organizing committee

Prof. Adam Ali : ahmed-adam.ali@umontpellier.fr
Prof. Mélanie Roy : melanie.roy@univ-tlse3.fr
Prof. Igor Drobyshev : igor.drobyshev@uqat.ca
Dr. Raphaël Chavardès : raphael.chavardes@uqat.ca
Sophie Laliberté : Sophie.Laliberte@uqat.ca

With the technical help of Jérôme Valina, Evick Mestre and Alexandre Raimbault.

Website : https://forets-froides.org/

Monday, 2nd of November

Start time: 12h UTC - 13h in France – 7h in Quebec, Canada – 20h in Shanghai, China
12h-12h10 Introduction about the IRN on Cold Forests – Adam Ali and Mélanie Roy
12h10-12h15 Helpful Zoom practices – Sophie Laliberté

Session 1. Disturbances and dynamics of cold forests

Time	Speaker	Title
12h15-12h35	Tongxin Hu	Soil respiration of the Dahurian Larch (Larix gmelinii) forest and the response to fire disturbance in high latitude boreal forest of China
12h35-12h55	Ange-Marie Botroh	Carbon losses in response to silvicultural practices in boreal forested peatlands
12h55-13h15	Mathilde Pau	A new approach suggests that climate warming could increase boreal tree growth
13h15-13h25	**Break**	
13h25-13h30	Sanghyun Kim	Continuous-cover forestry maintains soil fungal communities in Norway spruce dominated boreal forests
13h30-13h35	Akib Hasan	Legacy of the ice age: Contribution of esker lakes to aquatic biodiversity of boreal macro-invertebrates and waterbirds
13h35-13h40	Olaloudé Judicaël Osse	Predicting the spread of spruce budworm epidemics in the context of climate change
13h40-13h50	Emmanuelle Pelletier	Assessing ecological drivers of intraspecific variability in serotiny in rear-edge jack pine populations
13h50-14h10	Boris Flotterer	Modeling of boreal forest dynamics using graph transformation
14h10-14h30	Maxence Martin	Assessing structural diversity, succession and disturbance history in mixed old-growth forest landscapes of Eastern Canada using combined LiDAR and Landsat data
14h30-14h40	Maxence Martin & Junior Tremblay	An indicator species highlights continuous deadwood supply is a key ecological attribute of boreal old-growth forests

This session will end with a poster presented on the 4th of November.
Can stand species mixture attenuate the vulnerability of boreal forests to climate change and insect epidemics? by Raphael Chavardes et al.

14h40-14h50 Break

Session 2. Global change and its impacts: Socio-economical responses of cold forests facing climate change (to be continued on the 4th of November)

Time	Speaker	Title
14h50-15h10	Junior Tremblay	A Regional Comparison of the Impacts of Climate Change and Forest Harvesting on Boreal Bird Communities of Canada
15h10-15h30	Ignacio Hermoso de Mendoza	Adapting MAIDENiso to high boreal regions: Mechanistic modeling of forests and reconstructing past hydroclimate
15h30-15h50	Sylvie Gauthier	Current and future exposure of the Canadian Wildland-Human Interface (WHI) and population to wildland fires

16h UTC : 'Midi de la Foresterie', Interactions between mycorrhizal type, biogeochemical cycles and allocation, by Frank Berninger.
https://uqat.zoom.us/j/62367165429?pwd=UDNMQTZwWXdEYkdvd0k3aVdFM01Vdz09

Meeting ID : 623 6716 5429 ; Password : Midis20-21

Tuesday, 3rd of November

Session 3. Biodiversity and biogeography of cold forests: From local to global patterns

Time (UTC)	Speaker	Title
12h00-12h40	Igor Drobyshev	Trends and patterns in annually burned forest areas and fire weather across the European boreal zone in the 20th and early 21st centuries
12h20-12h40	Yves Bergeron	Influence of habitat availability and fire disturbance on the northern range boundary of eastern white cedar (Thuja occidentalis L.)
12h40-13h	Martin Philippe Girardin	A national tree-ring data repository for Canadian forests (CFS-TRenD): structure, synthesis, and applications
13h-13h10	Muriel Deslauriers	Eco-evolutionary dynamics of natural populations in the face of global climate change: the case of jack pine at its southern distribution limit
13h10-13h20	**Break**	
13h20-13h40	Magali Couture	Intraspecific variability in serotiny contributes to the long-term persistence of rear-edge jack pine populations
13h40-14h00	Fabio Gennaretti	Impact of drought on European beech forest ecosystems
14h00-14h20	Ana Verhulst-Casanova	Regional overview of the Forested peatlands of the St. Lawrence Lowlands, Quebec and a local study of a peatland strongly affected by human activities
14h20-14h40	Catherine Caron	Recent afforestation of an isolated ombrotrophic peatland in an urban matrix of the St. Lawrence Lowlands, Quebec

14h40-14H50 break

Sessions 4 & 5. Lessons from the past: Paleoecology and landscape ecology of cold forests & Adapting sylvicultural practices

Time (UTC)	Speaker	Title
14h50-15h00	Dorian Gaboriau	Temperature and fuel availability control fire size/severity in the boreal forest of central Northwest Territories, Canada
15h00-15h10	Andy Hennebelle	Learning from the present to improve paleoreconstructions
15h10-15h20	Julia Cigana	Holocene dynamics and expansion potential of the northernmost sugar maple in Abitibi-Temiscamingue
15h20-15h30	Romain Claudepierre	Origin and historical dynamics of jack pine (Pinus banksiana) at its southern limit of distribution
15h30-15h50	Tadeusz Splawinski	Modelling the potential of silvicultural practices to limit the impact of regeneration failure on forest productivity
15h50-16h00	Anoj Subedi	Assessing the historical impact of climate on the defoliation of boreal stands by the spruce budworm
16h00-16h20	Mélanie Roy	Facilitation of fir growth by ectomycorrhizal fungi in boreal forest: or how below-ground interactions could modulate species migration and establishment in a context of climate change

Wednesday, 4th of November

Session 2. Global change and its impacts: Socio-economical responses of cold forests facing climate change (to be continued on the 4th of November)

Time	Speaker	Title
13h00-13h10	Raphaël Chavardès	Can stand species mixture attenuate the vulnerability of boreal forests to climate change and insect epidemics?
13h10-13h30	William Marchand	Effects of inter-annual climate variability on physiological processes and growth performance of black spruce and jack pine in Quebec's boreal forests
13h30-13h50	Mélanie Saulnier	Presentation of the BENDYS project: The last European old-growth ("subnatural") fir-BEech forests: a loNg-term and global stuDY for their better understanding, conServation and management

13h50-14h break

Session Special issues : This session will be entirely dedicated to brainstorming and will introduce contributions to a special issue.

Time (UTC)	Speaker	Title
14h-14h45	Miguel Montoro Girona	Synthesis and brainstorming on **Natural Disturbances under Climate Change: Challenges, Trends, and Management Implications.** Presentation of a book edited by the IRN, Sustanaible forest management in the face of climate change.
14h45-15h30	Junior Tremblay	Synthesis and brainstorming on **Cold Forest Biodiversity and Conservation in a Changing Climate**
15h30-16h	Mélanie Roy and Adam Ali	Closure and perspectives on funding and project opportunities

Link to attend the zoom meeting

https://univ-tlse3-fr.zoom.us/j/81059927042?pwd=VU9MUmgySmdkYnFsYjZ6ZFVpR1FiZz09

Meeting ID: 810 5992 7042
Password: @Cold2020@

Presentations will be given with the Zoom software. If you are not familiar with how it works, it is **highly** recommended that you test its functions by clicking here: https://zoom.us/test

- Try to turn your microphone on and off
- Try to turn your camera on and off
- Try to share your screen and stop sharing

Since presenters will be based out of their homes in most cases and that the quality and speed of internet connections vary, here are a few different scenarios for presenters

- Plan A: With a good internet connection, the presenter will be able to share their own screen and control their presentation while speaking. The presenter's screen will be seen by all participants. Sound and video from the presenter will be activated. If small internet connection issues arise, the presenter's video may be disabled to improve sound quality.
- Plan B: With a weak internet connection, the presenter will share their screen and control their slides, but will join Zoom by phone for the audio part.
- Plan C: With a very poor internet connection or no internet connection, an organizing committee member will share their screen with the slides and handle slide changing. The presenter will join the meeting by phone only. In that case, it will be important to indicate when to change slides and number your slides. You will also be required to send a copy of your presentation to melanie.roy@univ-tlse3.fr and r

raphael.chavardes@uqat.ca using https://wetransfer.com/ (no registration required to send files) by the 30th of November.

Once you have done tests on Zoom, if you want to do some tests prior to the meeting, the organizing committee will be online one hour before the event starts on November 2th and 3th.

En Français

Les présentations seront données avec le logiciel Zoom. Si vous ne connaissez pas son fonctionnement, il est fortement recommandé de tester ses fonctions en cliquant ici : https://zoom.us/test

- Essayez d'allumer et d'éteindre votre microphone
- Essayez d'allumer et d'éteindre votre appareil photo
- Essayez de partager votre écran et arrêtez de partager

Puisque les présentateurs seront à distance, à leur domicile dans la plupart des cas, et que la qualité et la vitesse des connexions internet varient, voici quelques scénarios différents pour les présentateurs.

- Plan A : Avec une bonne connexion internet, le présentateur sera en mesure de partager son propre écran et de contrôler sa présentation tout en parlant. L'écran du présentateur sera vu par tous les participants. Le son et la vidéo du présentateur seront activés. Si de petits problèmes de connexion Internet surviennent, la vidéo du présentateur peut être désactivée pour améliorer la qualité sonore, ce qui règle la majorité des problèmes de son qui coupe dans la plupart des cas.
- Plan B : Avec une connexion Internet faible, le présentateur partagera son écran et contrôlera ses diapositives, mais rejoindra Zoom par téléphone pour l'audio.
- Plan C : Avec une très mauvaise connexion Internet ou aucune connexion Internet, un membre du comité organisateur partagera son écran avec les diapositives et s'occupera de changement les diapositives pour le présentateur. Le présentateur se joindra à la réunion par téléphone seulement. Dans ce cas, il sera important d'indiquer quand changer les diapositives et le numéro de vos diapositives. Vous devrez également envoyer une copie de votre présentation à melanie.roy@univ-tlse3.fr et Raphael.Chavardes@uqat.ca en utilisant https://wetransfer.com/ (aucune inscription requise pour envoyer les fichiers) d'ici 30 octobre 2020.

Une fois que vous avez fait les tests sur Zoom, si vous voulez faire quelques tests avant les présentations, le comité sera en ligne 1h avant le début des conférences pour faire les 2 et 3 novembre.

Session 1. Disturbances and dynamics of cold forests

Soil respiration of the Dahurian Larch (*Larix gmelinii*) forest and the response to fire disturbance in high latitude boreal forest of China

Presenter: Hu, Tongxin

Email: htxhtxapple@sina.com

Authors and affiliations:
College of Forestry, Northeast Forestry University

Abstract: The Da Xing'an Mountains are the largest area of boreal forests in China, which is the southern edge of the Eurasian boreal forests (a cold-temperature forest transition zone), which is sensitive to climate change. The Da Xing'an Mountains have the highest incidence of forest fires in China. Despite the importance of this ecosystem in regulating the global climate and its economic value from timber production, the effects of fire disturbance on C cycling in the high-latitude boreal forests of China have received little attention. In this study, we analysed C emission from forest fires and soil carbon balance after fire disturbance in the Da xing'an Mountains, China. Our results indicated that 1) annual CO2, CO, CH4 and NMHC emissions from forest fires during 1965-2010 was 2.12×106, 2.07×105, 1.18×104 and 4.65×103 t, which is 5.22%, 7.63%, 10.60% and 4.12% of annual national carbon emissions respectively; 2) Fire disturbance can significantly reduce the soil respiration and snow cover can increase the soil respiration during non-growing season after fire disturbance; 3) Soil carbon stocks recovered slowly after burned. The soil carbon sequestration was significantly correlated with the recovery of undergrowth vegetation after medium fire disturbance; 4) Prescribed burning in Da xing'an Mountains can not only reduce soil carbon emission, which can decrease the fire danger by reducing the fuel load, but also can decrease the soil carbon sequestration ability. Our findings demonstrated fire as potent disturbance should not be ignored in the study of the boreal forest of China, which is critical for evaluating forest post-fire C allocation. Meanwhile, a pro-active management of forest regeneration should be carried out after fire forest disturbance in this area.

Carbon losses in response to silvicultural practices in boreal forested peatlands

Presenter: Botroh, Ange-Marie

E-mail: ange-marie.botroh@uqat.ca

Authors and affiliations:
Ange-Marie Botroh - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Benoit Lafleur - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
David Paré - Canadian Forest Service, Natural Resources Canada
Yves Bergeron - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue

Abstract:
Soils of boreal forested peatland are important terrestrial carbon (C) stocks. This large terrestrial C stock results from the low decomposition of plant organic matter, mainly that of bryophytes and the accumulation of a think organic layer (OL). However, this thick OL create conditions (e.g. low nutrient availability) unfavourable for three growth, which reduces forest productivity and potential wood supply. The development of silvicultural practices that maintain or restore forest productivity (e.g. by fostering organic matter decomposition and nutrient cycling) is needed. However, there exist the risk that these practices increase forest productivity (i.e. C fixation by trees) at the expense of C loss from the organic layer, resulting in a negative C balance. In this context, forested peatland management requires a thorough understanding of how various silvicultural practices influence C fluxes.

Our objective was to assess the short-term effects of different silvicultural practices on soil carbon losses in forested peatland of northwestern Quebec. Mass loss rates of three species of bryophytes were measured for one growing season in three different treatments: (1) cut with protection of regeneration and soils (CPRS; low soil disturbance), (2) CPRS followed by mechanical soil preparation (harrowing; severe soil disturbance) and (3) unharvested controls. Carbon stocks were also evaluated.

Results show that bryophytes % mass loss was higher in the harrowing treatment (7.2 ± 0.6 %) than in control sites (3.4 ± 0.4 %); CPRS was intermediate with 5.4 ± 0.5% mass loss. Soil C stocks were lower in both the CPRS (36.2 tons/ha ± 8.42) and harrowing (64.2 tons/ha ± 15.19) than in control sites (118 tons/ha ± 25.25). However, when taking OL thickness into account, only the harrowing was significantly lower than control sites. These results show the importance of soil disturbance severity in assessing the effects of silvicultural practices on carbon loss.

A new approach suggests that climate warming could increase boreal tree growth

Presenter: Pau, Mathilde

E-mail: mathilde.pau@gmail.com

Authors and affiliations:
Mathilde Pau - University of Quebec at Montreal & Canadian Forest Service, Natural Resources Canada
Sylvie Gauthier - Canadian Forest Service, Natural Resources Canada & University of Quebec at Montreal
William Marchand - University of Quebec at Montreal & Canadian Forest Service, Natural Resources Canada
Raphael Chavardes - University of Quebec in Abitibi Temiscamingue
Yves Bergeron - University of Quebec at Montreal & University of Quebec in Abitibi Temiscamingue

Abstract:
Studies of climate change effects on boreal forest productivity are not unequivocal: some show that a longer growing season would increase growth, while others show that low water availability could limit growth. We propose a new approach using climate normals and site index rather than diameter growth to assess the impact of climate change on black spruce (*Picea mariana* [Miller] BSP) and jack pine (*Pinus banksiana* Lambert) growth, the two main tree species in boreal forests of North America. From these retrospective analyses, we forecast what could be trends in growth over the coniferous boreal forest by 2100, if the study area were entirely covered by each of the two species. The originality of our approach considers the following three variables: (1) height growth (rarely used, but nevertheless better reflecting site potential than other growth proxies); (2) climatic normals corresponding to the growth period of each stem; (3) site type, as a function of texture, stoniness and drainage, which has been shown to greatly modify the effects of climate on tree growth. The sample includes 2591 black spruces from 570 plots and 890 jack pines from 177 plots located in the temperate and boreal vegetation domains of southern Quebec (46.69–51.38°N, 79.42–60.44°W). Our results show positive effects of temperature on the growth of both species. For black spruce, temperature effects are stronger in wet conditions than in dry conditions, and growth is better on mesic and sandy sites than on rocky and sub-hydric sites. For Jack pine, growth is slower on sandy/rocky sites. Jack pine appears to be better adapted to future climatic conditions than black spruce. For these two boreal forest conifers, global warming thus appears to affect their growth positively. Our findings also provide evidence that height growth, as an integrative measure of productivity, might be a better indicator of future growth than other measures.

Predicting the spread of spruce budworm epidemics in the context of climate change

Presenter: Osse, Olaloudé Judicaël

E-mail: OlaloudeJudicaelFranck.Osse@uqat.ca

Authors and affiliations:
Olaloudé Osse - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Philippe Marchand - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Miguel Montoro Girona - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue

Abstract:
Increasing temperatures and CO2 levels, as well as changes in precipitation and the frequency and severity of extreme weather events are some of the changes caused by current climate change. These changes are having a significant impact on forest ecosystems due to longer seasons and changes in the ranges of insect species such as spruce budworm. In boreal forests, much is known about the influence of biotic and abiotic factors on spruce budworm population epidemics. Recent studies have shown that global warming has increased the timing of emergence of spruce budworm larvae. This would accentuate defoliation and consequently the severity of epidemics in the coming years. The adaptation, mitigation, and prediction of the impacts of climate change represent the greatest challenge of the boreal forest, particularly in Quebec where this forest plays a crucial economic and ecological role. Moreover, few models have been developed to predict the spread of spruce budworm. The existing ones often account for only one source of data. However, spruce budworms are integrated into complex food webs. Interactions with trophic levels, meteorological conditions, and forest structure play key roles in population dynamics. The main objective of this doctoral project is to develop a predictive model of the spatiotemporal dynamics of the spread of spruce budworm, capable of integrating several sources of data such as stand structure, biodiversity and distribution of spruce budworm host species. Such a model can then be applied to simulate epidemic periods and their impacts on the composition of forest stands under different change scenarios.

Continuous-cover forestry maintains soil fungal communities in Norway spruce dominated boreal forests

Presenter: Kim, Sanghyun

Email: sanghyun.kim@uqat.ca

Authors and affiliations:
Sanghyun Kim - Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences & Umeå Plant Science Center, Department of Plant Physiology, Umeå University & Forest Research Institute, University of Quebec in Abitibi-Temiscamingue & Centre for Forest Research, University of Quebec at Montreal
Petter E. Axelsson - Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences
Miguel M. Girona - Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences & Forest Research Institute, University of Quebec in Abitibi-Temiscamingue & Centre for Forest Research, University of Quebec at Montreal
John K. Senior - Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences

Abstract:
Traditional clear-fell forestry greatly alters community structure and ecosystem function within boreal forests and alternative management practices may reduce these impacts. Continuous-cover forestry can maintain similar invertebrate and plant communities to unmanaged forest, but whether this extends to soil fungal communities remains unclear. Within four sites across the mid-boreal zone of Sweden, we conducted a comprehensive study to assess the impact of continuous-cover and clear-felling on soil fungi and chemical properties within Norway spruce dominated forests, using unmanaged forest as a control. We sampled soils for chemical properties (pH, carbon, nitrogen, C/N and Organic matter) and used both surveys of fungal fruiting bodies and state of the DNA metabarcoding techniques to assess treatment effects on soil fungal communities. We found that forest management practices had significant effects soil pH, C and C/N ratio and that continuous-cover forestry had more similar soil properties to unmanaged forest. Furthermore, the biodiversity of fruiting bodies, as expressed by species richness and Shannon's diversity index, was higher in continuous-cover forestry and unmanaged forest compared to clear-felled areas. However, the opposite was true for the diversity of soil fungal communities, which was probably due to the high level of disturbance in clear-felled areas, and thus, ample habitat for early successional colonisers and some remnants of mature forest communities. However, in agreement with predictions we found that the composition of both fruiting body and soil fungal communities broadly similar in continuous-cover and unmanaged forest, but fundamentally different to clear-felled areas. Consequently, our findings highlight that continuous-cover forestry is an alternative to conventional practise, maintaining communities associated with unmanaged forest and mimicking natural disturbance regimes.

Web link: https://www.sciencedirect.com/science/article/pii/S0378112720314286

Legacy of the ice age: Contribution of esker lakes to aquatic biodiversity of boreal macro-invertebrates and waterbirds

Presenter: Hasan, Akib

Email: akib.hasan@uqat.ca

Authors and affiliations:
Akib Hasan - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Miguel Montoro Girona - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue & Restoration Ecology Research Group, Department of Wildlife, Fish, and Environmental Studies, Swedish University of Agricultural Sciences
Guillaume Grosbois - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue & Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences
Louis Imbeau - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue

Abstract:
Eskers are complex geological formation formed by glaciers during the last ice age about 10,000 years ago. Eskers provide now important resources in all northern countries and are considered one of the most important ecosystems economically and ecologically. This is particularly true in the Abitibi-Temiscamingue region where eskers provide drinking water and important sites for outdoor activities. This ecosystem is particularly vulnerable to human pressure such as mining and logging practices. However, there is a huge knowledge gap about the biodiversity and functioning of eskers, and baseline ecological information is lacking to build an appropriate sustainable management and conservation of those important ecosystems. Esker lakes are unique as compared to most other lakes because they are fed by groundwaters and precipitations and are thus usually not connected to other aquatic ecosystems. Esker lakes often have reduced or absent fish communities, which promotes a unique diversity and abundance of aquatic invertebrates at the base of the food web for numerous waterbirds. The objective of the study is to characterize the waterbird communities associated to esker lakes and identify the resources that determine their presence and abundance. Benthic macro-invertebrate communities will be characterized as they represent important feeding resources for waterbirds and are important ecological indicator of the lake health. The experimental design includes 50 lakes over the territory of the MRC-Abitibi including lakes situated on eskers and more typical boreal lakes situated on the clay belt. The observational point and flush count method will be applied to identify the bird communities and stable isotope analysis will permit to characterize the aquatic food web structure and links to the waterbird community. This project will permit to characterize for the first time the unique biodiversity associated to esker lakes and evaluate the state of health of those ecosystems.

Web link: https://www.researchgate.net/profile/Akib_Hasan3

Assessing ecological drivers of intraspecific variability in serotiny in rear-edge jack pine populations

Presenter: Pelletier, Emmanuelle

E-mail: emmanuelle.pelletier@uqar.ca

Authors and affiliations:
Emmanuelle Pelletier - University of Quebec at Rimouski
Guillaume de Lafontaine - University of Quebec at Rimouski

Abstract:
Rear-edge populations, located at the warm margin of a species range, are often small and isolated. They are prone to local extirpation when faced with changes in climate or perturbation regime. In the Lower Saint-Lawrence region, disjunct rear-edge jack pine stands persist locally south of the fire-prone boreal forest despite the virtual absence of wildfires, an essential part of this species' obligate pyriscent ecology. Although the species is generally serotinous, read-edge populations might exhibit lower and more variable levels of serotiny, which could contribute to the local persistence of jack pine stands despite an unfavorable fire environment. This study seeks to uncover ecological factors associated with intraspecific variability in serotiny at the rear edge of the species' distribution and assess the effect of this variability on the demographical trajectory of marginal jack pine populations. We studied 20 rear-edge sites in the Lower Saint-Lawrence region and eight sites from the core of the range in the boreal forest. At each site, we sampled nine closed cones on each of 10 individual trees. We determined the opening temperature of 1527 cones and ran germination tests on ca. 30 000 seeds to assess their viability. We tested for associations between putative physiological or environmental drivers (e.g., cone age, branch height, site location) and ecophysiological responses (cone opening temperature and seed germination rate). This study explores the importance of intraspecific variability in a reproductive trait that directly affects the fitness of a transcontinental species at its rear-edge, where populations are at the limit of their climatic envelop. We expect higher variability in the opening temperatures of the cones at the rear edge. This would be consistent with the idea that climatic stress can promote phenotypic variability, and eventually local adaptation. It would explain the persistence of marginal jack pines stands despite long fire-free intervals.

Modeling of boreal forest dynamics using graph transformation

Presenter: Flotterer, Boris

E-mail: b.flotterer@gmail.com

Authors and affiliations:
Boris Flotterer - Institute of Evolution Sciences of Montpellier, University of Montpellier
Christelle Hély - Institute of Evolution Sciences of Montpellier, University of Montpellier
Cédric Gauchrel - Botany and Modelling of Plant Architecture and Vegetation, University of Montpellier

Abstract:
Our understanding of forest dynamics is of critical importance in the context of current global change. Various models, based on different approaches, exist to understand and analyse forest processes. Here, we model ecological dynamics of meta-ecosystems using the formal technique of Graph Transformation. We build a GT model to describe how a natural meta-ecosystem (modeled as a graph) may evolve over time (modeled by GT rules), and to analyse these GT models with respect to qualitative properties such as the existence of structural stabilities. We used as components the five most representative tree species of the coniferous and mixedwood boreal forests (black spruce, jack pine, trembling aspen, white cedar and balsam fir), as well as three soil-substrate types (humus, moss and lichen). Rules represent interactions between these abiotic and biotic components (including plant regeneration), as well as fire events (crown, surface, and recurrent fires, respectively). Results of this first GT model for boreal forest show in a simplified way the dynamics that may have led to the post-glacial recolonization of the territory. They also highlight the current forest dynamics with irreversible transition from the closed-canopy coniferous moss forest to open lichen woodland, whereas mixedwood and closed-canopy coniferous forests seem to belong another but unique stability.

Assessing structural diversity, succession and disturbance history in mixed old-growth forest landscapes of Eastern Canada using combined LiDAR and Landsat data

Presenter: Martin, Maxence

E-mail: maxence.martin.phd@gmail.com

Authors and affiliations:
Maxence Martin - University of Quebec in Abitibi-Temiscamingue & University of Quebec at Chicoutimi
Osvaldo Valeria - University of Quebec in Abitibi-Temiscamingue

Abstract:
Boreal old-growth forests provide essential ecosystem services but their areas are rapidly declining in managed landscapes. These forests are also defined by a wide variety of structures, depending partially on landscape disturbance history, which need to be maintained. The objective of this study is to define a model that can identify and discriminate between different structures of boreal old-growth forests using remote sensing data. The study area is the Parc National des Monts-Valin, located in the mixed boreal forest of Quebec, Canada, as well as adjacent managed territories. Four structural classes were defined: second growth (logged between 1970 and 1980), transition forests (burned in 1920), old-growth forest (unburned for at least 120 years) and disturbed old-growth forest (unburned for at least 120 years, severe insect epidemic in 1980). A multivariate Random Forest model was used to discriminate these classes using metrics derived from LiDAR and Sentinel data on 7992 square 1 ha plots. This model demonstrated high predictive efficiency (area under the ROC curve = 93.73, overall error rate = 20.33%), correctly identifying 90% of transition and old-growth forests. The prediction rate was lowest for disturbed old-growth forests (39.7%), as most of them were classified as old-growth (59.2%). The resilience of these stands after disturbance could explain this result. Second-growth forests were also confused with old-growth forests in 39.4% of cases, probably due to the presence of residual trees and conifer dominance after the harvest. The combination of LiDAR and satellite remote sensing data therefore seems to be effective in discriminating old-growth forests defined by different structures and disturbance histories. The model presented in this study could thus contribute to better management of old boreal forests.

An indicator species highlights continuous deadwood supply is a key ecological attribute of boreal old-growth forests

Presenters: Tremblay, Junior A. & Martin, Maxence

E-mail: junior.tremblay@canada.ca

Authors and affiliations:
Maxence Martin - University of Quebec at Chicoutimi
Junior A. Tremblay - Environment and Climate Change Canada & University of Quebec at Chicoutimi
Jacques Ibarzabal - University of Quebec at Chicoutimi
Hubert Morin - University of Quebec at Chicoutimi

Abstract:
Old-growth forests are optimal habitats for woodpeckers, which are themselves excellent indicators of deadwood-associated biodiversity. Old-growth forests are, however, heterogeneous ecosystems in terms of structure, composition, and deadwood characteristics, thus implying a varied use of these forests by woodpeckers. In boreal landscapes, old-growth stands are threatened by forest harvesting; however, there is little information in regard to the consequences for biodiversity with the loss of specific types of old-growth forests. This study aims to assess how the Black-backed Woodpecker (Picoides arcticus), a biodiversity indicator species associated with old-growth forest attributes, uses different types of old-growth forests for its foraging needs. We identified woodpecker foraging marks in 24 boreal old-growth forest stands in eastern Canada that were dominated by black spruce (Picea mariana), located within the home range of the Black-backed Woodpecker. We identified the various old-growth forest types using a typology based on the structural attributes of old-growth stands. We classified the sampled stands into four old-growth forest types, corresponding to different successional stages (recent or old, relative to the onset of the old-growth stage), composition (pure black spruce or mixed black spruce–balsam fir (Abies balsamea)), and productivity (ongoing paludification or not). The Black-backed Woodpecker foraged in all types of old-growth forests, but favored dense old-growth forests that were not paludified and that showed a high temporal continuity. The continuity of the old-growth state allows for the continuous supply of large, slightly decayed snags, the preferred foraging substrates of the Black-backed Woodpecker. The old-growth forest type most favored by this woodpecker is, however, also the forest type most often targeted first by logging operations. Protecting the biodiversity associated with recent deadwood in managed areas thus requires maintaining a sufficient area and density of dense, old-growth black spruce–dominated forests in managed areas.

Can stand species mixture attenuate the vulnerability of boreal forests to climate change and insect epidemics?

Presenter: Chavardes Raphael

Email: raphael.chavardes@uqat.ca

Authors and affiliation :
Chavardès Raphaël - Université du Québec en Abitibi-Témiscamingue
Gennaretti Fabio - Université du Québec en Abitibi-Témiscamingue
Cavard Xavier - Université du Québec en Abitibi-Témiscamingue
Grondin Pierre - Ministère des Forêts, de la Faune et des Parcs
Balducci Lorena - Université du Québec à Chicoutimi
Hubert Morin - Université du Québec à Chicoutimi
Leduc Alain - Université du Québec à Montréal
Kainelainen Ari - Université du Québec en Abitibi-Témiscamingue
Charron Danielle - Université du Québec à Montréal
Châtellier Théo - École Nationale Supérieure Agronomique de Toulouse
Bergeron Yves - Université du Québec en Abitibi-Témiscamingue ; Université du Québec à Montréal

Abstract:
This research helps identify whether stand species mixture can attenuate the vulnerability of Québec's northern forest ecosystems to climate change and insect epidemics. We evaluated for a 36 km2 study area in the Nord-du-Québec, the climate-growth associations for two dominant tree species, black spruce and trembling aspen, based on the mixture of these species in stands dominated by black spruce, trembling aspen, and mixed stands composed of both species. We also compared mean basal area increments across species and stands to assess the impacts on growth by spruce budworm and forest tent caterpillar epidemics recorded in the area. We found longer growing seasons favoured black spruce growth, but summer heat stress limited that growth, especially in pure black spruce stands. Trembling aspen was less influenced by temperature and precipitation than black spruce. We also found that stand mixture attenuated the impact on growth from forest tent caterpillar epidemics. Our findings provide support for boreal forest management strategies that include stand species mixture to foster resilient forests to climate change and its indirect impacts on insect epidemics.

Session 2. Global change and its impacts: Socio-economical responses of cold forests facing climate change

A Regional Comparison of the Impacts of Climate Change and Forest Harvesting on Boreal Bird Communities of Canada

Presenter: Tremblay, Junior A.

E-mail: junior.tremblay@canada.ca

Authors and affiliations:
Junior A. Tremblay - Environment and Climate Change Canada
Yan Boulanger - Canadian Forest Service, Natural Resources Canada
Philippe Cadieux - Environment and Climate Change Canada & Canadian Forest Service, Natural Resources Canada
Dominic Cyr - Environment and Climate Change Canada
Anthony R. Taylor - Canadian Forest Service, Natural Resources Canada
Peter Solymos - University of Alberta
Diana Stralberg - Canadian Forest Service, Natural Resources Canada & University of Alberta

Abstract:
Climate change is expected to strongly influence boreal bird communities through changes in boreal forest composition and age structure in the coming decades. In this study, we use the LANDIS-II forest landscape model to project the impacts of climate change and forest harvesting on boreal bird communities in two provinces of Canada (Alberta and Québec). More specifically, we project changes in forest landscapes, and associated bird population trends according to climatic forcing scenarios (Baseline, RCP 4.5, and RCP 8.5), and different forest management scenarios. Both forest harvesting and climate-related drivers are projected to have great impacts on bird communities in both regions. Simulations projected significant changes in dominant tree species biomass, from coniferous to broadleaved deciduous, and reduction of mature / old forest stands. In Alberta, our results projected a remarkable transition of ca. 20% of the forest stands into treeless habitats mainly due to an increase in wildfire with climate change. Moreover, changes are projected to occur earlier and more drastically in western region than in eastern region of the Canadian boreal zone. Consequently, with climate change, important declines are projected for bird species associated with old forests, especially coniferous dominated ones in both regions, and a higher increase of bird species associated with early stage of forest succession and treeless habitats in western region. Furthermore, our results shown that impacts of climate change and forest harvesting may impact species differently between across their range, and regional-specific measures should be implemented to ensure adequate conservation of climate-sensitive species.

Adapting MAIDENiso to high boreal regions: Mechanistic modeling of forests and reconstructing past hydroclimate

Presenter: Hermoso de Mendoza, Ignacio

Email: hermoso_de_mendoza_naval.ignacio@courrier.uqam.ca

Authors and affiliations:
Ignacio Hermoso de Mendoza - University of Quebec at Montreal
Etienne Boucher - University of Quebec at Montreal
Fabio Gennaretti - University of Quebec in Abitibi-Temiscamingue
Alienor Lavergne - Imperial College London
Laia Andreu-Hayles - University of Columbia

Abstract:
The ecophysiological forest model MAIDENiso (Modeling and Analysis In DENdroecology + isotopes) uses a set of mechanistic rules to simulate the production, allocation and growth of virtual trees. MAIDENiso is adapted to the boreal tree species Picea mariana Mill. (Black spruce), but lacks a hydrological module adapted for boreal meteorological conditions. With the recent addition of a snow/ice module, MAIDENiso is now capable of realistically simulating snow cover and discharge in high latitude regions, while at the same time capturing climate-sensitive processes such as the enrichment of heavy water isotopes due to snow sublimation. We have applied the new version of MAIDENiso to a variety of sites in Quebec, Alaska and West Canada, where the available meteorological records of snow and tree ring records (ring widths and stable isotopes) can be used to calibrate the model. The successful reconstruction of the tree ring records during the instrumental period allows us to use an inversion algorithm (based on a Metropolis Hastings random walk) to estimate past hydroclimate conditions that are in line with physiological and hydrological processes of high boreal regions. We apply this methodology to a millennial chronology of tree ring width and cellulose isotopes from sub-fossil tree remains in North Quebec, and produce an updated hydroclimate reconstruction of the last 1000 years in this region.

Current and future exposure of the Canadian Wildland-Human Interface (WHI) and population to wildland fires

Presenter: Gauthier, Sylvie

E-mail: Sylvie.gauthier2@canada.ca

Authors and affiliations:
Sandy Erni - Canadian Forest Service, Natural Resources Canada
Lynn Johnston - Canadian Forest Service, Natural Resources Canada
Yan Boulanger - Canadian Forest Service, Natural Resources Canada
Francis Manka - Canadian Forest Service, Natural Resources Canada
Pierre Bernier - Canadian Forest Service, Natural Resources Canada
Brian Eddy - Canadian Forest Service, Natural Resources Canada
Amy Cardinal Christianson- Canadian Forest Service, Natural Resources Canada
Tom Swystun - Canadian Forest Service, Natural Resources Canada
Sylvie Gauthier - Canadian Forest Service, Natural Resources Canada

Abstract:
In Canada, recent fire seasons have demonstrated the threat of wildland fire in the Wildland-Human Interface (WHI) areas, where forest fuels intermingle or abut housing, industry, and infrastructure. Despite the expected increase in fire activity from climate change, no WHI-specific estimates of wildland fire exposure are currently available. This study combines spatial and demographic information sources to estimate the current and future wildland fire exposure as reflected by fire return intervals (FRIs) of WHI areas and populations across Canada. The WHI covers 17% of the forested area in Canada. Within the WHI, we found that 19.4% of the area currently experiences more frequent fire (FRI < 250 years), but by the end of the century this could increase to 28.8% under RCP 2.6 and to 43.3 % under RCP 8.5. Approximately 12% of the Canadian population currently live in the Wildland-Urban Interface (WUI), which includes 32% of the on-reserve First Nations population. Currently, 17.8% of the on-reserve WUI population is exposed to FRIs < 250 years, compared to only 4.7% of the remaining WUI population. By 2100, these proportions could reach 39% and 18%, respectively under the less optimistic climatic scenario (RCP 8.5).

Effects of inter-annual climate variability on physiological processes and growth performance of black spruce and jack pine in Quebec's boreal forests

Presenter: Marchand, William

E-mail: william.marchand@uqat.ca

Authors and affiliations:
William Marchand - Centre for Forest Research, University of Quebec at Montreal
Martin P. Girardin - Canadian Forest Service, Natural Resources Canada
Henrik Hartmann - Department of Biogeochemical Processes, Max-Planck Institute for Biogeochemistry
Sylvie Gauthier - Canadian Forest Service, Natural Resources Canada
Yves Bergeron - Centre for Forest Research, University of Quebec at Montreal & Forest Research Institute, University of Quebec in Abitibi-Temiscamingue

Abstract:
A rise in annual temperature, together with more frequent and intense drought episodes, has been registered over the last century. Global climate models predict that this warming and drying trend will continue and amplify by the end of the century. High latitudes and altitudes forest ecosystems, i.e. `cold forests`, are particularly at risk of being severely impacted by these changes. Thus, assessing their response to past inter-annual climate conditions could allow to improve predictions of their future capacity to sustain wood demand and mitigate global warming. Our main objective was to assess how jack pine and black spruce responded to inter-annual climate variability over the past three decades. More specifically, we used ring width series of more than 2000 trees from a broadly distributed forest inventory network to quantify growth trends and climate growth-relationships over the period 1970-2005. For a subset of trees, we measured carbon and oxygen isotopic signatures of 1985-1993 growth rings to approximate temporal variations in intrinsic water-use efficiency and stomatal conductance. Overall, black spruce growth rates declined over 1970-2005. Spruces, especially older individuals and those on the high end of the elevation gradient, were negatively affected by hot summers occurring the year prior to ring formation. Higher-altitude spruce trees were also negatively affected by warm springs. At the opposite, pines were relatively unaffected by warmer-than-average summer conditions, with no significant trend in their growth rates. We also observed a drop in growth rates of the two species over 1989-1992. This decline occurred in parallel with an increase in intrinsic water-use efficiency and a decrease in stomatal conductance in response to drier-than-average conditions. It persisted into the year following drought for black spruce only. Together, these findings suggest that black spruce would be less able to cope with future, warmer and drier climate than jack pine.

Facilitation of fir growth by ectomycorrhizal fungi in boreal forest: or how below-ground interactions could modulate species migration and establishment in a context of climate change

Presenter : Mélanie Roy

E-mail: melanie.roy@univ-tlse3.fr

Authors and affiliations:
Mélissande Nagati - University of Quebec in Abitibi-Temiscamingue
Mélanie Roy – Université Paul Sabatier, Laboratoire Evolution et Diversité Biologique
Sophie Manzi – Université Paul Sabatier, Laboratoire Evolution et Diversité Biologique
Annie DesRochers - University of Quebec in Abitibi-Temiscamingue
Monique Gardes – Université Paul Sabatier, Laboratoire Evolution et Diversité Biologique
Yves Bergeron - University of Quebec in Abitibi-Temiscamingue

Abstract :
Ectomycorrhizal fungi (EMF), that form mutualistic symbiosis with tree roots, are dominant in temperate forests, and hyper diverse in boreal soils. Being hidden in soils, their response to climate change is far less studied than tree migrations or adaptations. However, comparison of past migrations of trees point out the importance of theses symbioses. In boreal forest, where trees are mostly ectomycorrhizal, the question remain if and how EMF could play a role tree migrations and changes of forest dynamic. We studied boreal forests where young firs are more and more abundant, notably under aspen but not under spruce. We hypothesized that EMF would be more abundant under aspen than under spruce, and that young fir would be more colonized by EMF under aspen. We tested in EMF from aspen soils alone would explain differences in fir growth, by comparing in situ and ex situ results. We show that EMF communities are not more diverse under aspen, but rather show a different composition. We also show that young seedlings show a higher growth under aspen, and accumulate more N in needles when Ericaceae are absent. Finally, we did detect a positive effect of EMF ex situ, but also show that N nutrition was higher under spruce than aspen. Altogether, these results show that shared EMF are important for fir growth, which invites to test if local networks contribute to fir establishment under aspen. Differences in EMF communities between aspen and spruce stands show that not only the ability to associate with EMF, but also EMF identity are important to allow tree species migration in new habitats. Finally, the case of fir facilitation by EMF and aspen illustrates how shared EMF and networks would modulate climate change effects in boreal forests.

Session 3. Biodiversity and biogeography of cold forests: From local to global patterns

Trends and patterns in annually burned forest areas and fire weather across the European boreal zone in the 20th and early 21st centuries

Presenter: Igor Drobyshev

E-mail: Igor.Drobyshev@slu.se

Authors and affiliations:
Igor Drobyshev - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Nina Ryzhkova - Karelian Research Centre of the Russian Academy of Sciences
Mara Kitenberga - Latvian State Forest Research Institute "Silava"
Jonathan Eden - Centre for Agroecology, Water and Resilience (CAWR), Coventry University
Guilherme Pinto - Swedish University of Agricultural Sciences
Henrik Lindberg - Häme University of Applied Sciences
Folmer Krikken - Dutch Royal Meteorological Institute
Yves Bergeron - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue

Abstract
Fire remains one of the main natural disturbance factor in the European boreal zone (EBZ) and understanding climatic forcing on fire activity is important for projecting effects of climate change on ecosystem services in this region. We analyzed available records of annually burned areas (ABA) in 16 administrative regions of EBZ (countries or sub-country units) and fire weather variability to test for their spatio-temporal patterns over 1901-2017. We clustered ABA chronologies in Euclidian space to identify regions of EBZ with temporally synchronous fire activity. We then selected one 117-year long ABA chronology from each cluster, representing its member with the highest correlation between observational fire record and climatological proxy for fire weather (monthly drought code, MDC). For each cluster we identified large fire years (LFY), i.e. years with the ABA being above 10% percentile of its long-term distribution. The climatic forcing of these events was tested in superimposed epoch analysis operated on the gridded 500 hPa pressure fields. Finally, we tested for (a) a temporal trend in synchrony of LFY's across clusters, (b) temporal trends in MDC values, and (c) spatial variability in July MDC over the EBZ.
Over the 1992-2017, EBZ exhibited large variability in forest fire activity with the fire cycles varying from ~1600 (St. Petersburg region) to ~37000 years (Finland). Clustering of administrative units in respect to their ABA suggested the presence of sub-regions with synchronous annual variability in ABAs. LFYs in each of the cluster was associated with the development of the high pressure cell over the regions in question in July, indicating climatic forcing of LFYs. Contingency analysis indicated no long-term trend in the synchrony of LFYs observed simultaneously in several administrative units.
We documented a trend towards higher values of MDC for the months of April and May in the western section of EBZ (April) and southern-eastern sections of the Baltic Sea region and North sections of EBZ in Russia (May). Trends in MDC during the summer months were largely absent. Geographical pattern of July MDC values, analyzed through principal component analysis over the entire EBZ, indicated the presence of a dipole, i.e. alternative behavior, of the July MDC values over the Scandinavian peninsular and the eastern section of the EBZ. Dynamics of summer precipitation likely acts a “synchronizing factor” in respect to the EBZ-wide forest fire activity. Positive correlation between biome-wide fire activity index and June SNAO (Summer North Atlantic Oscillation) ($r = 0.41$) pointed to the importance of large scale atmospheric circulation, in particular – the summer European blocking pattern, in controlling forest fires across EBZ. Despite exhibiting strong gradients in climate conditions, modern and historical patterns of forest use, the infrastructure and human population densities, the forest fire activity of the European boreal zone remains strongly connected to the annual climate variability. Higher frequency of strongly positive SNAO states in the future will likely synchronize years with large area burned across the EBZ.

Influence of habitat availability and fire disturbance on the northern range boundary of eastern white cedar (*Thuja occidentalis* L.)

Presenter: Bergeron, Yves

E-mail: yves.bergeron@uqat.ca

Authors and affiliations:
Yves Bergeron - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Bronwyn Rayfield - Apex Resource Management Solutions
Véronique Paul - Ministry of Forests, Wildlife and Parks, Government of Quebec
Francine Tremblay - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Marie-Josée Fortin - Department of Ecology and Evolutionary Biology, University of Toronto
Christelle Hély - Institute of Evolution Sciences of Montpellier, University of Montpellier

Abstract:
Non-climatic constraints on species northern range boundaries are often overlooked in attempts to predict climate-induced range shifts. Here, we examined the effects of habitat availability and fire disturbance on the distribution of eastern white cedar (Thuja occidentalis L.) at the northern boundary of its range in North-western Quebec. We used forest inventory data (n = 4,987) to characterize white-cedar habitat based on edaphic and topographic conditions at sampled sites along a 600-km latitudinal gradient. Non-metric multidimensional scaling was used to assess habitat similarity of sites in the south, where white-cedar stands are abundant, and sites in the north, where white-cedar stands are rare. We constructed ensemble white cedar distribution models based on habitat variables in the south and compared ensemble forecast projections of white cedar in the north with observed occurrences to determine if habitat availability was limiting. We independently estimated the age of white-cedar stands and adjacent stands without white cedar along the gradient. We tested the age difference between white-cedar and adjacent stands to determine whether the location of white-cedar stands was influenced by disturbance, primarily stand-replacing fire. Habitat availability was not limiting the distribution of eastern white cedar at its northern range boundary. White cedar did not occupy most sites with suitable habitat in the north, suggesting that other factors prevent white cedar from establishing more stands northward. White-cedar stands were older than adjacent stands without white cedar all along the gradient, but the difference was more pronounced in the north. This suggests that white-cedar stands in the north are restricted to undisturbed areas. Fire disturbance, more than habitat availability, limits the distribution of white cedar at its northern range boundary. Projections of white cedar distribution (as well as other species) under climate change that ignore fire could overestimate the ability of warming temperatures to extend its northern range limit.

A national tree-ring data repository for Canadian forests (CFS-TRenD): structure, synthesis, and applications

Presenter: Girardin, Martin P.

E-mail: martin.girardin@canada.ca

Authors and affiliations:
Martin P. Girardin - Canadian Forest Service, Natural Resources Canada
Xiao Jing Guo - Canadian Forest Service, Natural Resources Canada
Juha Metsaranta - Canadian Forest Service, Natural Resources Canada
David Gervais - Canadian Forest Service, Natural Resources Canada
Elizabeth Campbell - Canadian Forest Service, Natural Resources Canada
André Arsenault - Canadian Forest Service, Natural Resources Canada
Miriam Isaac-Renton - Canadian Forest Service, Natural Resources Canada
Jill E. Harvey - Canadian Forest Service, Natural Resources Canada
Jag Bhatti - Canadian Forest Service, Natural Resources Canada
Edward H. Hogg - Canadian Forest Service, Natural Resources Canada

Abstract:
Understanding the magnitude and cause of variation in tree growth and forest productivity is central to sustainable forest management. Measurements of annual growth rings allow assessments of forest ecosystem vulnerabilities. Given a heightened demand for tree-ring data, we consolidated and synthesized tree-ring studies and datasets gathered over the past 30 years in Canada by scientists with the Canadian Forest Service and research partners. We incorporated these datasets into a data repository that currently contains tree-ring measurements from 40,206 tree samples from 4,594 sites and 63 tree species from all Canadian provinces and territories. Through our synthesis, we demonstrate the value of such large ensembles of tree-ring data for identifying patterns in tree growth over large spatial scales by mapping pan-Canadian drought sensitivity. Overall, we found high coherence in the samples analysed; low coherence was generally limited to data- poor regions and species. Drought sensitivity was widespread across species and regions: 34% of sampled trees displayed a significant positive relationship between annual growth increment and summer soil moisture index. Dependence upon water availability in species Picea mariana, Pinus banksiana, Pinus contorta, and Pseudotsuga menziesii was more strongly expressed in warm regions; for species Picea glauca and Populus tremuloides, drought sensitivity was stronger in the driest regions. This unprecedented consolidation and synthesis of tree-ring data will enable new research initiatives (e.g., meta-analyses) aimed at improved understanding of the drivers, patterns, and implications of changes in tree growth, as well as facilitating new research collaborations in earth and environmental sciences. Amongst other things, there is a need for expanding the spatial distribution of sites across Canada's northern regions, increasing the number of samples collected from older stands and angiosperm species, and integrate datasets from studies that evaluate the effects of silvicultural experiments, including provenance and progeny trials, on tree growth.

Eco-evolutionary dynamics of natural populations in the face of global climate change: the case of jack pine at its southern distribution limit

Presenter: Deslauriers, Muriel

E-mail: muriel.deslauriers@uqar.ca

Authors and affiliations:
Muriel Deslauriers - Université du Québec à Rimouski, Rimouski
Julie Godbout - Ministère des Forêts, de la Faune et des Parcs, Direction de la recherche forestière, Québec
Guillaume de Lafontaine - Chaire de recherche du Canada en biologie intégrative de la flore nordique,
Université du Québec à Rimouski, Rimouski

Abstract:
Global climate change is accelerating at an unprecedented rate and it is expected that many species will not be able to persist, leading to rapid biodiversity loss. In response, natural populations must migrate or adapt to avoid local extirpation. Many plant species are unlikely to migrate rapidly enough to track current climate change velocity. Along with migration, adaptation may be instrumental to specie's long-term persistence. As genetic variation is the raw material for evolution, populations' capacity to adapt to environmental changes depends on standing genetic variation. Marginal populations at the rear edge of species distribution could exhibit high genetic diversity and adaptive potential due to their proximity to glacial refugia and strong selection pressures. Here we compare patterns of genetic diversity in core and rear-edge natural jack pine populations and test for associations between genotypes, environmental variables, and serotiny, a highly heritable phenotypic trait. Using genetic markers and provenances trial, our goal is to infer a) demographic evolutionary processes at the rear edge; b) the level of northward gene flow from the rear-edge populations to the core of the range; c) genomic imprints of local adaptation in response to rear-edge environmental conditions. We expect that small, isolated rear-edge populations will have lower intrapopulation genetic diversity, but higher interpopulation differentiation compared to core populations. We also expect asymmetrical gene flow from the rear edge to the core of the range margin, reflecting ongoing poleward migration of the southernmost populations. Finally, we hypothesize that some loci will indicate genomic regions under natural selection involved in local adaptation. A better understanding of the eco-evolutionary dynamics of rear-edge populations is essential to predict the future adaptive capacity of the species.

Intraspecific variability in serotiny contributes to the long-term persistence of rear-edge jack pine populations

Presenter: Magali Couture

E-mail: magali.couture@uqar.ca

Authors and affiliations:
Guillaume de Lafontaine ; Titulaire de la Chaire de recherche du Canada en biologie intégrative de la flore nordique. Département de biologie, chimie et géographie. Université du Québec à Rimouski
Emmanuelle Pelletier ; Candidate M.Sc. (Superviseur : G. de Lafontaine, UQAR)

Abstract:
Populations located at the geographical margins of species' distribution are usually facing environmental conditions at the limit of the species' physiological and ecological tolerance. Indeed, in the context of global warming, those populations should readily experience novel environments and corresponding evolutionary pressures. As a result, peripheral populations might exhibit a high degree of phenotypic variation in traits, conferring fitness advantage in currently peculiar marginal conditions that may become increasingly widespread under future climates. This study assesses the potential role of intraspecific trait variability on the persistence of marginal populations of a transcontinental boreal species (i.e. jack pine, Pinus banksiana) at the rear edge of its distribution. We assessed how variation in serotiny can contribute to the persistence of rear-edge jack pine populations experiencing an otherwise deleterious fire environment. With respect to core boreal populations, we first hypothesized lower mean serotiny due to reduced fire activity but higher intrapopulation variability, reflecting less predictable fire events at the rear edge. We also expected that those populations with lower or more variable level of serotiny would display uneven-sized stand structure with steady regeneration. Our results indicate that, in contrast to core populations, most rear-edge populations of jack pine are facultative pyriscent, displaying lower and more variable level of serotiny. Quadratic models fitted to the empirical stand size structure showed that highly serotinous stands are even-aged (hump shape) while weakly serotinous stands are generally uneven-aged (reversed-J shape) and include seedlings and saplings. Identifying such key variable traits and assessing their impacts on the dynamics of range-edge populations will aid conservation efforts and improve forecasting accuracy about the conditions under which locally-adapted populations will be instrumental for species persistence.

Lien web (optionnel): https://www.uqar.ca/recherche/la-recherche-a-l-uqar/unites-de-recherche/flore-nordique/presentation-objectifs-et-mission-flore-nordique

Impact of drought on European beech forest ecosystems

Presenter: Gennaretti, Fabio

Email: fabio.gennaretti@uqat.ca

Authors and affiliations:
Fabio Gennaretti - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Jérôme Ogée - INRAE Nouvelle-Aquitaine Bordeaux Centre
Julien Sainte-Marie - University of Lorraine
Matthias Cuntz - University of Lorraine

Abstract:
Drought is expected to be the most important limiting factor for European beech forests over the next decades. Here, we develop simulation experiments to analyze the impact of drought on beech ecosystems over Europe. We use for our experiments the MuSICA ecosystem model calibrated on observed data from the Hesse forest experimental site in northeastern France. First, we quantify the reductions of ecosystem fluxes during severe droughts (the 2003 dry summer) and we attribute these reductions to heat stress and water limitations during drought. We also assess the impact of specific drought trajectories during the growing season. Finally, we evaluate of the potential impact of future extreme dry years over the species distributional range in Europe. Our results show that the 2003 drought resulted in a 17% reduction of annual gross primary production and in a 21% reduction of evapotranspiration at our study site. The studied forest ecosystem is mostly sensitive to negative precipitation anomalies (82% of the reduced forest productivity in 2003) and almost insensitive to heat stress due to high temperatures (16%). Moreover, we show that the ecosystem fluxes are limited more by fast drought onsets in the early growing season (June–July) than by onsets later in the season. Deciphering the impact of future climate change on beech productivity is complicated by large uncertainties in projected future precipitation and in the severity of extreme dry years. Drastic reduction of ecosystem fluxes is only predicted with climate projections that show marked reductions in precipitation. However, increased CO2 fertilization in the future will counterbalance negative drought impacts. This modelling-based study improves our understanding of the functioning of an emblematic European tree species during extreme events and informs on potential future forest responses to projected climate change.

Recent afforestation of an isolated ombrotrophic peatland in an urban matrix of the St. Lawrence Lowlands, Quebec

Presenter: Catherine Caron

E-mail: catherine.caron.7@ulaval.ca

Authors and affiliations:
Catherine Caron - Département de géographie, Université Laval, Québec (Québec), Canada
Alayn Larouche - Département de géographie, Université de Montréal, (Québec), Canada
Pierre Grondin - Ministère des Forêts, de la Faune et des Parcs du Québec, Direction de la recherche forestière, Québec (Québec), G1P 3W8, Canada
Martin Lavoie - Centre d'études nordiques, Université Laval, Québec, Canada
Véronique Poirier - Ministère des Forêts, de la Faune et des Parcs du Québec, Direction de la recherche forestière, Québec (Québec), G1P 3W8, Canada

Abstract

During the last half of the twentieth century, the combined action of climate, fires and human activities led to accelerated afforestation of peatlands in Quebec. Urban regions are the most affected by this phenomenon. This study focuses on the Sainte-Foy Base de Plein air bog located within the semi-urban landscape of Quebec City. This peat bog is distinguished by the development of a continuous tree cover on previously open sites. The objectives of this project were: 1) to characterize the contemporary dynamics of the transformation of the open peat bog, into larch then into red sugar bush in order to specify at what time-period the bog dotted with a few stems-trees would have densified to the point of annihilate the process of peat accumulation as well as 2) reconstruct the long-term evolution of tree species in order to characterize the abundance of species making up the peat bog, and more particularly those currently subject to afforestation. Using dendrochronology, palaeogeography as well as the analysis of aerial photographs, the recent and millennial history of the peatland has been reconstructed. The results obtained show that the bog has undergone a drastic increase, first in larch and subsequently in red maple over the past 50 years. This transformation followed several millennia during which the bog was open and mainly composed of a few black spruce and tree larches. The afforestation of the bog was caused by several factors including the recent warming of the climate, fires and an increase in human activities since the 1970s. In the long term, the bog should be covered with red maple, a highly ubiquitous species.

Regional overview of the Forested peatlands of the St. Lawrence Lowlands, Quebec and a local study of a peatland strongly affected by human activities

Presenter: Ana Verhulst-Casanova

E-mail: verhulstcasanova.ana@gmail.com

Authors and affiliations:
Ana Verhulst-Casanova (Université d'Orléans, France), Maude Demers (Université Laval, Québec QC), Pierre Grondin (MFFP, Québec QC), Martin Lavoie (Université Laval, Québec QC).

Abstract:

Despite the large size of the surface area and the rich biodiversity, there is no overall portrait of the contemporary vegetation of the forested peatlands of the St. Lawrence Lowlands. The scattered contemporary studies show that some peatlands present a forest cover dominated by coniferous species (e.g. black spruce, eastern larch, white cedar). Some other peatlands are dominated by deciduous tree species, (e.g. red maple, grey birch). Furthermore, the dynamics of forested peatlands, mainly in regard to the anthropogenic activities, are still little known. To fill these gaps, we classified the forest vegetation of the St. Lawrence Lowlands peatlands using available forest data. Regional analysis of the vegetation shows forest communities, developed along two gradients: increase in Sphagnum species associated to the trophic regime, and increase in red maple cover corresponding to the importance of anthropogenic activities. This regional overview of forested peatlands introduces the study of one of them: Saint-Georges-de-Clarenceville peatland where we studied the contemporary (19th-20th centuries) dynamics of six forest stands. This peatland show the evidences of ancient white pine tree stumps resulting from an 1840s logging carried out by the owners of the peatland lots. It has enabled the development in great abundance of deciduous species (e.g. red maple). We also studied the past vegetation (several millennia) in two stands. Botanical identification shows that the peatland was dominated by coniferous species. White pine, present since at least 3,000 years, must have once been relatively abundant. It is the first time that the Holocene presence of white pine growing directly in peatlands has been demonstrated in the eastern of North America. No indication of a past presence of deciduous species was found. Today, red maple is abundant and dominates regeneration. This species will continue its expansion in coming decades, forming of dominant red maple stands on peat.

Session 4 & 5. Lessons from the past: Paleoecology and landscape ecology of cold forests ; Adapting sylvicultural practices

Temperature and fuel availability control fire size/severity in the boreal forest of central Northwest Territories, Canada

Presenter: Gaboriau, Dorian

E-mail: gaboriau.dorian@gmail.com

Authors and affiliations:
Dorian M. Gaboriau - School of Indigenous Studies, University of Quebec in Abitibi-Temiscamingue & Institute of Evolution Sciences of Montpellier, University of Montpellier
Cécile C. Remy - Department of Biology, University of New Mexico
Martin P. Girardin - Canadian Forest Service, Natural Resources Canada & Centre for Forest Research, University of Quebec at Montreal
Hugo Asselin - School of Indigenous Studies, University of Quebec in Abitibi-Temiscamingue & Centre for Forest Research, University of Quebec at Montreal
Christelle Hély - Institute of Evolution Sciences of Montpellier, University of Montpellier & École Pratique des Hautes Études, PSL University & Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Yves Bergeron - Centre for Forest Research, University of Quebec at Montreal & Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Adam A. Ali - Institute of Evolution Sciences of Montpellier, University of Montpellier
& Forest Research Institute, University of Quebec in Abitibi-Temiscamingue

Abstract:
The north-central Canadian boreal forest experienced increased occurrence of large and severe wildfires caused by unusually warm temperatures and drought events in the last decade. It is, however, difficult to assess the exceptional nature of this recent wildfire activity, as few long-term records are available in the area. We analyzed macroscopic sedimentary charcoal from four lakes and pollen grains from one of those lakes to reconstruct long-term fire regimes and vegetation histories in the boreal forest of central Northwest Territories. We used regional estimates of past temperature and hydrological changes to identify the climatic drivers of fire activity over the past 10,000 years. Fires were larger and more severe during the Holocene Thermal Maximum (ca. 7,000-5,000 cal. yrs. BP) when the forest landscape was characterized by high fuel abundance, especially fire-prone spruce. In contrast, colder conditions combined with landscape opening (i.e., lower fuel abundance) during the Neoglacial (after ca. 5,000 cal. yrs. BP) were related with a decline in fire size and severity. Fire size and severity increased during the last five centuries, but remained within the Holocene range of variability. According to climatic projections, fire size and severity will likely continue to increase in central Northwest Territories in response to warmer conditions, but increased abundance of deciduous species or opening of the landscape related to future precipitation rates could limit fire size and/or severity in the future.

Learning from the present to improve paleoreconstructions

Presenter: Hennebelle, Andy

E-mail: hennebelle.andy@gmail.com

Authors and affiliations:
Andy Hennebelle - University of Montreal
Olivier Blarquez - University of Montreal
Pierre Grondin - Ministry of Forests, Wildlife and Parks, Government of Quebec
Julie Aleman - University of Montreal

Abstract: Paleoecology allows for the reconstruction of ecosystem dynamics in various types of ecosystems. In the western part of the boreal forest of Québec (Canada), we have a good understanding of pluri-millennary vegetation composition dynamics and fire regimes during the Holocene. These descriptions are however mainly qualitative and recent studies are trying to establish more quantitative reconstructions of vegetation composition and fire regime dynamics. In this study, we extracted short sediment cores at the transition between water and sediments for 6 lakes located in the western spruce feathermoss subdomain in Québec. We established the history of fire events that occurred up to 30 km around the lakes from 1976 to 2015. Burned areas were measured using freely available data from the Ministry of Forest, Wildlife and Parks of Québec and fire severity were calculated via the dNBR index using LANDSAT images. We combined the charcoal records from the 6 lakes to establish a semi-regional composite reconstruction of charcoal number, charcoal surface area and charcoal median surface area. We used linear regressions between the charcoal record and the fire characteristics and found marginally significant parameters between charcoal number and fire severity ($r2 = 0.18$, P-value = 0.058) and with burned area ($r2 = 0.16$, P-value = 0.076). The limited performances of these models highlight the taphonomic processes that affect charcoal signal and that blurry the relationships with the fire characteristics. Finally, we will discuss our results with regard to the current knowledge on the different taphonomic processes that affect charcoal particles between the production, the transportation and the deposition. We will propose an interpretation of the results and the insights they bring for the analysis of charcoal signals.

Holocene dynamics and expansion potential of the northernmost sugar maple in Abitibi-Temiscamingue

Presenter: Cigana, Julia

E-mail: Julia.Cigana@uqat.ca

Authors and affiliations:
Julia Cigana - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue & Canada Research Chair in northern flora integrative biology, University of Quebec at Rimouski
Guillaume de Lafontaine - Canada Research Chair in northern flora integrative biology, University of Quebec at Rimouski
Pierre Grondin - Ministry of Forests, Wildlife and Parks, Government of Quebec
Yves Bergeron - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue

Abstract:
In the context of contemporary global warming, it is assumed that temperate species will extend their range to higher latitudes. However, in eastern Canada, this expansion could be limited by the current forest matrix dominated by conifers, but also by the presence of fires, and topographic and/or edaphic constraints. Marginal, isolated, small populations located at the cold margin (northern limit) of the ranges could be essential to ensure a rapid response of the species to climate change. In western Quebec, the northern limit of the sugar maple (Acer saccharum) is in contact with the temperate forest and the boreal forest. Paleoecological studies suggest that the distribution of maple was more extensive and more northern during the Holocene. To validate this hypothesis, our study focuses on the northernmost maple grove in Abitibi-Temiscamingue: the Ruisseau-Clinchamp maple grove. To evaluate the potential for maple expansion, we characterize the historical origin and dynamics of this marginal stand as well as its current forest composition at the local scale. For this purpose, a macrofossil analysis of the charcoal in the soil (extraction, identification and radiocarbon dating of charcoal present in the mineral soil) and an analysis of the current vegetation (size structure, age of the stand) are carried out within a 4 km² study area centered on the Ruisseau-Clinchamp maple grove. All these analyses will help determine the origin and dynamics of the northern maple groves and support the appropriate forest management measures that account for future climate.

Origin and historical dynamics of jack pine (Pinus banksiana) at its southern limit of distribution

Presenter: Claudepierre, Romain

E-mail: r.claudepierre@hotmail.fr

Authors and affiliations:
Romain Claudepierre - Canada Research Chair in northern flora integrative biology, University of Quebec at Rimouski
Guillaume de Lafontaine - Canada Research Chair in northern flora integrative biology, University of Quebec at Rimouski

Abstract:
Species respond to climate change by changing their range. Studying the effects of these constant phenomena on animal and plant populations during the Holocene allows for a better understanding of the effects of future global changes. It is anticipated that the effects observed at the warm margin of a species' range will become generalized at the heart of the range with the climate changes expected by the end of the century. Jack pine (Pinus banksiana) is a species that has been recovering its previously contracted range during the last glacial maximum. In the Lower St. Lawrence, small isolated populations located at the warm margin of the species' range remain little studied. Given the close link between forest fires and jack pine, the presence of this species is surprising in the region. A short fire cycle (<220 years) is necessary to maintain the species. However, the region does not appear to have allowed this condition during the Holocene. We studied the marginal jack pine populations in the Lower St. Lawrence to determine the dynamics of these stands and their history. We applied the method of macro charcoal analysis to study each stand. We collected 25 mineral soil samples at each site, which contained coals produced locally during previous fires. The anatomical identification of the coals and radiocarbon dating of the macro coals will allow us to determine whether jack pine has only recently established itself in the area or whether, on the contrary, it has been present throughout the Holocene. In addition to studying the dynamics of the species, the results will help determine changes in the past fire regime and provide insight into future changes.

Modelling the potential of silvicultural practices to limit the impact of regeneration failure on forest productivity

Last and First Name: Splawinski Tadeusz

Email: tsplawinski@gmail.com

Authors and institution (use index if necessary) :
Tadeusz B. Splawinski: Institut de recherche sur les forêts, Université du Québec en Abitibi-Témiscamingue.
Dominic Cyr: Environment and Climate Change Canada, Pollutant Inventories and Reporting Division.
Sylvie Gauthier: Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Center.
Jesus Pascual Puigdevall: Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Center.
Alain Leduc: Département des sciences biologiques, Université du Québec à Montréal.
Nelson Thiffault: Natural Resources Canada, Canadian Forest Service, Canadian Wood Fibre Centre.
Yves Bergeron: Institut de recherche sur les forêts et Chaire industrielle en aménagement forestier durable, Université du Québec en Abitibi-Témiscamingue.

Abstract:
Changes in the fire regime can affect the post-disturbance regeneration potential of boreal forest tree species, thereby modifying tree density and cover. This could adversely affect the sustainability of forest management, especially in regions currently characterized by high fire activity and low productivity. As a case study, we use a real landscape (1.3 Mha) in the boreal forest of northwestern Quebec, characterized by a high annual area burned and where fire activity is projected to strongly increase, to model the effect of current and climate-induced changes in the annual area burned, and harvest and salvage logging on the regeneration failure potential of pure black spruce (Picea mariana (Mill.) BSP) and jack pine (Pinus banksiana Lamb.) stands, as well as changes in productivity. Next, we tested different adaptive silvicultural practices (plantation and species selection, variable retention harvesting) under two road access scenarios, in order to assess their potential in minimizing the loss of forest cover. Simulations were carried out over a 150-year period. Results indicated that the greatest losses in productivity and regeneration failure occurred under the business-as-usual (no intervention) scenario under both fire cycles. The effectiveness of simulated adaptive management scenarios in reducing loss in forest cover was highly variable. With limited road access, variable retention harvesting combined with plantation establishment reduced losses in productivity and regeneration failure more than with traditional harvesting and plantation, however full access with traditional harvesting and plantation establishment (jack pine) was most effective. Conversely, the most effective adaptive management scenarios also incurred the greatest costs, and present a risk in terms of loss of investments should stands burn before becoming merchantable. These results can aid in the development of a risk management approach that will allow planning decisions to be made while controlling risk factors that may compromise the success of adaptive management strategies.

Assessing the historical impact of climate on the defoliation of boreal stands by the spruce budworm

Presenter: Subedi, Anoj

Email: anojsubedi99@gmail.com

Authors and affiliations:
Anoj Subedi - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Miguel Montoro Girona - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue & Ecology Restoration Group, Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences
Philippe Marchand - Forest Research Institute, University of Quebec in Abitibi-Temiscamingue
Hubert Morin - University of Quebec at Chicoutimi
Marie-Josée Fortin - Department of Ecology and Evolutionary Biology, University of Toronto

Abstract: Natural disturbances bear significant importance in modifying the structure of forests, associated ecosystems, and initiating the natural succession process. Global change predictions indicate that effects on the boreal ecosystem will be profound and natural disturbance cycles (fire insect outbreaks and windthrow) will generally increase in number and severity. With the rapid trend in the climate shift, the spruce budworm (SBW) (Choristoneura fumiferana), recognized as the major defoliator of the North American forest, is increasing its damage and distribution area making forests more vulnerable. Despite its major ecological implications, challenges remain in understanding the historical impact of climate on defoliation caused by the SBW, the severity of its impact on host trees, and how it has changed over time. Thus, we aim to evaluate the trend and the impact of climate on SBW outbreaks during the last century and to reconstruct the spatiotemporal patterns in Quebec. For this, we will use the dendrochronological time series, as well as complementary fieldwork, and use the climate datasets to model climate normalized growth. We will be seeing, during the outbreak, the effect of changing climate on the growth of the boreal stands over the years. We will extract the rate and the extent of the impact of the defoliating insect, and its interaction with climate, on the boreal stands. This study will provide invaluable information to understand major ecological shifts caused by the defoliator and the climate at a spatiotemporal scale. It will help to project the results on future climate to predict a general trend in the range and severity of future outbreaks, and thus, helps tackle the major concerns of the Boreal forest.

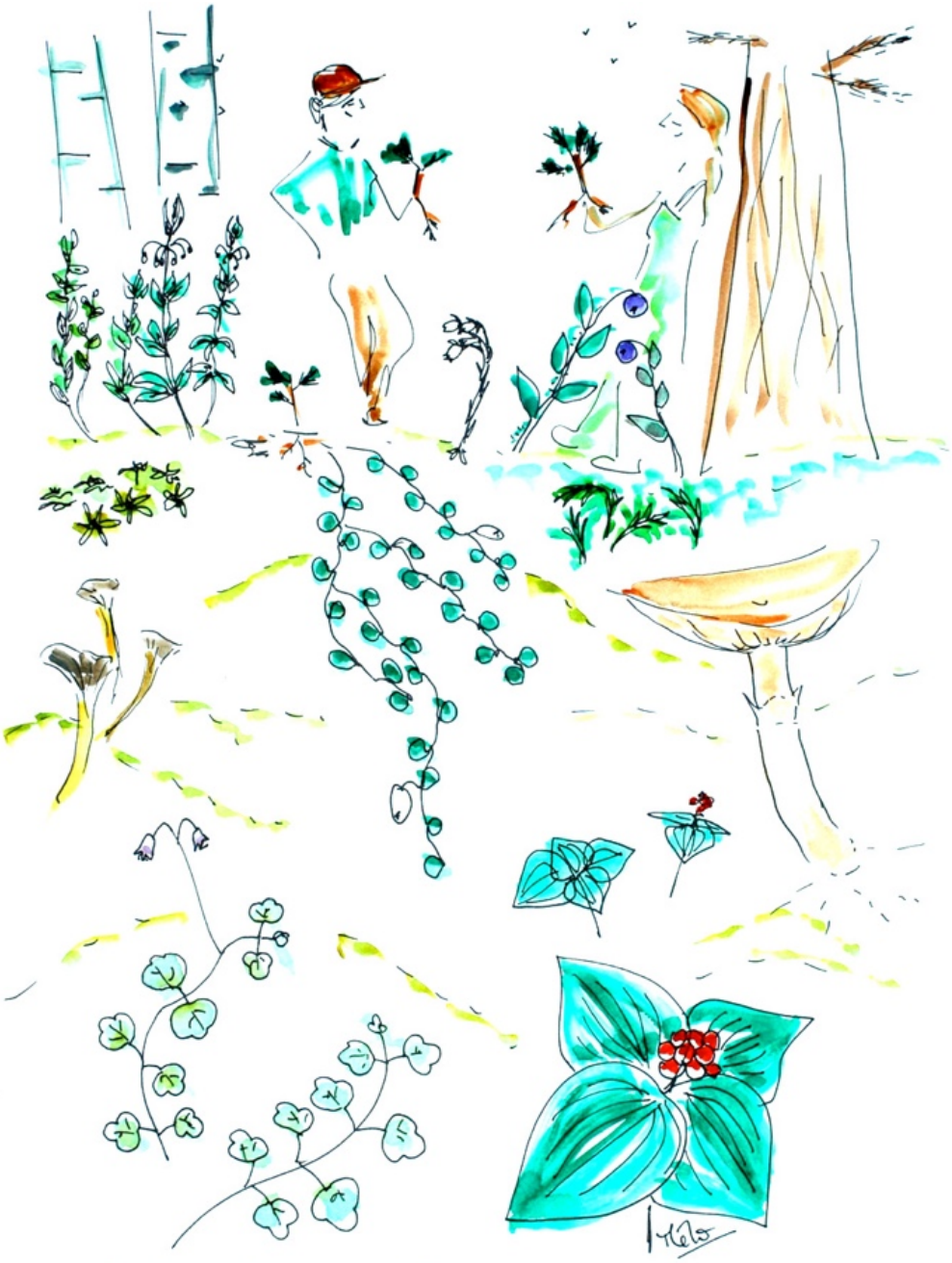
Presentation of the BENDYS project: The last European old-growth ("subnatural") fir-BEech forests: a loNg-term and global stuDY for their better understanding, conServation and management.

Presenter: Saulnier, Mélanie

E-mail: melanie.saulnier14@gmail.com

Authors and affiliation:
Mélanie Saulnier - CNRS UMR 5602 Laboratoire GEODE , 5, allées A. Machado, 31058 TOULOUSE, FRANCE
Vanessa Py-Saragaglia - CNRS UMR 5602 Laboratoire GEODE , 5, allées A. Machado, 31058 TOULOUSE, FRANCE

Abstract:
Old-growth beech forests are often considered as the last remaining relics of European primary forests. These forests, which are mainly located in the European mountains such as the Carpathians and the Pyrenees, are characterized by their exceptional attributes such as a high biodiversity, a high amount of dead wood, the presence of numerous very large trees, and a current low level of anthropisation.
However, many questions arise as to their "primary" nature. Indeed, mountain forests have been profoundly shaped by human activities since the beginning of the Metal Age, leading to favor certain species to the detriment of others. The naturality indicators used to characterize these forests do not allow us to assert that they are close to the original primary forests. The BENDYS project, which brings together a consortium of researchers from different disciplines, aims to study these forests through the prism of an interdisciplinary approach in order to better understand their Holocene trajectories. After selecting 6 study areas spread over two mountain areas of the Carpathians (3) and Pyrenees (3), the three tasks of the BENDYS project will explore the long-term evolution of these forests in relation to humans (paleoecology, archaeology, historical ecology), their current ecological characteristics (forest ecology, pedology, population genetics) and the institutional aspects that organize their management/preservation. Finally, this project could refine our knowledge of the naturalness of Europe's remarkable forests and set up appropriate management tools.



All sketches come from field works close to lac Duparquet, in North of Québec.