Groupe de recherche en écologie des tourbières

Peatland Ecology Research Group

21st PERG Symposium

Wednesday February 18th, 2015

University of Waterloo, Waterloo, ON
Environment Building 3 / Auditorium Room 1408

Schedule and abstracts

UNIVERSITÉ LAVAL

University of Waterloo

21st PERG Symposium

Peatland Ecology Research Group

Program

Wednesday, February 18th, 2015

University of Waterloo
Auditorium Room 1408, Environment Building 3

8h00	**Registration and coffee (25 min.)**	**Language**
8h25	**Jonathan Price** (PERG/GRET, U. Waterloo) *Introduction and brief presentation of the main projects* (5 min.)	**E**
	Session **Theme: Peatland Restoration** **Session chair: Colin McCarter**	
8h30	**Roxane Andersen** (U. Highlands and Islands) An overview of *Sphagnum* peatland restoration in Scotland (20 min.)	**E**
8h50	**Rémy Pouliot** and Line Rochefort (U. Laval) Do plants have a similar ecological niche in natural, restored or spontaneously revegetated bogs? (15 min.)	**E**
9h05	**Line Rochefort** (U. Laval), Roxane Andersen (U. Highlands and Islands) & Claire Boismenu (U. Laval) A reference system for peat and water chemistry in peatlands of Canada and Alaska (20 min.)	**E**
9h25	**André-Philippe Drapeau Picard**, Line Rochefort and Maxim Larrivée (U. Laval) Man-made pools: what do spiders and predacious diving beetles look for? (15 min.)	**E**
	Session **Theme: Carbon & *Sphagnum* fibre production** **Session chair: Sarah Scarlett**	
9h40	**Maria Strack** (U.Waterloo), Kelly Nugent, Tracy Rankin and Ian Strachan (McGill U.) Methane flux from restored Canadian peatlands: How long does it take to recover? (20 min.)	**E**
10h00	**Catherine Brown** and Jonathan Price (U. Waterloo) Impacts of sub-surface irrigation of carbon uptake of *Sphagnum* moss (15 min.)	**E**
10h15	**Coffee break (15 min)**	**E**
10h30	**James Elliot** and Jonathan Price (U. Waterloo) Effects of straw mulch on evaporation from a peat profile: Implications for *Sphagnum* restoration (15 min.)	**E**
10h45	**Neil Taylor** and Jonathan Price (U. Waterloo) Hydrophysical evolution, soil water dynamics, and productivity of *Sphagnum* carpets in a regenerating cutover peatland (15 min.)	**E**

11h00	**Pete Whittington** and Melanie Hawes (Brandon U.) The hydrology of a 'spontaneously' re-vegetated, vacuum harvested peatland, eastern Manitoba (15 min.)	**E**
	Session **Theme: Impacted peatlands & mining** **Session chair: Scott Ketcheson**	
11h15	**Colin McCarter** and Jonathan Price (U.Waterloo) Transport and hydrological response of simulated wastewater from a continuous point source in a Northern ribbed fen (15 min.)	**E**
11h30	**Mazda Kompaniere**, Jonathan Price (U. Waterloo) and Pete Whittington (Brandon U.) The effect of mine dewatering and the barrier layers on the pattern of surface recharge around the Victor diamond mine, James Bay Lowlands (15 min.)	**E**
11h45	**Ryan F. Connon**, W.L. Quinton (U. Waterloo) and J.R. Craig (Wilfrid Laurier U.) The effects of climate change on peatland hydrology in discontinuous permafrost (15 min.)	**E**
12h00	**Emma Bocking**, Jonathan Price (U. Waterloo) and David Cooper (Colorado State U.) Impacts of road construction on the development of a poor fen in northeastern Alberta (15 min.)	**E**
12h15	**Lunch (1h05)**	
13h20	**Elise Gabrielli** (Wilfrid Laurier U.) and Richard Petrone (U. Waterloo) Quantifying and characterizing conifer evapotranspiration in two natural Boreal fens, Fort McMurray (15 min.)	**E**
13h35	**Jenna Pillon** and Richard Petrone (U. Waterloo) Characterizing physical and hydraulic properties of the peat column: A hydrogeological assessment of temporary access infrastructure impact, and the immediate effects on surrounding fen hydrology (15 min.**)**	**E**
	Session **Theme: Oil Sands Reclamation** **Session chair: Emma Bocking**	
13h50	**Scott Ketcheson** and Jonathan Price (U. Waterloo) Water table dynamics and hydrophysical variability of reclamation material properties in a constructed fen watershed (15 min.)	**E**
14h05	**Sarah Scarlett** and Jonathan Price (U. Waterloo) Plot scale hydrodynamic variability of a constructed fen in a post-mined oil sands landscape (15 min.)	**E**
14h20	**Coffee Break (20 min.)**	
14h40	**Eric Kessel** and Jonathan Price (U. Waterloo) Fate and transport of sodium and naphthenic acids in a constructed fen peatland (15 min.)	**E**
14h55	**Andrea Borkenhagen** and David Cooper (Colorado State U.) Nikanotee fen: Fen vegetation update (15 min.)	**E**
15h10	**Rubi Simhayov**, Christina M. Smeaton, Christopher T. Parsons, Phillip Van Cappellen and Jonathan S. Price (U. Waterloo) Assessment of pools and potential redistribution of sodium in a constructed fen peatland system (15 min.)	**E**
15h25	**Felix Nwaishi** Towards developing a functional-based approach to constructed peatlands (15 min.)	**E**

15h30	**Vote and student awards (10 min.)**
15h40	**Closing remarks from Line and Jonathan**
16h00	**End**

Man-made pools: what do spiders and predacious diving beetles look for?

André-Philippe Drapeau Picard[1], Line Rochefort[1] and Maxim Larrivée[1]

[1]Peatland Ecology Research Group and Centre d'études nordiques, Université Laval.

The moss layer transfer technique, widely used for peatland restoration in North America, aims to facilitate plant cover re-establishment. Efficient in that regard, it however fails to restore habitat heterogeneity that supports the high biodiversity of natural peatlands. Pools are habitats with an associated characteristic fauna and flora, contributing significantly to species diversity in peatlands. In restored peatlands, man-made pools should increase habitat heterogeneity and thus, species diversity. In virtually all ecosystems, arthropods are diverse and abundant, and they are sensitive to fine-scale environmental changes, making them relevant as ecological indicators. To assess how pools should be designed in order to facilitate arthropod recolonization, 21 pools of variable depth and vegetation were created in a restored fen in the Bas-Saint-Laurent region. Four natural fens of the same region were designated as reference ecosystems. Ground-dwelling spiders (Araneae) and predacious diving beetles (Coleoptera: Dytiscidae) were sampled around and within pools using pitfall traps and funnel minnow traps. Multivariate analyses were conducted to investigate how arthropod assemblages vary between pools and sites, and which environmental variables explain these differences.

Do plants have a similar ecological niche in natural, restored or spontaneously revegetated bogs?

Rémy Pouliot[1] and Line Rochefort[1]

[1]Peatland Ecology Research Group and Centre d'études nordiques, Université Laval.

remy.pouliot.1@ulaval.ca

Several hypotheses or principles have been enunciated over the years to explain the development of ecological niches. That includes principles of competitive exclusions or hierarchies as well as stochastic, stress gradient or maximum niche overlap hypotheses. These ideas have been used in order to compare breadth and overlap (intra- and interspecific) indices for the ecological niches of common plant species in natural, restored or with a spontaneous revegetation (after the end of peat extraction activities) bogs. To do this, vegetation surveys and water chemical analyses have been made in 140 peatland sectors belonging to one of those three bog categories. Niche breadth and interspecific overlap indices were higher in natural bogs than in spontaneously revegetated ones. An intermediate situation was observed in restored bogs. Also, the intraspecific overlap for a given species was relatively different between the three bog categories. The method, the depth and the number of years for the peat extraction on a given site as well as the time since the return of vegetation through the restoration or spontaneous revegetation could explain the observed differences between the abiotic conditions in the three bog categories, influencing the niche development opportunities for a given species. However, helping the plant recovery during the restoration process could lead, with time, to a niche development more and more similar to those observed in natural bogs. Finally, no principle or hypothesis involving the ecological niche concept seems to be fully applicable to one of the three bog categories.

A reference system for peat and water chemistry in peatlands of Canada and Alaska

Andersen, Roxane[1], Claire Boismenu[2] and **Rochefort, Line**[2]

[1]Environmental Research Institute; North Highland College, University of the Highlands and Islands
[2]Peatland Ecology Research Group (PERG), Département de phytologie, Université Laval
Line.Rochefort@fsaa.ulaval.ca

Chemistry variables are valuable tools for investigating the impacts of disturbances in ecosystems, since they mirror the efficiency of nutrient and mineral cycling and can be compared to natural references. In Canada and Alaska, peatlands represent a dominant feature of the landscape, whether they are found in natural, disturbed or restored states and have been monitored for many years. Thus, a large body of literature on peatland chemistry exists; however, not always in an easily accessible format (e.g. technical reports, student's theses, articles in French, etc.). The main objective of this review was to group and synthesize the available peat and water chemistry data to build an up to date database for Canada and Alaska. The database was then used to explore general trends in water and peat chemistry. Even using coarse geographical divisions (provinces) and categories (fen, bog, restored, extracted) we were able to highlight and explain differences in the chemical composition of peat and peatland water. Values for water pH were similar across Canada within a given peatland type, but differed between peatland types, averaging 4.2 ± 0.5 (Bogs), 6.3 ± 0.8 (Fens), 4.9 ± 0.8 (Peat extracted), 4.9 ± 1.1 (Restored cutover bogs). Using only a limited subset of most commonly measured elements in the water (EC, Na and Ca), we revealed that it is possible to monitor progress of chemical rehabilitation of restored sites towards natural sites. For a more functional understanding of restoration progress, nutrients (e.g. K, PO_4, NH_4, NO_3, Dissolved Organic Carbon, etc.) should be measured throughout the year. A common and shared meta-database could be useful in particular for those evaluating the success of peatland restoration or the impact of disturbances, as it will provide a pool of regionally relevant reference data to use as a baseline for comparison (reference ecosystems concept).

An overview of *Sphagnum* peatland restoration in Scotland

Roxane Andersen[1]

[1]Environmental Research Institute, North Highland College,
University of the Highlands and Islands, Scotland
roxane.andersen@uhi.ac.uk

The Flow Country of Caithness and Suthertland is the largest blanket bog in Europe, and the single largest soil carbon store in the UK, holding an estimated 400MT of carbon. Afforestation with non-native coniferous in the 1980s and associated drainage damaged large areas of deep peat blanket bog in the Flow Country. Trees do not naturally grow on most British peatlands, thus ploughing, ditching and fertilisation are required for the establishment of conifer plantations. As a consequence of drainage and evapotranspiration, the water table drops, peat cracks and tree roots allow oxygen to reach previously anaerobic horizons and this poses a threat to carbon reserves.

Afforestation and the creation of a highly fragmented landscape also led to a significant decline in waders. This was the trigger for the start of restoration work in the late 1990s, which aimed to bring the afforested areas back towards open blanket bog through combinations of drain blocking and tree removal. Restoration has since been recognised as one of the most cost-effective way to mitigate climate change, and is specifically integrated in Scotland's biodiversity and peatland strategies.

This presentation will 1) briefly discuss current research on the impact of afforestation and restoration of Scottish blanket bogs on various ecosystem services 2) point out gaps in knowledge and challenges for the restoration of *Sphagnum* peatland in Scotland.

Methane flux from restored Canadian peatlands: How long does it take to recover?

Maria Strack[1], Kelly Nugent[2], Tracy Rankin[2] and Ian Strachan[2]

[1]Department of Geography and Environmental Management, University of Waterloo;
[2]Department of Natural Resource Sciences, McGill University
mstrack@uwaterloo.ca

Northern peatlands are globally important sources of the greenhouse gas methane (CH_4). Peat extraction largely eliminates CH_4 emissions from peat fields, although emissions from ditches may remain high. Although restoration has been shown to increase CH_4 fluxes, they have often been reported to remain lower than nearby undisturbed peatlands. This is likely partially attributable to deeper water tables that often remain post-restoration; however, there is still relatively little known about how long it takes CH_4 dynamics in restored peatlands to approach those of natural systems. Using data from several Canadian peatlands, including ongoing studies of unrestored and restored peatlands in Alberta (Seba Beach) and Quebec (Bois-des-Bel, St. Alexandre), we determined CH_4 fluxes from restored and unrestored peatlands, and changes in controls on CH_4 flux over time post-restoration.

On average, restoration increased CH_4 flux compared to unrestored sites, but fluxes remained lower than natural peatlands. As in natural systems, water table and plant cover were significant controls on spatial variation in flux. Due to a limited number of flux measurements from only a few restored peatlands, there was large variability in CH_4 flux from peatlands of different ages post-restoration; however, it appears that CH_4 flux from restored peatlands is lower at any given water table than natural systems, suggesting a limitation of CH_4 production. This limitation is more pronounced at newly restored sites, while data from Bois-des-Bel indicates that fluxes may be similar to undisturbed sites by 15 years post-restoration.

Impacts of sub-surface irrigation on the carbon uptake of *Sphagnum* moss

Catherine Brown[1], Maria Strack[1] and Jonathan S. Price[1]

[1]Department of Geography and Environmental Management, University of Waterloo

c5brown@uwaterloo.ca

Sphagnum biomass production is a feasible and sustainable alternative to current peatland harvesting practices; however, maintaining optimal hydrological conditions for fiber accumulation (i.e. net carbon sequestration) can be challenging. The objectives of the research are to evaluate the efficacy of different sub-surface irrigation techniques on water distribution within S*phagnum* fiber production plots, and to assess the optimal hydrological conditions for S*phagnum* biomass accumulation. An abandoned block-cut peatland in Shippagan, New Brunswick, has been manipulated to control the water table in six S*phagnum* biomass production basins. The hydrology of each basin is controlled by a change in irrigation arrangement or position of the water table (-20 cm or -10 cm) below the surface.

Instantaneous CO_2 fluxes under various light conditions were measured to calculate the gross primary productivity (GPP) of each basin. GPP values were compared to various hydrological variables, such as water table level, soil water tension, and volumetric soil moisture content. Preliminary data suggests that there is a weak relationship between instantaneous water table and carbon flux measurements, but there is a strong relationship between the average seasonal mean water table and productivity values between basins with sub-surface irrigation. The most productive site had an average seasonal water table of -7.8 cm from the surface, and GPP of -4.1 g C m^{-2} d^{-1}. The two least productive sites were the only basins without sub-surface irrigation, and had average seasonal water table of -14.1 cm and -8.1 cm, and GPP of -3.0 C m^{-2} d^{-1} and -2.5 C m^{-2} d^{-1}, respectively. The least productive site had a high water table (-8.1 cm), but combined with saturated soil conditions and frequent pooling of water at the surface, could indicate that frequent saturation may decrease productivity**.** These results suggest that sub-surface irrigation is an effective water management technique during the first growing season.

Effects of straw mulch on evaporation from a peat profile: Implications for *Sphagnum* restoration

James Elliott[1] and Jonathan S. Price[1],

[1]Department of Geography and Environmental Management, University of Waterloo

jbelliot@uwaterloo.ca

Peat harvesting creates conditions that are not favourable for the recolonization of *Sphagnum* mosses. As such, straw mulch is commonly used to restore harvested peat surfaces to reduce the duration and frequency of periods of hydrologic stress for *Sphagnum* diaspores. Periods of stress have are characterized by a surficial pressure head below -100 mb. This study aims to quantify interception loss of straw mulch, evaporative reduction and how it alters surficial pressure head. Hydrus 1D was used to simulate three straw treatments (bare, 1x straw, 2x straw) over a 22 day period. Maintaining a water table of -20 cm. Meteorological data collected from the Shippagan filed station from 25 of July, 2014 to 16 of August, 2014 was used. Mulch samples were saturated with a squirt bottle to approximate the rainfall interception loss. Approximately 11% and 19% of rainfall was intercepted with 1x straw and 2x straw treatments. Instantaneous evaporation was measured over peat columns in the lab with the three straw treatments; 1x straw density (0.23g/m^2) and 2x straw density (0.46g/m^2) and reduced evaporative flux by 45% and 62% respectively. Model results show that the bare treatment attained lower surficial pressure than mulched treatments during rain. Mulched treatments showed a more gradual increase in surficial pressure after rain events. Initial findings suggest that increased straw density reduces the amount of time that *Sphagnum* diaspores are under periods of stress.

Hydrophysical evolution, soil water dynamics, and productivity of *Sphagnum* carpets in a regenerating cutover peatland

Neil Taylor[1] and Jonathan S. Price[1]

[1]Department of Geography and Environmental Management, University of Waterloo

n6taylor@uwaterloo.ca

Previous work has suggested that *Sphagnum* mosses regenerating on cutover peat surfaces quickly become vulnerable to water stress as the thickness of the regenerated layer increases. However, uncertainties regarding the storage and transmission properties of this layer and how these might evolve over time have made this assertion difficult to evaluate. This study investigates the hydrophysical properties and hydrologic behaviour of regenerating *Sphagnum* layers ranging from 3-43 years in age using both field and laboratory methods. The regenerated layers appear to follow a pattern of structural evolution whereby the bulk density and retention capacity of the basal layers directly overlying the cutover peat increase over time. Capillarity was a much stronger control on surficial water content (θ) than precipitation, which was poorly retained in the *Sphagnum* canopy, suggesting that regulation of water table position can be an effective method of controlling θ as a means of optimizing productivity. In general, the θ sustained at a given water table position decreased as layer thickness increased, although this was not always the case. Productivity measurements indicate a broad tolerance within all study plots to observed environmental conditions, and in particular that insufficient supply of water does not limit productivity at the site even when the water table is >40 cm below the surface or when no direct precipitation is received for 16 days. Conversely, productivity may have been frequently limited at the site by above-optimal water contents.

The hydrology of a "spontaneously" re-vegetated vacuum harvested peatland, eastern Manitoba

Pete Whittington[1] and Melanie Hawes[1]

[1]Department of Geography, Brandon University

whittingtonp@brandonu.ca

Peatlands cover over 38% of Manitoba's land area and represent an important component of the natural landscape. Nearly 13% of Canada's horticultural peat is produced in Manitoba in the southeastern part of the province. Vacuum harvesting requires the removal of all surficial vegetation and ditches to drain the peatland, lowering the water table. A consequence is that vacuumed harvested sites do not re-vegetate themselves naturally; active restoration efforts in eastern Quebec have been largely successful, though with considerable trial and error to get the ecohydrological processes correct.

The Moss Spur peatland was a large (~3 km diameter) domed bog, harvested from the 1940s and was abandoned in the early 1990s. With little intervention, the natural re-vegetation of the site has been remarkable, with over 90% wetland vegetation coverage and *Sphagnum* hummocks in a few locations, something that has not occurred naturally in Quebec. Preliminarily results suggest that the success of the re-vegetation is due to groundwater discharge under the site, which contradicts the ombrogenous requirement of bog hydrology. In areas with regeneration indicative of bogs (e.g., *Sphagnum*), hydraulic gradients of groundwater discharge averaged 0.02; in areas with more fen vegetation hydraulic gradients averaged 0.002; and in areas with no re-vegetation, hydraulic gradients averaged -0.1 (groundwater recharge). It is speculated that these groundwater flow reversals are occurring due to the lowered hydraulic head in the now abandoned former bog. This has been observed in other Western Boreal Plain peatlands in times of extreme drought, and thus peat harvesting may act as a surrogate extreme drought which causes groundwater flow reversals in large peatlands. Supporting this as a mechanism that aids restoration is that Moss Spur's hydrogeomorphic setting is quite different than Quebec sites, as eastern boreal shield peatlands are more typically situated on a thin veneer of sediment over bedrock, thus precluding regional groundwater exchanges.

Transport and hydrological response of simulated wastewater from a continuous point source in a northern ribbed fen

Colin McCarter[1] and Jonathan S. Price[1]

[1]Department of Geography and Environmental Management, University of Waterloo,
cmccarte@uwaterloo.ca

To minimize the discharge of wastewater contaminants from remote northern communities and mining operations, fen peatlands in sub-arctic regions are used for tertiary wastewater treatment to detain, transform, and remove these contaminants. However, there is a limited understanding of contaminant transport in fen peatlands, particularly in sub-arctic Canada. To better characterize contaminant transport in these systems, approximately 44 m^3 day^{-1} of simulated wastewater (concentrated custom-blend fertilizer and Cl^- diluted with water) was pumped into a small 0.5 ha sub-arctic northern ribbed fen continuously for 47 days (July 15th –August 31st 2015). Electrical conductivity (EC) of 3 similar northern ribbed fens varied between 15 (min) and 88 (max) µm cm^{-1} over the study period (May – September, 2014). Water table increased quickly (~0.16 m in 6 days) nearest the point source (8 m down-gradient), resulting in rapid solute transport, as measured by electrical conductivity (EC) (20 to 140 µm cm^{-1} in 11 days). This rapid transport was due to the large increase of hydraulic conductivity (~2 to 180 m day^{-1}) as the water table rose. More gradual increases in water table (0.18 m in 13 days) and EC (140 µm cm^{-1} in 15 days) were observed farther (~50 m) from the point source; this delay was likely due to increased total storage capacity rather than differences in hydraulic conductivity. After 34 days the water table had risen on average 0.16 m across the site, but EC (113 µm cm^{-1} in 25 days) was limited to a final distance of 119 m. Northern ribbed fens have a large capacity to detain wastewater as illustrated by the conservative solute plume only travelling 49 % of the total site length (notwithstanding the large increase in hydraulic conductivity as the water table rose) and have the potential to significantly decrease wastewater contamination in northern aquatic environments.

The effects of climate change on peatland hydrology in discontinuous permafrost

Ryan F. Connon[1], W.L. Quinton[1] and J.R. Craig[2]

[1]Centre for Cold Regions and Water Science, Wilfrid Laurier University, Waterloo, ON

[2]Department of Environmental Engineering, University of Waterloo, Waterloo, ON

rfconnon@gmail.com

In the high-Boreal region of NW Canada, permafrost occurs predominantly in the form of tree-covered peat plateaus within a permafrost-free mosaic of wetlands (i.e. flat bogs and channel fens). This region is experiencing unprecedented rates of permafrost thaw as a result of climate warming. Over the last several decades, such thaw has significantly expanded the areal extent of the permafrost-free wetlands at the expense of the plateaus. This rapid change in land-cover has raised concerns over its impact on northern water resources, since remotely sensed data and ground observations indicate that the two major land-covers in this region have very different hydrological functions. Peat plateaus have a limited capacity to store water, a relatively large snowmelt water supply and hydraulic gradients that direct excess water into the adjacent permafrost-free wetlands. As such, the plateaus function primarily as runoff generators. Plateaus also obstruct and redirect water movement in adjacent wetlands since the open water surfaces of the latter occupy an elevation below the permafrost table. By contrast, bogs are primarily water storage features since they are surrounded by raised permafrost and therefore less able to exchange surface and near-surface flows with the basin drainage network. This research examines how permafrost thaw is increasing streamflow in four gauged river basins (152 - 2050 km^2) in the lower Liard River valley, Northwest Territories. Annual runoff in this region has nearly doubled since 1996. As permafrost thaws, the connectivity among the major land-cover types increases, giving rise to expansion and greater spatial integration of runoff contributing areas. The area of the basin able to contribute to streamflow is increasing in a non-linear fashion in response to permafrost thaw, and in doing so is fundamentally changing the basin hydrograph.

Quantifying and characterizing conifer evapotranspiration in two natural Boreal fens, Fort McMurray

Elise Gabrielli[1] and Richard Petrone[2]

[1]Department of Geography and Environmental Studies, Wilfrid Laurier University
[2]Department of Geography and Environmental Management, University of Waterloo
gabr3950@mylaurier.ca

Despite the dominance of fens within the Western Boreal Plan (WBP) landscape, previous oil-sands reclamation projects have neglected to restore landscapes to its previous capacity and functioning. An understanding of moisture dynamics is fundamental when implementing design reclamation strategies. It is necessary to understand processes controlling water storage and the dominant peatland hydrologic flux. Wetlands within the WBP are subjected to a water-deficit by which evapotranspiration (ET) exceeds precipitation, and thus very important to its water budget. Therefore the main objective of this study is to partition ET within two natural Boreal fens.

At each site, water flux to the atmosphere was measured in natural stand varieties of Larix laricina, and Piecea mariana, using heat dissipation sensors and compared against above canopy eddy correlation measurements and community-scale chamber measurements of ET within varying microforms. Results were used to quantify the spatial partitioning of ET and how the partitioning of ET varies with the density and spatial organization of the trees. Results showed above canopy dominated ET is controlled primarily by the vegetation present. It may be further assumed that ET losses will increase as a result of tree growth during the succession of a peatland with tree species acting as water conserving agents. This will modify the sub-canopy species composition and reduce the available energy for moss evaporation that provides the dominant component of the ET flux. Thus it is essential to understand how the rate of ET varies from the surface in different degrees of cover and what the different layers of vegetation contribute to the overall site ET. This is needed to understand how a peatland ecosystem may respond ecohydrologically to disturbance, as well as to establish appropriate donor peat amounts and types to create a functioning system in different AOS mine closure conditions.

The effect of mine dewatering and the barrier layers on the pattern of surface recharge around the Victor diamond mine, James Bay Lowlands

Mazda Kompanizare[1], Jonathan S. Price[1] and Pete Whittington[2]

[1]Department of Geography and Environmental Management, University of Waterloo
[2]Department of Geography, Brandon University, Brandon, MB
mkompani@uwaterloo.ca

The peatlands surrounding the Victor Diamond mine have been shown to be variably affected by the aquifer dewatering required to keep the open-pit mine dry, mostly based on the near surface marine sediment thickness underlying the peat. However, the role of other, deeper subsurface barrier layers, as well as their spatial extent, has not been studied. The watershed was modelled using HYDRUS 3D for a 7 year period (2 years pre, and 6 years post dewatering) for a 106 km^2, 300m deep domain. The basic stratigraphy (with average depth below surface, m) is peat (2), marine sediments (2 to 20), upper part of limestone bedrock (48), claystone (50), lower part of limestone bedrock (210), mudstone (230) and granite bedrock (300). The results show that the average recharge rate changed from 0.07 to 0.32 mm/day in pre-mining and mining conditions, respectively. It was found that in mining conditions when the dewatering rate approached 86,000 m^3/day, ~42% of the dewatering rate recharge to the surface and ~ 25% of this percolate through the claystone barrier layer (layer between upper and lower bedrock aquifers). The model suggests the areas with recharge rates more than 0.3 mm/day (the average available water) are limited to the areas within a 2-3 km radius around the mine where the claystone and marine sediment layer are thinner or absent. The thin, low hydraulic conductivity claystone and mudstone with their variable thickness and local openings are a significant control on the recharge and vertical percolation pattern through the area.

Impacts of road construction on the development of a poor fen in northeastern Alberta

Emma Bocking[1], Jonathan S. Price[1] and David J. Cooper[2]

[1]Department of Geography and Environmental Management, University of Waterloo
[2]Department of Forest and Rangeland Stewardship, Colorado State University
ecbockin@uwaterloo.ca

Roads that bisect wetlands can alter their hydrologic connectivity on a local or landscape scale. These impacts were studied in a poor fen in northeastern Alberta, where a raised road was built in 1977. Black spruce dieback on the up-gradient side of the road suggests a period of flooding that drowned the tree roots. Examination of the fen's response to this impoundment provided insight into post-disturbance vegetation succession patterns and peatland development. The objectives of this study are to compare the impacts of the road on fen vegetation composition and tree growth, and to predict its successional trajectory. Hydrological change was reconstructed by determining the rate and spread of tree dieback through cross-dating and individual tree growth curve analysis. Vegetation cover along with several abiotic variables was measured in 281, 1 m^2 plots. The majority of tree dieback occurred in 1989, over a decade after road construction and likely after blockage of the culvert (probably by beavers) caused widespread flooding in the fen. There is a critical elevation threshold above the height of the culvert of 83.5 cm, below which the tree dieback mostly occurred in 1989. Multivariate analysis of the vegetation cover reveals dominance of non-hummock forming species closest to the culvert, and assemblages of poor fen species approximately 200 m up-gradient. There is a relationship between proximity (distance and elevation) to the culvert and vegetation succession patterns, suggesting that the culvert continues to regulate local hydrological regimes in the fen.

Characterizing physical and hydraulic properties of the peat column: A hydrogeological assessment of temporary access infrastructure impact, and the immediate effects on surrounding fen hydrology

Jenna Pilon[1] and Richard Petrone[1],
[1]Dept. of Geography and Environmental Management, University of Waterloo
jk.pilon@shaw.ca

Due to disrupted hydrology and altered water chemistry, permanently leaving roads and well pads within wetlands has become highly discouraged. Moreover, incremental disturbances over time can be reduced as fill materials are re-used, avoiding the expansion of additional excavation pits. However, knowledge gaps exist of untried and innovative wetland reclamation practices, which demonstrates the growing need for adaptive reclamation management. For example: Will structure removal leave a permanently water-filled void? Are there economic benefits to wetland reclamation? Can the removed structure fill be re-used?

In the summer of 2013, Suncor and the UW Meteorology Research Group reclaimed the Pad 106 Access Road, constructed within a fen peatland at Suncor's Firebag site in northeastern Alberta, with the intent of evaluating fen peatland response immediately and over time. The road hindered the natural water flow. Elevated and contained water on the upstream side was evidently causing high mortality of vegetation.

The long-term goal of the Suncor Firebag Road Removal Reclamation Study is to determine the capacity of the affected fen to self-correct and self-regulate naturally before additional attempted intervention. The goal of this presentation is to evaluate the immediate response of the fen directly following the removal of the road. The main research questions presented here are: Will the once anoxic, buried, compressed peat decompress naturally and regain its pre-disturbance hydraulic conductivity? Will the site-specific hydrologic conditions show signs of regaining their pre-disturbance state? Anticipated potential causes of failure of self-correction and self-regulation include prevention of peat decompression by flooding and inability of the system to sustain peatland vegetation due to a non-conducive hydrologic regime of the pre-disturbance state.
Under-road sites and transects running perpendicular to the road were sampled for cores, and had groundwater wells installed. Instrumentation to monitor hydrology and peat decompression was installed. The initial response of peat physical parameters was evaluated in comparison to outer pristine transect sites (relative to the road). Physical peat hydraulic properties such as bulk density and specific yield will be observed and measured over several years.

Results of groundwater measurements indicate that the direction of flow was perpendicular to the road. Physical parameters (bulk density, specific yield, porosity) varied significantly between the wet and dry side of the road. Specific yield and bulk density were higher on the dry side, while porosity was lower. After removal, peat consolidation underneath the road was minimal over time. Off-road changes in peat consolidation were significantly smaller than the road peat response. Of the road material removed, about 83% of the road fill was immediately reusable for parking lot construction, and almost 100% of the reusable material was at or near optimal moisture content for construction, which further supports reclaiming these sites.

Water table dynamics and hydrophysical variability of reclamation material properties in a constructed fen watershed

Scott J. Ketcheson[1] and Jonathan S. Price[1]

[1]Department of Geography and Environmental Management, University of Waterloo, Waterloo, *sjketche@uwaterloo.ca*

Reclamation in the oil sands areas requires that entire landforms and drainage systems be reconstructed. Fen peatlands rely upon a combination of ground and surface water inflows to sustain the water balance. This makes them an attractive candidate for peatland creation, since climactic factors (i.e., dry conditions) can be mitigated by providing a suitable geomorphic setting to provide supplementary water flows under dry conditions, common in the Athabasca Oil Sands Region of northern Alberta. In the constructed fen system, peat from newly developed lease areas is placed at the base of an upland watershed (tailings sand capped with a reclamation soil) designed to supply the requisite groundwater flow to sustain fen processes and functions. The hydrophysical properties of some materials used in the reclamation process can change substantially with time since placement, as the vegetation community is established and the soils undergo freeze-thaw cycling. The implications of these changes on the hydrological functioning of constructed reclaimed landscapes must be addressed as the system evolves. Additionally, little is known about the nature and magnitude of these potential changes in reclaimed peat materials following placement. Thus, this research aims to characterize the spatial and temporal variability in the hydrophysical properties of reclamation materials (including peat) and assess the implications for the hydrological functioning of a constructed fen watershed in a post-extraction oil sands environment.

Inter-year comparisons of peat placed in 2013 revealed that saturated hydraulic conductivity (K_{sat}) increased at all depths in 2014 compared to 2013; however, the placed tailings sand showed negligible change. K_{sat} of the shallow (50 cm) placed peat varied by over an order of magnitude spatially within the fen (~2.9 ha). Nonetheless, high water table levels were sustained in the fen throughout the summers of 2013 and 2014, with persistent ponded water in localized depressions in the surface of the placed peat. Strong upward gradients were measured in the fen, which suggests strong connectivity with the uplands aquifer; however very low surface infiltration rates on the capping upland reclamation soil constrained recharge to the sand aquifer, which remains below designed water contents in much of the upland.

Plot-scale hydrodynamic variability of a constructed fen in a post-mined oil sands landscape, Fort McMurray, Alberta

Sarah Scarlett[1] and Jonathan S. Price[1]

[1]Department of Geography and Environmental Management, University of Waterloo

sjscarlett@uwaterloo.ca

In the Athabasca Oil Sands region, oil sands companies are now required to include peatlands in their reclamation efforts, as they cover >60% of the regional pre-mined landscape. The construction of Suncor's pilot fen reclamation project was completed in 2013, engineered with the intent to support natural fen vegetation and hydrologic processes. The purpose of this study is to evaluate the fen's hydrodynamic variability, with respect to vegetation treatments and placed-peat properties. Multiple study sites (n=31) were monitored across the fen during June-August 2014, located in vegetation plots (control/moss/seedlings) with varying treatments (mulched/unmulched). Water table position, volumetric water content (VWC) and pore water pressure were monitored at each study plot. Over the season the fen had an average water table of 6 (+/-5) cm below the peat surface. Average water table position only varied +/-2 cm between plot types, however showed large spatial and temporal variability across the fen. Near-surface VWC differed between plot types due to changes in water table and evapotranspiration (ET). Control and seedling plots experienced the highest evaporative demands and lower VWC during these periods, despite higher water tables. Mulch plots were sheltered from ET losses and showed a stronger relationship between VWC and water table position. Peat samples (n=9) were collected at 7 sampling locations across the fen to determine intra-site variability of hydrophysical properties (i.e. porosity, bulk density, saturated hydraulic conductivity). Samples showed large spatial variability across the fen, especially in saturated hydrologic conductivity (10^{-4} to 10^{-6} m/s). The large heterogeneity in water table position, peat properties and the complex relationship between vegetation, treatment type and hydrology illustrates the difficulty in characterizing plot-scale hydrology of a constructed fen. Results conclude that the fen's hydrology will be highly variability during the initial years post-construction until greater vegetation establishment and the formation of a peat structure closer to that of a natural fen peatland.

The fate and transport of sodium and Naphthenic Acids in a constructed fen peatland

Eric Kessel[1], Scott J. Ketcheson[1], and Jonathan S. Price[1]
[1]Department of Geography and Environmental Management, University of Waterloo
e2kessel@uwaterloo.ca

Reclamation of the Athabasca oil sands region requires the reconstruction of fen peatlands in which mine waste materials (e.g., petroleum coke and tailings sand) and salvaged reclamation materials (including peat) are commonly used. Tailings materials used to construct the upland areas that provides water to a constructed fen on the Suncor Energy lease have elevated concentrations of sodium (Na) and Naphthenic acids (NAs) being transported into the fen via a permeable layer beneath the peat. Peat (2 m thick) is expected to disperse and adsorp Na and NAs moving upwards through the peat profile. Water chemistry samples taken in 2013 and 2014 indicate the presence of Na and NAs at the base of the peat profile, and little in the rooting zone. For example, in 2013 Na concentrations averaged 314 mg/L in the upland (tailings sand) and 121 mg/L, 78.5 mg/L, and 87.3 mg/L in the fen peat at 150, 90, and 50 cm depths, respectively. In 2014, Na concentrations averaged 154.6 mg / L in the upland and 109 mg/L, 70.6 mg/L, and 82.1 mg/L in the fen at comparable depths, which indicates that Na present in the system was diluted. However, in 2013 NAs concentrations averaged 24.1 mg/L in the upland and 12.5 mg/L, 1.19 mg/L, and below detection in the fen at 150, 90, and 50 cm depths, respectively, generally increasing in 2014 to 26.8 mg/L in the upland and 11.1 mg/L, 5.47 mg/L, and 1.23 mg/L in the fen at comparable depths. The different behavior of Na versus NAs may be a result of NAs moving through “windows” faster than the mean rate; further assessment is required to understand this. The success of future reclaimed fen peatlands depend on designs accounting for the management of water quality. Further monitoring is required to characterize the rate of solute movement.

Nikanotee fen: Vegetation establishment update

Andrea Borkenhagen[1], David J. Cooper[1] and Kristen Kaczynski[1]

[1]Department of Forest and Rangeland Stewardship, Colorado State University
andrea.borkenhagen@colostate.edu

The Nikanotee Fen was planted in 2013 with a factorial experimental design to determine the most effective treatments for establishing peat-forming vegetation. We established 12 blocks with five different planting treatments: control, seeded, seedlings, moss layer transfer, and moss layer transfer + seedlings. Regionally collected seeds were used to introduced three saline fen dominant species (Juncus balticus, Triglochin maritimum, Calamagrostis stricta) and two rich-fen dominants (Carex aquatilis, Betula glandulosa). The moss layer was harvested from a rich fen, and planted at a 1:10 ratio. Plots were further split to test WoodStraw mulching and weeding treatments. Variation is prominent at the site and hydrologic and geochemical gradients are influencing moss and plant species cover and distribution.

Moss established from the transfer and increased significantly under mulch and seedlings treatments as well as in plots with lower salinities and little to no flooding. Seedling cover continued to increase over time and was greater when planted with the moss layer transfer. Above and belowground biomass and tiller density differed by species but not consistently with original planting density. Exotic plant invasions were most common in plots with long-term flooding but were reduced by weeding and seedling planting treatments. Distinct vegetation communities developed from planting treatments and were different from the regenerating harvested area of the fen, but similarities in species composition were apparent in some treatment plots. In this presentation we review each of the experimental treatments and results that inform future direction for establishing vegetation in constructed fens.

Assessment of pools and potential redistribution of sodium in a constructed fen peatland system

Reuven B. Simhayov[1], Christina M. Smeaton[2], Christopher T. Parsons[2], Phillip Van Cappellen[2] and Jonathan S. Price[1]

[1]Dept. of Geography and Environmental Management, University of Waterloo
[2]Dept. of Earth and Environmental Science, University of Waterloo
rbsimhay@uwaterloo.ca

A constructed fen peatland on a post-mined oil sands landscape in northern Alberta incorporates materials from the mining site into the constructed system. Peat is used for the fen, tailings sand is used for the upland and petroleum coke is used for a high permeability connecting basal layer. The use of these byproducts of oil production requires an understanding of the transport and attenuation mechanisms of potential solutes they may contain such as sodium (Na), since they may impact the plants and microbial community of the fen. To meet this goal we need a prior understanding of the type of solutes, their concentration and movement. We believe sodium (Na) to have the highest potential toxicity to plants. Material digestion results indicate that following construction peat contained the highest concentration of Na (445 mg/kg) compared with coke (215 mg/kg) and sand (80 mg/kg). However, results of a batch experiment showed that peat has the lowest range of available Na of the building materials examined. Using the results a mass balance of Na was done and the calculations indicate that a large pool of available Na exists in the created upland. This pool, which through groundwater flow is directed to the peatland, exceeds the adsorption capacity of the peat. If the outflow of Na in surface runoff from the fen is limited, as is expected, Na is likely to accumulate in the fen over the short- and medium-term, with implications for vegetation succession.

Towards developing a functional-based approach for constructed peatlands evaluation in the Alberta Oil Sands Region, Canada

Felix Nwaishi[1], Richard Petrone[2], Jonathan S. Price[2] and Roxane Andersen[3]

[1]Department of Geography & Environmental Studies, Wilfrid Laurier University
[2]Department of Geography & Environmental Management, University of Waterloo
[3]Environmental Research Institute, University of the Highlands and Islands
nwai5240@mylaurier.ca

Peatlands support vital ecosystem services such as water regulation, specific habitat provisions and carbon storage. In Canada, anthropogenic disturbance from energy exploration has undermined the capacity of peatlands to support these vital ecosystem services, and thus presents the need for their reclamation to a functional ecosystem. As attempts are now being made to implement reclamation plans on post-mining oil sands landscapes, a major challenge remains in the absence of a standard framework for evaluating the functional state of a constructed peatland. To address this challenge, we present a functional-based approach that can guide the evaluation of constructed peatlands in the Alberta Oil Sands region. We achieved this by conducting a brief review, which synthesized the dominant processes of peatland functional development in natural analogues. Through the synthesis, we identified the interaction and feedback processes that underline various peatland ecosystem functions and their quantifiable variables. By exploring the mechanism of key ecosystem interactions, we highlighted the sensitivity of microbially mediated biogeochemical processes to a range of variability in other ecosystem functions, and thus the appropriateness of using them as functional indicators of ecosystem condition. Following the verification of this concept through current pilot fen reclamation projects, we advocate the need for further research towards modification to a more cost-efficient approach that can be applicable to large-scale fen reclamation projects in this region.

Poster Session Schedule: Tuesday, February 17th, 17h00, University Club

"*Recovery of Alberta peatlands used as a source of vegetation donor material for restoration: greenhouse gas exchange and ecohydrology evaluation*" Kimberley Murray[1], Maria Strack[1]. [1]Dept. of Geography and Environmental Management, University of Waterloo.

"Conceptualizing restoration processes in peatlands"
Anne Quillet[1]; Nigel Roulet[1] and Jianghua Wu[2], [1]Dept. of Natural Resource Sciences, McGill University, [2]Memorial University of Newfoundland.

"Man-made pools: what do spiders and predacious diving beetles look for?
André-Philippe Drapeau Picard[1] and Line Rochefort[1], [1]Dépt. de phytologie (FSAA), Université Laval.

"The hydrologic function of a saline spring wetland in the Athabasca oil sands region, Alberta, Canada"
Corey Wells[1] and Jonathan Price[1], [1]Dept. of Geography and Environmental Management, University of Waterloo.

"Restoration of linear disturbances in peatlands under hydroelectric right of way."
Kathy Pouliot[1] and Line Rochefort[1], [1]Dépt. de phytologie (FSAA), Université Laval.

"Net carbon dioxide and methane fluxes at paired restored and unrestored peatlands in Quebec and Alberta, Canada" Kelly Nugent[1], Tracy Rankin[1], Luc Pelletier[1], Ian Strachan[1] and Maria Strack[2], [1]Dept. of Natural Resource Sciences, McGill University, [2]Dept. of Geography and Environmental Management, University of Waterloo

"*Hydroclimatic controls on peatland CO_2 exchange following adjacent forest harvesting on the Western Boreal Plain"* Janina M. Plach[1], K. J. Devito[2], and R. M. Petrone[1]. [1]Dept. of Geography and Environmental Management, University of Waterloo; [2]Dept. of Biological Sciences, University of Alberta.

"Water use efficiency at the community to ecosystem scales of a newly reclaimed fen" Richard Petrone[1], George Sutherland[1], Corey Wells[1], Jonathan Price[1] and Felix Nwaishi[2], [1]Dept. of Geography and Environmental Management, University of Waterloo; [2]Dept. of Geography & Environmental Studies, Wilfrid Laurier University.

"Analyzing the growth response of black spruce to road construction in a boreal fen using tree-ring analysis" Emma Bocking[1], Jonathan Price[1] & David Cooper[2]. [1]Dept. of Geography and Environmental Management, University of Waterloo; [2]Dept. of Forest & Rangeland Stewardship, Colorado State University.

"Assessment of ecological functions seven years post black spruce plantation on a cutover peatland in Alberta" Tania G. Bravo[1], Maria Strack[1,2] and Line Rochefort[3] [1]University of Calgary, [2]Dept. of Geography and Environmental Management, University of Waterloo, [3]Dépt. de phytologie (FSAA), Université Laval.

"Evaluation of snow dynamics in a basin fen-bog complex in the Western Boreal Plains, Canada" James. H. Sherwood[1], Scott J. Ketcheson[1], and Jonathan Price[1], [1]Dept. of Geography and Environmental Management, University of Waterloo

"Evaluating function of a constructed fen in Alberta's Oil Sands region using dissolved organic carbon concentration and chemistry" Bhupesh Khadka[1] and Maria Strack[2] [1]University of Calgary, [2]Dept. of Geography and Environmental Management, University of Waterloo

"Post-fire nutrient supply rates across a peatland-ppland hillslope in the Western Boreal Plains".
Midori Depante[1] and Richard Petrone[1], Kevin J Devito[2], Nicholas Kettridge[3], James M. Waddington[4, 1]Dept.of Geography and Environmental Management, University of Waterloo, [2]Dept. of Biological Sciences, University of Alberta, [3]School of Geography, Earth and Environmental Sciences, University of Birmingham, [4]School of Geography and Earth Sciences, McMaster University

"Developing a functional approach to assessment of equivalent capability: utilizing ecosystem water, carbon, and nutrient fluxes as integrated measures of reclamation performance".
Richard Petrone[1], Sean K. Carey[2] and Justin Straker[3]. [1]Dept.of Geography and Environmental Management, University of Waterloo, [2]School of Geography and Earth Sciences, McMaster University, [3]Integral Ecology Group, Canada

"Impacts of donor peat management practices on peat quality and the functional characteristics of a constructed peatland in the Alberta oil sands region, Canada".
Felix Nwaishi[1], Richard M. Petrone[2], Roxane Andersen[3] and Jonathan Price[2]. [1]Dept. of Geography & Environmental Studies, Wilfrid Laurier University, [2]Dept.of Geography and Environmental Management, University of Waterloo, [3]Environmental Research Institute, North Highland College, University of the Highlands and Islands

*"*Simulated mechanical compression of regenerated *Sphagnum* moss potentially accelerates the return of hydrological functionality in restored *Sphagnum* bogs*".*
Colin McCarter[1] and Jonathan Price[1]. [1]Dept.of Geography and Environmental Management, University of Waterloo