



**Book of Abstracts Symposium
International Peatlands
Society 50 years**

**Scientific Sessions
Thursday 13 September 2018**

**Editor J.J.H. van den Akker
Wageningen Environmental Research**



International Peatland Society

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Preface



Summary



1 Oral presentations

1.1 Trinidad Room PEATLANDS AND ECONOMY (1)

Chair Hannu Salu, vice chair - Sakari Sarkkola

Peatlands for Agriculture, Peatlands for Forestry, Peatlands and Climate Change

Trinidad Room 1: 9:00 - 9:15

1.1.1 GHG emissions from a Swedish field trial adding sand and lime to the soil.

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Peatlands for Agriculture

GHG emissions, sand addition, lime

Peatlands store a large share of the world's soil organic carbon and are widespread in Northern and Central European countries. Drainage is a precondition for traditional agricultural production on organic soils. Drainage increase peat mineralization and changes the physical and chemical soil quality. Only a few decades after initial drainage, agricultural systems on drained organic soils start experiencing a high risk of crop failure. Decreased hydraulic conductivities lead to decreased infiltration, ponding, and finally to abandonment as drainage will not be effective anymore. Another problem is the low trafficability.

The aim of the first experiment is to investigate if the addition of foundry sand to the top soil will improve the trafficability and how it will affect the CO₂ emission. In the Swedish part of the EU-funded PEATWISE project, a field experiment (randomized block design, 3x3) was set up at a former cultivated, but now abandoned, fen peat located at Bälänge Mossar (60.03N, 17.43E). We compare trafficability, yield, oxygen concentration in the soil and CO₂ emission from plots sown with Timothy (*Phleum pratense*) treated with 0 cm, 2.5 cm or 5 cm foundry sand. The sand was applied in the autumn of 2015 and mixed in the top 10 cm of the soil. CO₂ emissions were measured with automatic chambers (ADC BioScientific, UK) taking 12 measurements per day in frames where we removed the vegetation.

The results from the autumn of 2015 (15/9-1/11) showed that the CO₂ emissions were highest from the plots without sand addition (3.4 $\mu\text{mol m}^{-2} \text{s}^{-1}$) and lowest from the plots where 5 cm sand was added (1.4 $\mu\text{mol m}^{-2} \text{s}^{-1}$). The emission from the 2.5 cm treatment was 1.8 $\mu\text{mol m}^{-2} \text{s}^{-1}$. During 2016 (4/5 – 27/9), the emissions were lowest from the plots treated with 5 cm foundry sand (4.26 $\mu\text{mol m}^{-2} \text{s}^{-1}$), and highest from the plots with 2.5 cm sand (6.10 $\mu\text{mol m}^{-2} \text{s}^{-1}$). The untreated plot had an average CO₂ emission of 5.09 $\mu\text{mol m}^{-2} \text{s}^{-1}$. The 5 cm plots had lowest emission 2017 as well, emitting an average of 4.53 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{s}^{-1}$ whereas the 2.5 cm treatment emitted 4.87 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{s}^{-1}$ and the 0 cm treatment 5.92 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{s}^{-1}$.

It seems that the addition of foundry sand changes the properties (physical and chemical) of the soil which reduce the CO₂ emission and increase the yield.

I will also present the first results from a new field trial at the same site, where the addition of lime at a rate of 10 t/ha and 20 t/ha is compared to a control. This is part of an EU-funded project called MAGGE-pH.

1.1.2 Future prospect of conventional agriculture and paludiculture on organic soils in Europe under a changing climate

Arndt Piayda, Michel Bechtold, Sasha Bertram, Rob Hendriks, Mikhail Semenov, Kristiina Regina, Merja Myllys, Poul Erik Lærke, Bärbel Tiemeyer

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Peatlands for Agriculture

paludiculture, SWAP-WOFOST, climate change scenarios, yield forecast

Conventional agriculture is current practice in many European countries as land use on drained peatlands and subsequent land use after peat mining, albeit the well known, negative impact on GHG emissions, water and soil quality and high water management costs. Drainage-based agriculture on peat is finite due to the ongoing soil degradation and loss of soil substrate. Consequently, the risk for yield loss increases due to ongoing soil hydrological problems like ponding, hydrophobicity and lowered field capacities and conductivities, potentially amplified under future climatic conditions. As an alternative to conventional agriculture, wetness adapted plants can be grown under wet soil hydrological conditions typical for natural peatlands ("paludiculture"), but necessary water management strategies need adaptation to deteriorated soil properties of previously drained sites and yields of suitable crops need to be quantified.

The aim of this study is to assess the impact of selected climate change scenarios on agricultural yields on peat soils in Northern and Central Europe, with particular focus on changes in soil hydrological conditions and associated feedbacks on crop yields. We conducted a modelling exercise, where the soil hydrological and crop growth model SWAP-WOFOST was parameterized by two years of observations from a Finnish cropland and Danish grassland site with different climate and water management regimes. The Finnish site was conventionally managed and drained by subsurface drains, while the contrasting Danish site was used for paludiculture bioenergy plants (*Phalaris arundinacea* L.) under wet conditions. Regionalized climate projections of two emission scenarios (RCP4.5, RCP8.5) from a CMIP5 subset ensemble were used to project crop and biomass yield until the year 2100.

Results showed a high model performance displaying the ground water table distribution as well as crop yields of both contrasting sites. Under the assumption of a static soil profile (no subsidence), the conventional cropland experienced a permanently low ground water level ranging from -50 to -80 cm below ground compared to 0 to -20 cm below ground under paludiculture management until 2100. This illustrates that the water availability in the test regions is unlikely to change in the future and wet management options developed under recent hydrological conditions will be successful under future climate. Yields of the conventional crop sites slightly decreased in the course of tested climate change scenarios by ~6% until 2100, whereas yields of the paludiculture crop increased by 20 to 50% during the same period. This disadvantage of conventional agriculture will be reinforced when the ongoing soil subsidence of the drainage based site is taken into account, leading to permanently anoxic conditions in the root zone of the conventional crop within the next decades and finally unmanageable field conditions when all peat substrate is lost to the atmosphere.

This study provides valuable insights to the future of agricultural land use on organic soils within Europe and provide scenarios for climate-smart crop growth and water management options."

1.1.3 Fluvial organic carbon losses from tropical peatland oil palm plantations

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Peatlands for Agriculture

fluvial organic carbon, oil palm plantations, carbon fluxes, tropical peatland, dissolved organic carbon, land-use change

Intact tropical peatlands are dense, long-term stores of carbon, with the largest share found within Southeast Asia. However, the future security of these ecosystems is under threat from land conversion – requiring deforestation, often accompanied by fire, and extensive peatland drainage. This can enhance peat oxidation and convert these carbon sinks into significant carbon sources. At present, there is a large knowledge gap surrounding the losses of fluvial organic carbon from intensively managed tropical peatlands, such as oil palm plantations (OPPs). The extensive drainage required to convert and sustain these plantations enhances carbon mineralization and associated dissolved organic carbon (DOC) losses which, in turn, contribute to global anthropogenic greenhouse gas emissions. Here we present the first annual estimate of exported fluvial organic carbon in the drainage waters of four semi-mature OPPs in Sarawak, Malaysia. Total organic carbon (TOC) fluxes from the plantation second and third order drains were dominated by dissolved organic carbon (DOC) and ranged from $34.0 \pm 2.8 \text{ g C m}^{-2} \text{ yr}^{-1}$ to $52.0 \pm 4.2 \text{ g C m}^{-2} \text{ yr}^{-1}$. The magnitude of the flux was controlled by water table depth. Higher TOC fluxes were observed from more deeply drained sites. ^{14}C dating and age attribution analysis of the DOC component revealed the presence of old (centuries to millennia) carbon, which was influenced by low (> 60 cm below the peat surface), fluctuating watertables. By contrast, sites which maintained watertables < 60 cm displayed a greater proportion of recently fixed carbon (30 years before present, 1950) with lower overall TOC losses. Overall, our investigation reinforces the importance of considering alternative carbon loss pathways in studies of tropical peatland land conversion. Maintenance of high and stable water tables in OPPs appears to be key to minimising TOC losses and in achieving responsible peatland management.

1.1.4 Modelling an integrated waterflow model in managed peatlands for oil palm plantation

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Peatlands for Agriculture

oil palm plantation, peatland, groundwater level, integrated waterflow model

Production and its continuity of oil palm plantation in peatland are highly dependent on a capability to manage groundwater table in a conducive range that supports plant growth and preserve peat properties. Managing the groundwater table requires a sufficient knowledge on water flow characteristics than depends among others upon the physical properties of peat, climate fluctuation, water demand of the plants and the application of management techniques. This study aims at building an integrated model of water flow a plot of peatland used to cultivate oil palm that can figure out how the groundwater fluctuates with space and time under any circumstances. The waterflow model is based on Darcy–Richards equation in two dimensions coupled with climate model and Manning model that represents waterflow in the surrounding canals. Another inserted model is waterflow through a rectangular watergate that is used to control water discharge from the canals. The integrated model is solved numerically with 5 m spatial interval, and computer programs are built in the visual basic editor available in MS Excel spreadsheet that makes this application is interactive and easy to use and develop further. Field observations were conducted early this year on 3 plots (each 300 m x 1000 m) of an oil palm plantation located in Riau province, Indonesia. Spacing between two plants was about 10 m. One water level logger was installed at the centre of each plot, and some in between with and in the surrounding canal and along with that climate data were recorded every hour for one year. Net rainfall minus evapotranspiration and percolation was inserted into the model as a sink–source term forming a time function while measured points of water level along with the boundary conditions were incorporated as known data. Each known data was represented by a polynomial equation so that interpolation could be done within the time interval set during iterated calculations. In general, the results show calculated values could depict the real conditions of groundwater level however some unmatched pairs existed due to uneven elevation and surface of the peatland in which the difference level between the lowest and the highest could exceed 50 cm. Inhomogeneity of peat’s property with space would also pay important influences. Land levelling and shorten the plot size would be a better possibility to tackle the constraints though it might be impractical when the plants have been there. This model can help to determine the optimum size of a new plot or old ones to be modified to get better water management practices. This model can be used to minimize canal size to prevent excessive drain and the most important is to reduce costs for construction and operation of water infrastructure.

1.1.5 Agricultural development, environmental degradation, and movement toward wetland restoration in Sarobetsu Peatland of northern Hokkaido, Japan

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Peatlands for Agriculture

agricultural development, Ramsar site, restoration, subsidence

Among 200 thousand hectares of peatlands in Hokkaido, the agricultural development began since early 20th-century. The peatlands in the southwestern part and the central part of Hokkaido have been reclaimed as paddy fields for rice, whereas peatland in the eastern and the northern part of Hokkaido was opened for grassland of dairy farming. Now ca. 70% of the peatlands in Hokkaido have lost their original natural landscape and are used for agriculture. Particularly after the World War II, the agricultural use of peatland became full-scale until the middle of the 1980s through the opening of the drainage ditch and the installation of subsurface drainage, and the soil dressing.

In the Sarobetsu Peatland located in the northern part of Hokkaido, the development of peatland as grassland rapidly promoted from the end of the 1950s until the middle of 1980s. Short-cut of river courses, the opening of numerous drainage ditches, installment of pipe drains, and soil dressing on top of farm plots were the main contents of agricultural development.

As a result, the lake in the peatland was filled with a vast quantity of sediment. The wetland adjacent to the ditches and farmland has been affected by the drainage. Land subsidence occurred not only in the farmlands on peat but also in natural peatland areas.

Meanwhile, the peatland in Sarobetsu with original wetland vegetation has been designated as a part of a national park and also registered as Ramsar Site in 2005. Numerous migratory birds stopover this area every spring and autumn.

Just like other rural areas in nowadays Japan, this area also is facing the problem of depopulation. Residents are making many efforts to promote the local industry through agriculture and tourism. Under such circumstances, many local stakeholders from various fields have started their collaborative approach to initiate their efforts to conserve and restore the peatland as a natural wetland and to promote agriculture that can coexist with peatland environment. This presentation will introduce these current circumstances and the issues, as well as required efforts for its future around Sarobetsu Peatland."

1.1.6 Effects of submerged drains on subsidence, water management and nutrient leaching in the Western peat soil area of The Netherlands: the Krimpenerwaard case study

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Peatlands for Agriculture

submerged drains, subsidence, CO₂-emission, modelling

Most of the peat soils in agricultural use in the Netherlands are drained. Drainage causes oxidation of peat and subsequently leads to subsidence and greenhouse gas emission. Submerged drains that enhance submerged infiltration of water from ditches during the dry and warm summer half year are regarded as a promising tool for reducing peat decomposition by raising groundwater levels. Since 2003 several pilots with submerged drains were started and subsidence rates are measured. Measurements show that subsidence rates can be reduced by 50% and even more, which implies a CO₂-emission with about 50%. One of the pilots was started in 2011 in the Krimpenerwaard in the Western part of the Dutch peat area. Its aim was to study effectiveness of submerged drains in reducing peat decomposition and the side effects on water management and loading of surface water with nutrients. Most of these parameters are not easy to assess and are strongly depending on the meteorological conditions during the field studies. Therefore, some of the Krimpenerwaard pilot study was modelled. The SWAP model was used for evaluating the results on groundwater table and water management. Effects of submerged drains were assessed by comparing the results of fields with and without drains. An empirical relation between deepest groundwater table and subsidence was used to convert groundwater table effects to effects on subsidence. With the SWAP-ANIMO model nutrient loading of surface water was modelled on the basis of field results of nutrient concentrations. Calibrated models were used to assess effects in the present situation, as thirty-year averages, under extreme weather conditions and for two extreme climate scenarios. In the Krimpenerwaard pilot monitoring during seven years showed that the use of submerged drains resulted in a reduction of the subsidence of about 1/3rd. This is less than the expected 50%. However, this might be explained by the relatively wet years during the monitoring period, so a longer monitoring period is needed. Model results show a halving of soil subsidence, a strong increase of water recharge but a lower increase of water discharge, and generally small to moderate effects on nutrient loading, all depending (strongly) on meteorological conditions.

Acknowledgement: The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 603498 (RE CARE project).

1.1.7 Submerged drains in managed peat soils, effect on CO₂ emissions in wet and dry periods

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Peatlands for Agriculture

Managed peat soil, CO₂ emission, submerged drains

Drained peatlands are responsible for 6% of the global anthropogenic greenhouse gas emissions. Thereby, peat oxidation causes soil subsidence, which gives damage to buildings and infrastructure, and could result in an increased frequency of flooding and crop failure.

In Friesland (northern part of the Netherlands) a pilot was set up in summer 2016, to evaluate the effects of groundwater management with a dense network of submerged drainage tubes, compared to drainage management with ditches only. Drains were placed at 70 cm depth to accelerate drainage in wet periods (spring, autumn) and to irrigate submerged in dry periods (summer). We tested how the change in groundwater levels during wet and dry periods affects CO₂ emissions.

At four farms with grassland, submerged drains were installed at a field size of about 3-4.5 ha. In 2017 CO₂ fluxes were measured with the chamber method on pastures with submerged drains and on control pastures (one per farm). Farms differed mainly in grazing frequency and topsoil clay content (presence of clay layers). Data from a dense network of groundwater dipwells with automatic level loggers will be presented to illustrate changes in hydrology. The effect of the submerged drains in spring and summer on the CO₂ fluxes will be shown and the effect size of submerged drains slowing carbon losses will be discussed. "

1.1.8 Five reasons why not to invest in underwater drains to reduce subsidence in intensively used peat grasslands

Ab Grootjans

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Peatlands for Agriculture

peat subsidence, underwater drains, GHG emissions

We analyzed research on the effects of underwater drains on peat subsidence and associated greenhouse gas emissions (GHG) over the period 2003-2012. This research has led to the claim that underwater drains strongly reduce peat subsidence and GHG emissions, a claim that regularly appears in outreach to the general public since 2004.

Based on the evidence presented we note that:

- 1) the positive effects of underwater drains in reducing peat subsidence are largely overestimated,
- 2) predictions based on extrapolated relationships found in the past, have been incorrectly imposed on expected future conditions,
- 3) underwater drainage will facilitate intensive fertilization in early spring, thus maintaining or even stimulating emissions of N₂O,
- 4) inflow of ditchwater with high sulphate concentrations can increase anaerobic peat mineralization, which will increase GHG emissions, and
- 5) inflow of ditchwater after periods of severe drought may increase aerobic peat mineralization if water stress in the soil is lifted, which will increase GHG emissions.

We conclude that the currently available studies do not support the heavy claims and constitute a weak basis for large-scale implementation.

"

1.1.9 Cost Benefit Analysis for land use options in peatland regions in the Netherlands

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Peatlands for Agriculture

cost benefit analysis, peatland use, Netherlands

Intensive dairy farming in peatland regions has increased the rate of land subsidence in the Netherlands. This results in increasing costs for water management, risks for saline waters in coastal polders and conflicts with other land use such as nature management and housing.

In recent years in several regions a cost-benefit analysis has been made to support policy making. Results for different peatland regions in the Netherlands will be presented, with special focus on the region of Fryslân. Attention will be given to key factors in socio-economic and geographic conditions which have an important impact on the preferred land use options for the future.

"

1.1.10 Effects of different water management regimes and grassland renewal methods on greenhouse gas emissions from intensive grasslands on fen and bog peat

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Peatlands and Climate Change

submerged drains, ditch blocking, greenhous gas measurements

Drainage of peatlands for conventional agricultural use causes high emissions of the greenhouse gases (GHG) carbon dioxide (CO₂) and nitrous oxide (N₂O). Currently, several projects explore approaches to reduce GHG emissions from peatlands under agriculture. The 'SWAMPS' project focuses on both on maintaining the trafficability for conventional grassland use and on the reduction of GHG emissions by managing the groundwater level by submerged drains and blocked ditches. Here, we aim to evaluate the effect of grassland renewal and water table management on the emissions of CO₂, N₂O and methane (CH₄).

We set up two field experiments on intensively used grassland on both fen and bog peat in North-Western Germany. The experiments combine three water management regimes (submerged drains, ditch blocking and control, i.e. drainage by open ditches and/or conventional drains) with three grassland renewal treatments (shallow ploughing, direct sowing and control, i.e. permanent grassland). In autumn 2016, the drainage pipes and weirs for the different water management regimes were installed and the grassland renewal took place. The different water management regimes have been fully operational since June 2017. At both sites, we measure CO₂, N₂O and CH₄ at six of the treatments: all water management controls, submerged drains with shallow ploughing and permanent grassland as well as blocked ditches with permanent grassland. CO₂ measurement campaigns using transparent and opaque chambers are conducted every third or fourth week depending on season. CH₄ and N₂O samples are taken every second week and, in addition, on the first, third and eighth day after grassland renewal and fertilizer application.

We will present results of the initial phase of our experiment. Due to constraints in the water management, the full potential of managing groundwater levels by submerged drains could only be realised from the second half of 2017 onward. Therefore, measured GHG emissions of the first year (2017) reflect a transition period between antecedent and experimental conditions. At the fen sites, N₂O emissions after grassland renewal were highest at the shallow ploughed sites followed by the site with direct sowing, but N₂O peaks occurred only when the groundwater table rose up to 0.2 m below the surface for the first time and the soil temperature fell to zero. After this initial effect of grassland renewal, N₂O of all treatments converged to similar values. At the bog sites, N₂O emissions from all treatments were low. CH₄ fluxes were low due to low groundwater levels. First results on CO₂ emissions will be presented as well."

1.1.11 Quantifying carbon accumulation and loss in afforested peatlands

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Peatlands for Forestry
carbon, afforestation, Flow Country,

"Over the course of the Holocene the development of peatlands has led to the storage of up to 600 Gt carbon globally. There is a growing recognition that these deposits are of international importance, and must be understood and conserved. This was not always so. During the late 20th Century the development of new planting techniques combined with tax incentives to encourage forestry across large areas of peatland in the UK.

The effects of this planting are poorly understood. As many of the stands reach harvesting age, the question arises of whether the bogs should be restored or replanted. Ground surface subsidence and diminishing peat depth can indicate compaction of the peat or carbon loss but there are few long-term datasets from afforested UK peatlands.

Bad a'Cheo Forest (Caithness, Scotland), was surveyed for ground level and peat depth in 1966, prior to drainage and plantation with a mixture of Sitka Spruce (*Picea sitchensis*) and Lodgepole Pine (*Pinus contorta*) in 1968. Surveys were repeated roughly twenty and thirty years after drainage, and then in 2016 as part of this study.

Significant subsidence has taken place since drainage, with an average reduction of 53 cm in peat depth under forest stands. There is however little indication of further change since the previous survey in 1996. This suggests a large initial loss of peat depth in the years immediately following afforestation with impacts slowing over time. The key unresolved question is whether this loss of peat depth equates to a loss of carbon stock.

Paleoenvironmental techniques can be used to address such questions. Peat deposits in the Flow Country are known to contain several layers of cryptotephra originating from volcanic eruptions in Iceland (most notably Hekla 4). The tephra can be used to delineate isochrones in peat cores, allowing for comparison of carbon stocks between forested stands and undrained bog. Work is currently underway to produce an inventory of stored carbon using 27 coring points from inside the afforested bogs and in adjacent undrained areas. A parallel study of the carbon content of the trees within the stands is being undertaken using both Forestry Commission models and fine scale subsampling. This will give a uniquely detailed picture of the amount of carbon gained and lost from the system.

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1.1.12 Feasibility of continuous cover forestry (CCF) on drained peatlands – the immediate effects of partial stand harvestings on hydrology and greenhouse gas emissions in a Norway spruce stand in Finland

Sakari Sarkkola, Meeri Pearson, Markku Saarinen, Mika Nieminen, Timo Penttilä, Hannu Hökkä, Raisa Mäkipää, Raija Laiho

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Peatlands for Forestry

water table level, nutrient leaching, carbon dioxide emissions, methane emissions, stand structure, selection cutting

Continuous cover forestry (CCF) relies on maintaining a tree stand with significant transpiration and interception capacity to moderate the water table, thereby potentially reducing the need for ditch network maintenance (DNM) as well as the negative impacts on water quality and climate caused by traditional forestry. Thus, CCF may be a feasible alternative to even-aged management. Water table level (WTL) drawdown after DNM exposes deeper peat layers to oxygen and may increase CO₂ emissions from the decomposing peat. On the other hand, the WTL drastically rises after clear-cutting which usually increases methane (CH₄) emissions. These detrimental impacts may be avoided by CCF resulting in smaller temporal variation in the water table level caused by stand treatments. However, all these assessments are based only on theoretical conjecture while empirical knowledge is scarce. The aim of this study was to elucidate the immediate effect of CCF-treatment (selection cutting) on water table levels, water quality and greenhouse gas (GHG) emissions in drained nutrient-rich Norway spruce (*Picea abies* L. Karst) peatland in Finland. The field experiment was established on a ca 6 ha peatland catchment area located in southern Finland (61° 0'; 24° 44') in spring 2016. The site represented a nutrient-rich *Vaccinium myrtillus* peatland site type and was initially drained in the 1940s. The site was dominated by pure, intensively managed, advanced spruce stands (dom. height (H100): 23 m, basal area (G): 22 m², stem number: 1450 stems/ha) with a small and sparse understorey of spruces. The experimental area was divided into 15 sample plots which were randomly treated as follows in winter 2017: untreated control, mild selection cutting (target remaining G: 17m²) and intensive selection cutting (target G: 12 m²). The selection cuttings were performed mainly from above and the post-harvesting diameter distribution of the stands in the sample plots followed the reverse J-shape form characteristic to an unevenly sized stand structure.

WTL was monitored on each sample plot both continuously using automatic data loggers as well as manually biweekly during the growing season in 2016 and 2017. The runoff discharging from the catchment was measured both automatically and manually from a V-notch weir and the element concentrations of runoff water were measured from the water samples taken biweekly. The CO₂ exchange of total and heterotrophic respiration as well as soil CH₄ production were monitored on four sample plots including the intensive selection cutting treatment and the control by closed-chamber method in the growing season 2017.

The results indicated only a slight average rise in the WTL during the first year after the selection cutting treatments. It remained between a level of 30-40 cm, which was sufficient for favourable tree growth in the late summer even though the summer was rainy. Furthermore, the impacts of the treatments on water quality and carbon emissions seemed to remain small. The preliminary results of this case support the environmental hypotheses of the feasibility of CCF for drained peatlands.

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1.2 Guadeloupe Room PEATLANDS AND SOCIETY

Chair Marie Kofod-Hansen

Peatlands and People, Health and Local Livelihoods, Peatlands and Culture, Peatland Restoration

Guadeloupe Room 1: 9:00 - 9:15

1.2.1 Tropical Peat Restoration Towards Achieving Sustainable Development Goals

Haris, Gunawan

Haris Gunawan, haris.gunawan@brg.go.id, Peatland Restoration Agency of Republic Indonesia, Jakarta, Indonesia

Peatland Restoration

Ecosystem services, sustainable developments goals, tropical peatland restoration

Peat restoration is an important measure to mitigate climate change playing important roles in achieving some global goals for sustainable development. The sustainable development goals consist of seventeen goals, of which four goals are attributed by peat restoration. They include: (i) end poverty in all its form everywhere (goal 1); (ii) end hunger, achieve food security and improved nutrition and promote sustainable agriculture (goal 2); (iii) take urgent action to combat climate change and its impacts (goal 13); and (iv) protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (goal 15). We discuss to describe the roles peat restoration towards achieving these sustainable goals. Peat restoration is at the first hand is aimed to prevent fires as the related policy is formulated due to fires in 2015. Nevertheless, it is the peak point of prolonged problems related peat degradation in Indonesia within two decades. The strategies of peat restoration include rewetting of drained peatlands, revegetation, and revitalisation of local economy. Following the logic of the restoration strategies, the roles of peat restoration strategies towards achieving sustainable development goals are described.

Regarding goal 1, the peatlands are occupied by > 5000 villages and the villagers live under poverty. Peat restoration revitalizes local economy by promoting local wisdoms and local commodities, for the livelihood of the villagers. Peatlands provide numerous ecosystem services which are potential to promote sustainable uses. They include timber and non-timber forest products, suitable for paludiculture practices. Peat community in Riau has practiced wet-cultivation with Sago planting; while in West Kalimantan, utilization of purun grass for handicraft has proven profitable, in South Sumatera several grasses like kumpeh grass are source of buffalo feeding (place or buffalo grazing), in Jambi coffee are cultivated in relatively wet peatlands with further analysis for more wet peatlands are required. The peat restoration agency has conducted actions research to revitalize the local economy starting from scooping studies in 2016 in four priority districts for peat restoration; they are Kepulauan Meranti District in Riau, Ogan Komering Ilir District and Musi Banyu Asin District, both are in South Sumatera, and Pulang Pisau District in West Kalimantan. The similar study was conducted in 7 provinces assigned peat restoration priorities; they are Riau, Jambi, and South Sumatera (in Sumatra Island), Central Kalimantan, West Kalimantan, and South Kalimantan (in Kalimantan Island), and Papua. Local commodities and local wisdoms are available, but require further development to enhance economic benefits. In 2018, the intervention to develop economic at village level is being conducted as well as business approaches are being done.

In terms of goal 2& 13, particularly in terms of the promotion of sustainable agriculture; peat restoration provides the basis to change the existing practices in agriculture (drainage base cultivation). Rewetting by blocking existing canals, maintaining water level to a the maximum level of

40 cm below peat surface, and/or canal-infilling is tried (regarding goal 2). Peat restoration is an urgent action to mitigate climate changes and its impacts because restoring peatlands means conserving carbon from releasing through oxidation and risk of peat fires. Revegetation of peatlands with indigenous species and adaptive commodities will recover the function of peatland as carbon sequester through biomass production. In addition, planting peatlands with indigenous species will recover the ecosystem functioning as a whole to provide much more services, for example trees and the landscapes belong to it are habitats for several species of bees producing honey (regarding goal 13). However, major efforts and long terms research for effectiveness of rewetting infrastructure is required, which may beyond the period of the peat restoration agency take effects (2020). Particularly, it is related to the perspectives of people to shift towards sustainable / wet cultivation. Overall, these restoration measures contribute to achieve goal 15, particularly in terms of sustainable use of terrestrial ecosystems, halting and reversing land degradation. peat restoration programs provide a bundle of measures to achieve some global goals for sustainable developments, which promotes economic benefit for the local, socially sounds, and ecologically promoting the recovery of degraded peatlands towards resilient ecosystem to prevent fires and climate change mitigation. Nevertheless, maintaining the efforts up to achieving resilient ecosystem and sustainable communities are paramount.

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1.2.2 The importance of fish(ing) to tropical peatland communities in Borneo

Sara Thornton, Erna Setiana, Krisyoyo, Mark Harrison, Susan Page and Caroline Upton

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Peatlands and People, Health and Local Livelihoods

Kalimantan, fishing, communities, livelihoods

It has become increasingly clear that conservation projects are likely to fail if plans to preserve the remainder of vital habitats do not consider the needs of local communities. The Sabangau peat-swamp forest (PSF) ecosystem is a vital habitat for numerous threatened species, is a significant carbon store and a provider of various ecosystem services to local communities surrounding the forest. Fishing is a main source of livelihood for the communities living along the rivers and forests in Central Kalimantan. However, freshwater habitats such as the PSF and surrounding peat rivers are facing growing pressures from increased human populations, deforestation, degradation and water pollution. This is cause for concern as the degradation of freshwater systems has serious implications not only for biodiversity, but also for the human communities who depend on forest and river ecosystems for their livelihoods. It is therefore vital to understand these wetland habitats and their importance for community livelihoods and cultures. We used interviews and focus groups in two villages to investigate human-nonhuman relationships through the lens of fish and fishing. The two case study villages were Kereng Bangkirai which is situated by the predominantly intact Sabangau PSF, and Taruna Jaya which is located in the highly degraded ex-Mega Rice Project area. We found fishing to be an important fall-back occupation in the case study area, and fish are considered the most relevant to people's lives compared to other forest species, such as the flagship orangutan. For both men and women, there was a higher dependence on fishing as a source of income in Taruna Jaya compared to Kereng Bangkirai and we discuss the implications of this. A belief in spirits is still important for some participants and this can determine the relationship which human community members have to fish and spiritual elements of the ecosystem (e.g. gestures or offerings are sometimes required for successful fish catches). The majority of participants perceived a decrease in fish populations over the years, in line with previous studies in other areas of Central Kalimantan. They also reported the use of harmful fishing methods (e.g. electric fishing). Of particular relevance to peatland restoration projects, some participants reported that they perceived drainage canal blocking as having negative impacts on fish populations. Our results indicate a clear necessity for future long-term fish population monitoring in Sabangau and for the consideration of local perspectives when it comes to peatland restoration projects. We conclude that peatland conservation initiatives that integrate the ecological and social values associated with fish and fishing into their project planning are likely to result in improved outcomes for peatlands, forests and people. Following from recommendations as presented, we also describe future plans to study the impact of dams on fish and to engage with fishing cooperatives to explore options of sustainable use of fish resources in Central Kalimantan.

1.2.3 Wise-use of peatlands in Indonesia and Russia: triple win for people, economy and the environment

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Peatlands and People, Health and Local Livelihoods

Indonesia, Russia, community, company, incentives, paludiculture, restoration

Both Indonesia and Russia face a tremendous challenge to curb peatland GHG emissions, fires and haze and stop peatland subsidence. In the context of ensuring equitable economic development this requires mobilisation of all stakeholders who depend on peatlands to determine sustainable development pathways.

The knowledgebase build over the past decade on the environmental impacts of peatland degradation in both temperate and tropical regions present the urgency of the issue. The scientific rigour cannot be contested any longer and requires urgent action.

The government of Indonesia is serious about stopping the peatland degradation trend by installing regulatory restrictions over peatland use and gazetting millions of hectares for peatland protection and restoration. This goal, however is not reachable without including all stakeholders in the landscape. Currently the alternative to drainage-based peatland use is insufficiently recognized by companies and communities. Peatlands are however already managed sustainably for centuries by local communities for its goods and services . This knowledge is of huge value to tackle today's challenges. For example, in Padamaran, South Sumatra local communities manage the land for production of Purun grass for basketry, mats and bags. In Mendawai, Central Kalimantan, rattan is harvested sustainably from natural peat swamp forests for furniture making that supports community livelihood in the bufferzone of the 150.000 hectare Katingan-Mentaya Peatland Restoration and Conservation area. In Sungai Tohor, on one of the peatland Islands of Riau province, for centuries communities enrich forests with Sago palms for the production of noodles and cookies from its starchy core.

With the increasing recognition of the problems, palm oil and pulpwood companies are increasingly interested to find alternative sources for their products. The edible oil from Shorea species called 'Illipe nut' is being tested in plantations as well as fast growing species to find an alternative source of pulpwood. This form of innovation for sustainable peatland use is called Paludiculture.

Also in Russia, the issues are increasingly recognized where in co-operation with the German government (IKI), one of the largest ecosystem restoration projects in the world, dealing with large-scale ecological rewetting of abandoned cutover peatlands in the Russian Federation is being implemented. To date, over 35,000 hectares of drained peatlands have been restored using ecological methods, with another 10,000 hectares currently underway. The total amount of emission reductions achieved is currently estimated at 175,000 to 220,000 ton CO₂e per annum.

The paradigm shift from drainage-based peatland use to non-drainage use will: 1) curb environmental issues and meet targets under the Paris agreement and haze mitigation plans; 2) enhance equitable development by ensuring local community recognition and participation and; 3) ensure land productivity to support livelihoods and economies. To make use of the current momentum stakeholders should step up to develop and invest in joint solutions in their landscape and exchange to learn from others. This will require changes in the regulatory framework and capacitate communities with knowledge, skills and financial resources to participate and benefit. "

1.2.4 Environmental change and peatland conflicts in North-Karelia, Finland - an environmental history perspective

Eerika Albrecht

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Peatlands and People, Health and Local Livelihoods

peatland conflicts, peat extraction, environmental change, environmental histories

In order to understand peatland conflicts, it is important to look at the historical developments related to the emergence of peat extraction and the mire conservation movement. Despite large amount of peatlands, relatively few areas remain in natural condition as peatlands have been drained for agricultural use, forestry or peat extraction. This study takes an environmental history perspective to study the interaction between peatlands and society.

Hence, it evaluates the environmental changes caused by human actions, the ways how environmental change affect societies and the ways how humans think and act on the environment. This study scrutinizes the environmental change between 1944 and 2018 in the Koitajoki watershed in eastern Finland, part of the North Karelia Biosphere Reserve. During this period the demands for natural resource use, such as peat and timber have intensified in the region. Initially, mires and peatlands have covered about 50% of the area but intensified natural resource use has led to changes in the environment in forms of peatland drainage and peat extraction and today many large mire areas in the region are part of Natura 2000 network. With forestland drainage intensification, mire conservation became a pressing issue and, local peatland conflicts opposing peat extraction in the area emerged. Currently there is a need for peatland restoration in the area. This shows that the attitudes and values in Finnish society have changed towards the recognition of multiple values of peatlands.

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1.2.5 Conditions of success: understanding the performance of integrated strategies for fire mitigation at the forest agricultural nexus in Indonesian peatland frontiers

Rachel Carmenta, Jacob Phelps, Bambang Trihadmojo, Aiora Zabala

Presented by: Marie Kofod-Hansen

Rachel Carmenta, rachelcarmenta@gmail.com University of Cambridge, Cambridge, United Kingdom

Peatlands and People, Health and Local Livelihoods

Indonesia, policy instruments, rewards, peatland, tropical, PES, public-private, governance, fire

Peatland fires in Indonesia are a persistent environmental, humanitarian and economic challenge with local to global impacts and drivers. Carbon dense peatland frontiers are a focal point of dramatic land use change as the oil palm frontier transforms peat forests. Associated burning for land preparation has induced large scale wildfires, which in the context of extending fire weather seasons represent a significant driver of global environmental change. Numerous legislations, policies and programs to mitigate peat fires and govern towards responsible peatland management have largely failed, indicating that solutions are complex. Interventions that couple land users agricultural and production needs with associated measures to induce forest protection have been proposed as an optimal strategy to secure dual outcomes. While multiple actors are associated with the prevalence of peatland fires, one stakeholder group engaged in the fire complex are smallholder farmers. A recent private sector initiative combined conditional rewards for forest protection from fire with agricultural assistance and awareness raising in an attempt to mitigate fire. The initiative met variable success. We collected primary survey data to understand the predictors of performance of this initiative across nine villages in Sumatra, Indonesia. We identify plausible conditions that may explain differentiated performance and apply a two-step Qualitative Comparative Analysis. This analysis can inform future interventions on what strategies and combinations of conditions are related to successful peat land fire mitigation.

1.2.6 Influence of climate changes and peatland formation on the Stone Age Settlements in Latvia

Laimdota Kalniņa, Līga Pāparde, Aija Ceriņa, Ilze Ozola, Ivars Strautnieks

Laimdota Kalniņa, Laimdota.Kalnina@lu.lv University of Latvia, Rīga, Latvia

Peatlands and Culture

Peatland, mire, fen, raised bog, natural conditions, anthropogenic impact

Peatlands during their development have grown both horizontally and vertically. Their characteristics and distribution over the time have been influenced by variety palaeogeographical and climate conditions. Due to changes in plant feeding changes appear also in the peat-forming plant composition and therefore also in peat types and properties.

Until the 20th century these changes in the territory of Latvia took place mainly under the natural conditions in the result of variability of climate and hydrology. Since the man decided to use peatland, dry up for the farmland expansion or peat extraction, he affects peatlands and peat properties. Study data from different peatland types show that the oldest mires in Latvia have been formed during the Early Holocene before 11,000 to 9,500 years in depressions or due to overgrowing shallow, where well or medium decomposed fen or grass-type peat accumulated. At the beginning of the Holocene Climatic Optimum in large part of former fens composition of peat formatting plants gradually has been changed and raised bogs widely developed, where medium decomposed sphagnum and cotton grass peat accumulated. They intensively grow during the Late Holocene, when climate become more humid and cooler. Raised bog type low decomposed, mainly sphagnum or cotton grass peat, has accumulated in bogs most intensively over the past 2,000 years.

Peatland drainage and peat cutting in Latvia intensively started during the first half of 20th century, but maximum took place during 1960-1970, what caused formation of cut-over peatland areas, which predominately were left for renaturalisation or become degraded. In the 21st century an attention is being put on identifying and researching affected and degraded peatland areas. In total, as a result of the peatland evaluation under different studies about 190 areas have been identified as objects in where during different periods of 20th century have been realized drainage and peat extraction with different methods.

Multidisciplinary studies of variously degraded bogs left after peat extraction show changes in peat properties in comparison with natural peatlands. The main differences have been determined in the upper layers of peat sections in degraded areas, where according study data increase in mineral matter, natural density, peat decomposition degree and decrease in pH values has been distinguished. Studies show also differences in some parts of large bogs, which are related to the diverse peatland formation conditions in different areas of the same peatland.

Similar results show also results from studies of fen peat profile, where upper peat layers contain an increased amount of heavy metals, which can be explained by anthropogenic impact.

Researching of peat sections by various methods is found differences and three parts can be subdivided. Characteristics of the upper part of natural peat section are characterized by anthropogenic influence including atmospheric pollution of heavy metals. The middle part of section usually is formed under the natural process, but deeper (lower) has been influenced by the groundwater and mineral sediments from the peat underlying layers. Changes of properties in peat sections from degraded areas are different and reveal strong anthropogenic influence.

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Chair Paddy Rowland, Vice chair Erki Niitlaan

Peat for Growing Media and Energy, Peatland Restoration, Environment and Outreach

Guadeloupe Room 7: 11:00 - 11:15

1.2.7 Recent sedimentation of 62 lakes in Finland – assessing the possible environmental impacts of peat production

Vähäkuopus T., Kauppila T., Mäkinen J.E., Ojala A.E.K. and Valpola S.E.

Tuija Vähäkuopus, tuija.vahakuopus@gtk.fi Geological Survey of Finland, Kokkola, Finland

Environment and Outreach

peat, peat production, lake, sediment, Finland

The impact of environmental loading of peat production compared to other land uses in lakes and waterways has been actively discussed in Finland for several years. Especially the question of enhanced sedimentation of organic matter possibly originated from peat production areas has been the most concerning issue. The scarcity of scientific evidence related to the rate of sedimentation in lakes affected by peat production activities has partially prevented a detailed scientific discussion on the topic.

In order to provide a scientific base for governance and decision making, the Geological Survey of Finland launched a lake sediment research project on this topic in 2013. Altogether 62 lakes from 48 different catchment areas were selected, and the majority of field work, data gathering and laboratory analyses were conducted during years 2013-2017. The data gathered from lakes without any connection to peat production areas (reference lake group) were compared to the data from lakes affected by drainage waters coming from peat production areas (target lake group).

For general classification of catchments the relative proportion of peatland and peat production areas, the amount of ditched peatland areas and relative proportion of lakes and waterways were collected from different national spatial datasets in order to determine the possible differences between lake groups. The results of echo soundings were used for modelling the sedimentation patterns, total amount and areal distribution of sediment. For determining the recent sedimentation development a selected short core samples were taken from each lake with Limnos gravity corer. From the samples ¹³⁷Cs dating and wide set of chemical and physical properties of sediments were analyzed.

The results show no significant differences in the accumulation rate and recent sedimentation development between two lake groups. According to ¹³⁷Cs results the 1986 Chernobyl peak is generally found between the sediment depths 3-17 cm. The variation in the lake and catchment characteristics is similar in both lake groups representing areally typical Finnish lakes, geology and land use. The results from chemical and physical analyses of the sediments will be discussed.

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1.2.8 Vapo's wetlands on cutaway peatlands — diversity and recreation

Juha Ovaskainen

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Peatland Restoration

Wetlands, restoration, diversity, peat production

About 35,000 hectares of land previously used in Vapo's peat production has been assigned to other uses over the past several decades, and several thousand hectares more are expected to be released from peat production during the next decade.

The possible uses of cutaway peatlands include reforestation, agriculture and the creation of wetlands. The choice largely depends on the starting point and goals of the planning for the area's land use.

Vapo has a long history of creating wetlands as an after-use of cutaway peatlands. Wetlands have been established on land exceeding 1,500 hectares, at more than 80 locations around Finland. There has been strong growth in the creation of wetlands, especially during the past few years. A fairly diverse range of plant and bird species has become established in wetlands created from cutaway peatlands. The species have been surveyed both recreationally by birdwatchers and professionally by conducting annual monitoring measures. Infrastructure to support nature watching has been built at several wetlands, such as duckboards, birdwatching towers and lean-tos.

The construction of wetlands is an integral part of Vapo's activities related to the after-use of cutaway peatlands, but the actual implementation of after-use methods is influenced by several different factors. The most important factor in determining the after-use is land ownership. A significant proportion of the land used for peat production has been leased to the producer. Following the conclusion of peat production, the area is returned to the landowner, who then decides on the next use of the land. Landowners have shown interest in wetlands as an after-use option in addition to the more traditional uses of agriculture and forestry.

There are also factors involved that are independent of land ownership, such as the topographical and geological characteristics of the area. If the bottom of the basin left behind by peat production is naturally filled by water, and extensive structures are not necessary for retaining water in the area, establishing wetlands is an option well worth considering.

This presentation highlights Vapo's wetlands construction through the years and illustrates the factors behind choosing wetlands as the land use method for cutaway peatlands.

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1.2.9 Carbon footprint of growing media constituents – from cradle to grave

Jan Köbbing

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Peat for Growing Media and Energy

Substrates, Growing Media, Emissions, Carbon Footprint, Sustainability

Klasmann-Deilmann is working continuously to improve its sustainability performance; this includes the calculation of a carbon footprint at both company (Corporate Carbon Footprint, CCF) and product levels (Product Carbon Footprint, PCF). A bundle of measures reduces the carbon emissions of the company and remaining emissions are more and more offset. By these, company emissions are expected to drop from 209.000 t CO₂e in 2016 to 160.000 t CO₂e in 2020, despite a forecasted growth in production. Lower company emissions will also result in lower emissions on product level (PCF), which is additionally pushed by increasing the use of alternatives to peat in substrates to 15% in the same period. Being able to calculate the PCF for every individual product sold, customers are consulted in using the most climate friendly substrates, which at the same time fits to his needs. In 2017, Klasmann-Deilmann did the next step by calculating also the CCF of two of its customers, active in growing vegetables and ornamental plants. This enables Klasmann-Deilmann to report on the PCF of substrates up to the final consumer and also led to the conclusion, that substrates contribute only to a small amount of the overall emissions of growing a plant. All efforts on precisely investigating the carbon emissions of substrates along the life-cycle are aiming to reduce the company's footprint and will continuously be intensified. It also helps to identify the most efficient ways to mitigate emissions in the substrates, but also beyond that, e.g. transportation or heating.

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1.2.10 From conversion of waste to production growing media constituents;
change of focus

Hans Verhagen, Hein Boon

Hans Verhagen, contact: boon@rhp.nl, RHP, s-Gravenzande, The Netherlands

Peat for Growing Media and Energy

growing media, risk-assessment, phytosanitary safety

Peat is by far the most important constituent for growing media. Nowadays (organic) residues from various sources, are offered as potential constituent for growing media. These flows are often derived from processes of waste collection and conversion. Often these products -as such- are not suitable as constituent for growing media, because they do not meet basic requirements with respect to, for example, phytohygienic and nutritional aspects.

In order to enhance future prospects of these potential constituents, the production processes need to be converted from waste treatment into the production of a suitable and safe constituent for the production of growing media.

A risk assessment is an important precondition and tool to organise and improve production processes with focus especially on phytosanitary safety and quality-guarantees.

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1.2.11 Good reasons for RPP certification

Maureen Kuenen

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Peat for Growing Media and Energy

RPP certified peat, RPP Chain of Custody, RPP label, mainstream in Europe

Foundation Responsibly Produced Peat, a multi-stakeholder organisation of peat industry, scientists NGOs, has been established in August 2013.

This 5 year anniversary is a good occasion to look back at the vision and mission of RPP, to take stock of where we are today, and draw a plan for the future.

When you think about it, it seems a crazy plan to distinguish and certify peat from responsibly managed peatlands from peat from other sources. You can't see any difference on the material itself. And how to make criteria that have to be applicable in all EU countries?

Nevertheless, several parties saw possibilities here and nowadays Foundation Responsibly Produced Peat (RPP) makes this happen by having completed the 'RPP Certification Scheme' with chapter 6, the Chain of Custody (from peat production, to processing, to retail).

RPP certification means that peat producers have delivered a great achievement with responsible peatland management. In doing so, they have taken into account many different aspects to minimize negative environmental impacts of operations. In addition they show commitment to take responsibility after production.

Why is this important again? To be sure about the long term availability of peat and a licence to operate!

Since the regulations for the chain of custody are defined and certified RPP Peat is (becoming) available on the market, the path is open to more recognition and exposure. RPP-certification of growing media is a valuable instrument to achieve this. Our goal is to achieve mainstream application of RPP certification in the European market. Therefor we need the support of all stakeholders!

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Guadeloupe Room 12: 12:15 - 12:30

Development of three Pilot Projects in Latvia, Lithuania and Germany to improve restoration methods of RPP certified extraction sites

Bernd Hofer, Maureen Kuenen

Bernd Hofer, hofer@hofer-pautz.de RPP, 2691 MG 's-Gravenzande, The Netherlands

Peatland Restoration

RPP, NABU, Life Peat Restore, Restoration, Sphagnum

NABU Germany – Responsibly Produced Peat Dialogue - The certification system “Responsibly Produced Peat” is an industry initiated system but from the very beginning on based a strong participation of eNGOs. Wetlands International and Estonian Fund for Nature are members of the executive board and were involved in the development of the RPP Principles and Criteria. During the certification process of RPP applications, NGOs are informed by a general invitation about the intended advice for certification to the Board. The related ‘documents for comment’ are published at the RPP website. Additional to those existing regulations, RPP, Life Peat Restore and the German NGO NABU want to start and improve their cooperation. Three pilot projects with three different companies and preferably different countries will be created as examples for exchange of knowledge and experiences in restoration methods. The outcome will be summarized in a common paper and implemented in the so named "tool box" of RPP.

1.3 Sky Room PEATLANDS AND ENVIRONMENT (1)

Chair Maria Strack

Peatland Restoration

Sky Room 1: 9:00 - 9:15

1.3.1 Impact of Peat Mining and Restoration on Methane Turnover Potential and Methane-Cycling Microorganisms in a Northern Bog

Max Reumera, Monika Harnisz, Hyo Jung Lee, Andreas Reim, Oliver Grunert, Anuliina Putkinen, Hannu Fritze, Paul L. E. Bodeliera and Adrian Hoa

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Peatland Restoration

Sphagnum methanogenesis methane oxidation nitrogen fixation land use change nifH

Ombrotrophic peatlands are a recognized global carbon reservoir. Without restoration and peat regrowth, harvested peatlands are dramatically altered, impairing their carbon sink function, with consequences for methane turnover. Previous studies determined the impact of commercial mining on the physicochemical properties of peat and the effects on methane turnover. However, the response of the underlying microbial communities catalyzing methane production and oxidation have so far received little attention. We hypothesize that with the return of *Sphagnum* spp. postharvest, methane turnover potential and the corresponding microbial communities will converge in a natural and restored peatland. To address our hypothesis, we determined the potential methane production and oxidation rates in natural (as a reference), actively mined, abandoned, and restored peatlands over two consecutive years. In all sites, the methanogenic and methanotrophic population sizes were enumerated using quantitative PCR (qPCR) assays targeting the *mcrA* and *pmoA* genes, respectively. Shifts in the community composition were determined using Illumina MiSeq sequencing of the *mcrA* gene and a *pmoA*-based terminal restriction fragment length polymorphism (t-RFLP) analysis, complemented by cloning and sequence analysis of the *mmoX* gene. Peat mining adversely affected methane turnover potential, but the rates recovered in the restored site. The recovery in potential activity was reflected in the methanogenic and methanotrophic abundances. However, the microbial community composition was altered, being more pronounced for the methanotrophs. Overall, we observed a lag between the recovery of the methanogenic/methanotrophic activity and the return of the corresponding microbial communities, suggesting that a longer duration (>15 years) is needed to reverse mining-induced effects on the methane-cycling microbial communities.

1.3.2 Peatland Group of the Finnish Board on Ecological Restoration

Lindholm Tapio

Lindholm Tapio, tapio.lindholm@ymparisto.fi Finnish environment institute, Helsinki, Finland

Peatland Restoration

peatland restoration, guide

In large parts of Finland over 75 % of the original peatland area has been drained for forestry. Forestry drainage has profound effects on function and diversity of mire ecosystems. To develop and to advise different restoration projects was understood that there is need to have joint advising body to avoid bad restoring results and to develop the profession to reach good results in restoration planning and managements.

The Finnish Expert Group for Peatland Restoration was established as a part of the Finnish Board on Ecological Restoration, established already in 2004. The Peatland Group concentrates on issues related to ecological restoration of forestry-drained peatlands, especially in protected areas. The Finnish working group for ecological restoration and management brings together experts in nature management

The working group for ecological restoration and management in Finland, known as the The Finnish Board on Ecological Restoration is a nationwide cooperation body established by Metsähallitus, Parks & Wildlife Finland.

Members include actors in the management of Finland's natural environments and semi-natural grasslands, researchers and other experts.

Its activities cover habitats on land and in freshwaters, in protected areas, in forests and on agricultural land, whether state-owned or in private ownership. In every case, activities in privately owned areas are performed in cooperation with landowners.

The working group's task is to evaluate, develop and promote the quality of the ecological restoration and management of natural and semi-natural habitats, and their impact on society. The working group has solid scientific expertise and develops practical expertise by preparing guidebooks on the topic in question, and organising training events and seminars.

The Finnish Board on Ecological Restoration consists of a steering group and three expert groups, whose activities promote the implementation of tasks defined for the working group.

Expert groups include the following, where Peatland Group of the Finnish Board on Ecological Restoration is one.

- Finnish Expert Group for Forest Restoration
- Finnish Expert Group for Semi-natural Grasslands
- Finnish Expert Group for Peatland Restoration

The Finnish Expert Group for Peatland Restoration, concentrates on issues related to ecological restoration of forestry-drained peatlands, especially in protected areas.

- designs monitoring schemes to study ecological effects of peatland restoration
- formulates guidelines for restoration of peatlands
- promotes the co-operation between research and practical management related to peatland restoration
- provides expert knowledge on peatland restoration

-
- organizes courses and seminars on peatland restoration.

The group members are experts of peatland restoration in their organizations:

- Metsähallitus, Parks & Wildlife Finland: Tuomas Haapalehto, Reijo Hokkanen, Santtu Kareksela, Sakari Rehell, Maarit Similä, Pekka Vesterinen
- Metsähallitus Forestry Ltd: Timo Nyman
- University of Eastern Finland: Teemu Tahvanainen
- Finnish Environment Institute: Kaisu Aapala (chair), Tapio Lindholm, Tapani Sallantaus
- Natural Resources Institute Finland: Mia Saarimaa
- Finnish Forest Centre: Irmeli Ruokanen
- Tapio Group: Samuli Joensuu

The group meets 2–4 times a year. One of the meetings is usually a field excursion, where is a mission to have join discussion on restoration questions and reality,

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1.3.3 Satellite Radar (ISBAS InSAR), Bog-Breathing and Peatland Management.

Marshall, Chris., Gilbert, Peter., Sterk, Henk Pieter., Bradley, Andrew., Roxane Anderson, Parry Lauren, Sowter, Andrew., Marsh, Stuart., Bonenburg, Lukasz., Large, David.

Chris Marshall, christopher.marshall@nottingham.ac.uk University of Nottingham, Nottingham, United Kingdom

Peatland Restoration

Peat Subsidence, Satellite InSAR, Bog-Breathing, Peatland Condition

With the development of the ISBAS InSAR method, low cost and high frequency Sentinel I Radar, measurements have the potential to measure peatland surface motion at regional scale. A recent development has been to move from long term mean motion measurements to higher periodicity measurements of peatland motion. A major barrier to achieving this is the lack of ground verification data globally as subsidence monitoring is not optimised for remote sensing validation. As Europe's largest area of blanket peatland, and with its history of high quality monitoring, the Flow Country was selected as an ideal place to develop this capacity.

Adapting (for peatland conditions) precise levelling techniques, originally developed for surveying large infrastructure projects has allowed repeatable sub-millimetric measurement precision and accuracy to be achieved, matching that of satellite radar. The survey design was also optimised for remote sensing validation, using a system of clustered point measurements (representing the major micro-topographic features present) located within sub-sites covering the approximate area of a single 100x100m InSAR pixel. This ensured local scale variations were adequately accounted for and aided comparability between ground and satellite data. Subsidence measurements were supplemented by other independent peat condition and environmental measures such as vegetation, gas flux, water level and climate monitoring.

Initial results indicate that mean annual peat motion from InSAR is generally comparable to that measured from the ground validation surveys, both in direction and extent. More interestingly, both ground and satellite studies indicate peatland motion has characteristic seasonal motion, akin to a heartbeat, which is distinct between stable, restored, damaged and very damaged sites. Peat in stable condition shows an overall uplift trend and reaches peak height in late summer whilst damaged peatland shows an overall subsidence trend with peak heights in early winter. Very degraded peatlands show a constant subsidence trend with little seasonal cyclicity. Unusually restored sites show a hybrid signal with features of stable and damaged peatlands. In addition to peak timing, condition has an effect on the amplitude of peat motion with sites peaking in Late Summer tending towards larger oscillations in peat surface height than those peaking in winter. It is likely that hydrology is a major driver of the peat surface motion observed alongside productivity and changes in gas storage. Restoration of hydrological function is also a primary goal of most forms of peatland restoration. Consequently, in differentiating between sites of functional and dysfunctional peatland hydrology, ISBAS InSAR has great future potential as a tool for assessing peatland risk, targeting resources, quantifying the effectiveness of restoration techniques and upscaling carbon storage monitoring from the site to the landscape scale.

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1.3.4 Techniques for rewetting cracked peat in forest-to-bog restoration

Russell Anderson, Colin Saunders

Russell Anderson, russell.anderson@forestry.gsi.gov.uk Forest Research, Roslin, UK

Peatland Restoration

forestry, mire, restoration, water table, trench, membrane

Many bogs in the UK and Ireland were afforested by drainage and planting during the 1960s-1980s. Some have now been restored to bog following harvesting of the forests. In a few cases, normal rewetting methods (damming drains and plough furrows) failed. These were sites where the peat had developed sub-surface dessication cracks that continued to drain the site after the drains and furrows had been blocked. Forest Research set up two trials to investigate whether new trenching techniques could successfully rewet sites with cracked peat.

The trials were at Longbridgemuir, a lowland raised bog in southern Scotland and Dalchork, a blanket bog in northern Scotland. Both trials were Before-After Controlled Impact (BACI) experiments using randomised block designs. Two trenching treatments were tested against a control at both trials and a normal rewetting treatment was included for comparison at Dalchork:

1. Repacked Trenching - trench to below cracking depth repacked with intact peat
2. Membrane Trenching - like Repacked Trenching but with a vinyl sheet lining one side
3. Control - no rewetting measures taken
4. Normal rewetting - dam drains and plough furrows at 0.2 m vertical intervals.

In both trials, the trenching treatments raised the annual minimum and mean water table levels significantly. The normal rewetting treatment at Dalchork also raised it but by a lesser and non-significant amount. Water table level exceedance curves show a very much improved water regime, especially in the 10-30 cm depth zone at Longbridgemuir and in the 5-15 cm depth zone at Dalchork. An operational study of the trenching treatments at Longbridgemuir identified Repacked Trenching as far more cost-effective than Membrane Trenching because the former was much quicker to implement. This study also identified potential safety issues involved in positioning the membrane. We recommend Repacked Trenching as a means of rewetting cracked peat. Trenching thick peat can increase the likelihood of a peat slide in some situations, so an assessment of peat slide risk is necessary at each site.

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1.3.5 Rapid & Reliable Restoration of Sphagnum using Micropropagated Sphagnum as BeadaHumok™

Neal Wright, Anna Keightley, Simon Caporn

Neal Wright, neal@microprop.co.uk Micropropagation Services, East Leake, Loughborough, UK

Peatland Restoration

Sphagnum, Restoration, Peatland, BeadaHumok,

Micropropagated Sphagnum grown into small Hummocks (Beadahumok™) has been shown to establish and grow profusely on both Upland and Lowland restoration sites.

Results from trial sites across England, Wales and recently in Germany will be discussed:

The Peak District (Upland):

Trials set up on Kinder Scout in 2015 have shown that 94% of BeadaHumok™ planted and grew by 207% after 2 years, (427% after 3 years) compared to Clump of wild harvested Sphagnum which only increased by 60%.

Manchester Mosslands (Lowland, Cut-over bog):

Beadahumok™ planted at high density produced a complete cover in approx. 2 years.

Cors Fochno (Lowland, Drained Agricultural Grassland):

Beadahumok™ thrived better than transplanted Sphagnum even in flooded conditions. Overall growth increase of BeadaHumok™ was 285% in just 5 months, versus 37% for larger translocated local Sphagnum. Sphagnum on overturned plots grew better than on scraped plots, probably because of better rainfall infiltration and reduced ponding compared to the scraped surface.

Yorkshire (Upland):

Large scale planting at a site in Nidderdale N. Yorkshire in summer 2016 established very successfully and have grown away, producing hummocks of 130mm in diameter by March 2018

Lower Saxony (Lowland, Re-wetted Cut-over bog):

Trials planted in May 2017 have proved very successful without any Straw cover and had made substantial growth by the early autumn and have done well in a very cold winter.

Analysis shows that a small hummock (plug) of BeadaHumok™ contains ~110 strands/plants and is ideal for restoration, and for establishing pure species. 17 species have now been micropropagated enabling pure species to be grown in very large quantities and ensuring clean; pest, disease and weed free Sphagnum. BeadaHumok™ can be produced in single (pure species) or in mixtures specific to a project.

Local origin material can be produced of specific species or mixes to meet site requirements and can be produced for restoration which only requires a few stands as starting material. This ensures there is no damage to donor sites.

In spring 2018 some 850,000 BeadaHumok™ were planted produced from local origin material, together with planting of 350,000 in 2017 means that over 800 hectares of peatland have now had Sphagnum successfully re-introduced in a wide range of species. These areas now have a much-improved biodiversity and will already be enhancing the carbon balance of these peatlands (see Keightley et al at IPS Rotterdam).

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1.3.6 Carbon fluxes on a degraded lowland raised bog undergoing restoration with micro-propagated Sphagnum

Anna Keightley, Simon Caporn, Chris Field, James Rowson, Neal Wright

Anna Keightley, anna.keightley1@virginmedia.com Manchester Metropolitan University, Manchester, UK

Peatland Restoration

restoration, lowland, peatland, carbon, GHG, Sphagnum, micropropagation

Peatlands are a priority habitat for conservation in the UK, and an important carbon store. However, due to drainage for agriculture, urbanisation and more recently, peat-extraction on a large scale, more than 80% of remaining peatlands are damaged, and even protected peatlands are impacted, with the majority not in a favourable condition. Repair of UK peatlands is essential to promote recovery of associated vulnerable and marginalised flora and fauna, and as a tool to help combat climate change in the UK's ambitious carbon emissions reduction targets.

The site for this study is Cadishead Moss, an 8 ha fragment of an originally large lowland raised bog complex west of Manchester, previously drained and hand-cut for peat, then colonised by trees. The Lancashire Wildlife Trust has undertaken scrub removal and re-wetting for conservation purposes and the site is now mostly re-vegetated with *Eriophorum angustifolium* in wetter areas and *Molinia caerulea* in drier areas, and an increasing cover of *Sphagnum* mosses, mostly through re-introduction, as local source-material is scarce.

To demonstrate the benefits of restoration in terms of the change in carbon fluxes over time, carbon greenhouse gases (GHGs) were measured with a Los Gatos Ultraportable GHG Analyzer, fortnightly during the growing season and monthly during plant senescence, over a period of two years. Measurements were made via permanent collars inserted in to areas of naturally regenerating *Eriophorum angustifolium* and introduced *Sphagnum* material, micro-propagated through tissue-culture techniques, with control plots in *Eriophorum*-only and bare areas. Water table, plant growth, peat temperature and PAR were recorded concurrently.

It appears that re-wetting a degraded bog does not necessarily create large CH₄ emissions, even with a cover of plants containing aerenchyma, but that CO₂ emissions can be high in conditions of high temperature and low water table, although the carbon budget for the study site is still to be calculated. Measurements and subsequent modelling with local weather data are ongoing, but are expected to demonstrate the impact of peatland restoration methods on carbon fluxes and help steer management efforts towards improving the carbon sequestration function of recovering lowland peatlands.

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1.3.7 25 years of peatland restoration in Canada

Marie-Claire LeBlanc, Line Rochefort

Marie-Claire LeBlanc, marie-claire.leblanc@fsaa.ulaval.ca Peatland Ecology Research Group (PERG) and Centre for Northern Studies (CEN), Université Laval, Québec, Canada

Peatland Restoration

Bog restoration, fens, vegetation recovery, rewetting, reference ecosystems

The Peatland Ecology Research Group (PERG) based in Université Laval, Québec, has been dedicated to peatland restoration for the last 25 years. As of today, 1147 hectares of cutover bogs have been restored across Canada with the Moss Layer Transfer Technique (MLTT), a restoration method developed by PERG in collaboration with the Canadian horticultural peat industry, provincial governments and Johnson & Johnson Inc. From the first unsuccessful trials of Sphagnum transfer (mostly by plugs) to the development of extensive, relatively simple and robust method of ecological restoration, we are now succeeding to re-green the former dark brown and bare peat fields back into thriving wet ecosystems. Most of these restored Sphagnum ecosystems are now again dominated by peatland plant communities sustaining a return of the carbon sequestration function, an ecological service characteristic to peatlands.

Since the very beginning of PERG activities, a long-term and large-scale monitoring program has been conducted on every site restored with the MLTT across the country. Based on the analysis of this unique database, the importance of management practices following the industrial activities has been highlighted (González & Rochefort 2014). A recent study (in prep.) about plant composition of restored peatlands, also concluded that on average, 82% of the species were effectively transferred from the donor to the restored sites. Both studies conclude that this success rate is closely linked to the management actions implemented. Restoration steps like the application of phosphorus fertilizer which supports the nurse plant *Polytrichum strictum* or efficiently rewetting the sites play a decisive role in the outcomes of the vegetation recovery. By examining specific research projects and case-studies of some of the more than 100 restoration projects where the restoration method has been applied, this talk will update the science supporting each step of the restoration method.

The new challenges forwards to improve and adapt the restoration method will also be discussed. Identifying the restoration goals to achieve by describing reference ecosystems and evaluating the recovery of peatlands has also become an important part of the research in ecological restoration. Developing a restoration method for sites presenting fen-like conditions is among the future objectives of PERG. Also, tackling other considerations such as indicators of the cost-efficiency of the restoration projects, species of special concern, water quality, biomass production and tweaking the method to be in line with the latest findings concerning greenhouse gases are among the research objectives of the group.

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1.3.8 Ecohydrological change following re-wetting of a deep-drained raised bog

Paul Gaffney, Sylvain Jutras, Olivier Marcoux, Sébastien Raymond, Sandrine Hugron, Line Rochefort

Paul Gaffney, Paul.Gaffney@uhi.ac.uk University of the Highlands and Islands, Thurso, United Kingdom

Peatland Restoration

Ditch blocking, tree felling, water table, water chemistry, vegetation

The Grande-Plée-Bleue bog is a raised bog in Quebec, which is soon to receive “protected ecological reserve” status by the Quebec government due to its high nature conservation value. However, two large ditches running through the site since the 1950s, caused damage to the bog habitat, by lowering the water table and encouraging the growth of trees. Restoration of the Grande-Plée-Bleue bog by damming of the ditches and removal of trees has been ongoing since 2010.

Recovery of the ecohydrological function of the bog has been monitored since 2010, with the collection of data on water table, water chemistry and vegetation cover. Using restoration sites close to the ditches (<25m) in comparison to control sites (>25m from the ditch), we show there was limited change towards functioning as intact bog.

In the first instance (prior to damming of ditches), it was experimentally shown through a paired transect study that trees lower the water table and this evidence was used to justify tree felling elsewhere on site. Water table increased significantly following blocking up to 25m from the ditch, both the height of the dam and the distance of the monitoring transect from the dam were associated with the water table rise observed. In the longer term, up to six years post-restoration, water table in restoration sites showed a similar mean level but a larger range compared to control sites.

Following restoration, no significant changes in water chemistry were found contrary to many other studies. Limited overall change in vegetation cover was found using principal response curves. Testing the cover of the main functional groups of vegetation, in a before-after-impact-control (BACI) design seven years post-restoration, showed that no significant changes were found.

Restoration schemes of this type should pay close attention to the number, spacing and height above the surface of dams used to block ditches to increase restoration success.

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1.3.9 Processes of vegetation change following the hydrological restoration of blanket mire in South West England

Paul Lunt, Bethan Harry

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Peatland Restoration

Blanket mire, vegetation change, hydrological restoration, Sphagnum, peatland restoration, carbon sequestration

This paper presents an assessment of vegetation change in six hydrologically restored blanket mire sites that form the Dartmoor Mires Restoration Project (2010-2018). The project was led by Dartmoor National Park Authority in partnership with Natural England, the Duchy of Cornwall, Dartmoor Commoners' Council, the Environment Agency, and South West Water, which provided significant funding under its Upstream Thinking Initiative.

The aim of the Dartmoor Mires Project was to restore degraded blanket mire sites to deliver benefits for upland wildlife, improve water quality, provide buffering for water flow, and maintain or increase carbon storage.

The presentation provides an overview of the project, methods of restoration (ditch blocking and gully blocking) and main findings from 10 years of vegetation monitoring. The work reviews progress towards the restoration of Sphagnum rich 'active' blanket mire; defined by JNCC (2006) as "supporting a significant area of vegetation that is normally peat forming".

Hydrological restoration was successful in all restored sites, with elevated water tables local to the restoration features and significant water retention in associated pools. Four of the six hydrologically restored sites showed a significant reduction in the area of eroding bare peat within 2-3 years of hydrological restoration. Following hydrological restoration all restored sites showed a significant increase in the % cover of blanket mire species, compared with pre-restoration baseline vegetation. The aquatic Sphagna, in particular *S. denticulatum* and *S. cuspidatum*, were able to colonise pools and standing water within two years of hydrological restoration.

On sites where 3-5 years had elapsed since hydrological restoration, lawn and hummock Sphagnum mosses (*S. papillosum*) and mire herbs (*Eriophorum angustifolium*) were able to colonise grass-dominated areas following the successful establishment of a high and stable summer water table. In comparison to the Sphagna, no consistent pattern of recovery and spread was apparent in broad-leaved mire herbs.

Declines occurred in the percentage cover of those herb and pleurocarpus moss species that were intolerant of high water tables and surface flooding. Surface water inundation also caused localised declines in the percentage cover of lawn and hummock mires species such as *Sphagnum capillifolium* and *S. tenellum*, which showed high sensitive to changes in water table depth.

The findings of this work demonstrate that ditch and gully blocking can successfully restore localised areas of eroding bare peat and degraded blanket mire to fully functioning, water-retaining, peat-forming blanket mire within ten years of hydrological restoration. The suitability of the restoration techniques and the application of vegetation monitoring methodologies are discussed.

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1.3.10 Bog restoration on the edge: biodiversity and other ecosystem services in Dutch raised bog remnants

Gert-Jan van Duinen

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Peatland Restoration

raised bog, biodiversity, greenhouse gas, paludiculture, lagg

The Dutch raised bog remnants 'Peelvenen' are remnants of a previously much more extensive raised bog landscape. The mire complex formed the natural border between two provinces. Due to climate the bog is situated on the southern edge of the distribution area of the Atlantic raised bog type. In this region the critical load of atmospheric nitrogen was and will be exceeded several times. Furthermore, drainage and peat extraction severely degraded the bog landscape. Monitoring and recent studies showed that the restoration measures performed in the last decades in and around these severely degraded bog remnants considerably improved the hydrological situation and resulted in an increase of Sphagnum growth. Also, estimation of the past, current and future greenhouse gas emission (using the GEST approach) show considerable improvements. Plant and (in)vertebrate species naturally inhabiting the edges of the bog complexes either disappeared, or survived the severe degradation of the bog landscapes inside the degrading remnants of the former mire expanse. To avoid restoration of the remnants to cause a further decline of the remaining populations of the characteristic and rare species, their current distribution and ecology was investigated in the reserves. This resulted in practical recommendations for measures. These will both further improve the conditions for bog restoration and enable relict populations to persist in the reserves and migrate to newly developed lagg and buffer zones, including areas with paludiculture.

1.3.11 Degraded Peatlands in Sumatra, Indonesia: Land titles, peatland abandonment, burning, and the restoration

Kosuke Mizuno

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Peatland Restoration

Peatland degradation, peatland restoration, land title

Peatlands in Sumatra, Indonesia, are one of Southeast Asia's last resource frontiers and they are currently being exploited on a large scale, leading to massive fires and carbon emissions. Despite the global implications of this problem, few studies have investigated the social aspects of peatland degradation, hence limiting our understanding of potential sustainable management regimes for peatland resources. This study focuses on the factors causing land abandonment and fire, key precursors to peatland degradation. Village formation and land history in a village in Riau province were investigated via detailed household questionnaires, paying particular attention to how land is acquired and the land titling process. In the case of peatland that has not been abandoned, people have customary land rights such as inheritance and clearing, and also have land certificates with customary land right documents. In case of abandoned peatland, peatland forests belong to the state forest area, and therefore people tend not to have any documents certifying land rights; these peatlands were vulnerable to peat fire and were abandoned. Those peat forests belong to the state, which were logged and distributed among villagers, especially after 1995, and have since been seriously burned and abandoned. State-designated forest areas have been rendering large areas of peatlands vulnerable to abandonment and fire. In many places, land conflicts appear because of the overlapping the land rights, concession to the company, and the land use by the local people. Solving the land rights issues are urgent matter for the people concerned. Peatland restoration program can include the program giving the land title to the people in the degraded land rights with the program such as social forestry program. This program of solving the land conflicts become the important incentive to promote the local people to take part in the peatland restoration program.

1.3.12 Gold Carbon Mechanisms of Tropical Peatland

Mitsuru Osaki

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Peatland Restoration

AeroHydro Culture, N2 Fixing, Restoration, Plant Growth Promotion

Summary

Peatland is gaining attention internationally due to its relationship with the climate change. In UNFCCC SBSTA, ecosystems with high-carbon reservoirs are addressed as ecosystem that is strategically important, and various full-scale efforts are being made internationally. The three main ecosystems with high-carbon reservoirs are meadow/peatland ecosystems, coastal ecosystems (mangroves, seagrasses, coral etc.), and permafrost (methane problem). Recently, carbon captured by coastal ecosystems is called "Blue Carbon", and especially the research on carbon accumulation of mangrove is proceeding rapidly by CIFOR and its associates. If the carbon in coastal ecosystem is "Blue Carbon", the water in peatland is vivid tea color so we started to call the carbon in peatland "Gold Carbon". Then the carbon in permafrost (mainly methane) can be "Silver Carbon". Here, we present the maintenance and restoration of tropical peatland have a possibility to change its carbon literally into the "Gold Carbon", that by changing tropical peatland we may change it into the gold land - the richest land in the world."

1.4 Sun Room PEATLANDS AND ENVIRONMENT (2)

Chair Lydia Cole

Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

Sun Room 1: 9:00 - 9:15

1.4.1 Does Sphagnum farming create habitat for bog species?

Grobe, Amanda; Zoch, Lotta; Reich, Michael; Graf, Martha

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Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

Sphagnum farming, paludiculture, biodiversity, bog, Lower Saxony

In addition to the production of a sustainable constituent for growing media, Sphagnum farming could provide a valuable habitat for characteristic plant and animal species of raised bogs. Two experimental sites for Sphagnum farming were established on industrially harvested and strongly-decomposed peat fields in Lower Saxony, Germany. On these sites a total of 5 ha were inoculated with peat moss (in particular Sphagnum papillosum, S. palustre, S. magellanicum and S. fimbriatum) from four donor sites.

In 2017 and 2018 plant and animal diversity (vascular plants, mosses, liverworts, birds, amphibians, dragonflies, beetles and butterflies) were assessed to evaluate to what degree these sites increase local species diversity and create habitats for rare and endangered species. Furthermore, the flora and fauna of nearby conventionally rewetted sites and near-natural raised bogs were also monitored. More than 50 plant species were found on the experimental sites (Sphagnum, other mosses, liverworts and vascular plants). About 20 of these species are endangered in Lower Saxony - for example Sphagnum magellanicum, Rhynchospora alba and Andromeda polifolia. Most of the occurring species are characteristic for bogs. In the near-natural bogs less species were found (an average of 35 plant species). The amount of endangered species is just as high as on the experimental sites. This indicates that many endangered species were transferred from the near-natural donor sites. The number of species on the conventionally rewetted restoration sites is, with an average of 15 species and 5 endangered species, comparatively low.

One season of the fauna monitoring shows that only few characteristic peatland vertebrate species were observed on the experimental sites (i.e. Anthus pratensis, Rana arvalis). Nevertheless, some endangered ground-nesting birds were breeding on the sites (e.g. Vanellus vanellus). Among the invertebrates, many generalists and pioneer species were found in the first year. Typical peatland dragonfly species like Sympetrum danae already reproduced on the sites and some characteristic and endangered beetle species (e.g. Myllaena kraatzi) were observed. On the older restoration sites more characteristic and endangered bird and dragonfly species were found (e.g. Tringa tetanus, Aeshna subarctica) in comparison to the experimental sites.

Both flora and fauna assessments indicate that Sphagnum farming sites have a high potential to increase local biodiversity. In particular, a higher number of characteristic bog plant species established on the experimental sites in contrast to conventionally rewetted restoration sites. These results indicate that many typical bog species need to be reintroduced and do not establish spontaneously on rewetted bogs. It can be assumed that the colonization by fauna species proceeds more slowly, but the experimental sites will provide suitable habitat conditions within a few years.

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1.4.2 Microbial-driven technological solutions can reduce the peat oxidation process and enhance the sustainability of agriculture on these peatlands

Shailendra Mishra, Jyrki Jauhiainen, Hanna Silvennoinen, Shivshankar Umashankar, Romy Chakraborty, Aswandi Idris, Janice S. H. Lee, David A. Wardle

Shailendra Mishra, shailmishra@gmail.com Asian School of the Environment, Nanyang Technological University, Singapore, Singapore

Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

Microbial diversity, Metagenomics, Rewetting, Revegetation , tropical peatlands

Southeast Asian peatlands are undergoing degradation through drainage and deforestation, accompanied with forest fires. This is occurring at unprecedented rates for agriculture and human settlement purposes. Exposure of carbon-rich peat to air has resulted in enhanced microbial-mediated peat oxidation emitting high levels of potent greenhouse gases (GHGs). Peat oxidation results in land subsidence, thus, increasing the risk of flooding that can affect the livelihoods of millions of people. Peatland restoration of drained peatlands by revegetation and rewetting is being planned on a large scale, as a strategy to reduce fire incidences as well as mitigate CO₂ emissions. However, the immediate consequences of saturating dry peat on greenhouse gas emissions, that result from carbon decomposition are not well understood. The overall aim of this study is to provide an in-depth understanding of how land-use change and peat management practices affect the microbial ecology and physicochemical processes leading to peat oxidation and release of GHGs. Firstly, we used molecular marker-based approaches (microbial and metabolic profiles) that revealed the profiles were most influenced by variations in water table and land-use patterns, followed by age of drainage and peat thickness in that order. Towards the revegetation efforts, we found that plantations with mixed cropping had the least peat oxidation (subsidence rates) when compared to monoculture plantation. This pattern is linked with release of diverse exudates from different crops, supporting high microbial and metabolic diversity in mixed crop plantation. We then used metagenomic approaches to determine the functional potential of peat microbiome associated with peat oxidation. Metagenomics analysis revealed that genes belonging to aromatic compound biosynthesis and degradations were mostly associated with degraded forest and degraded land. Actinobacteria and Firmicutes were among the most abundant taxonomic groups, demonstrating their linkages in oxidation of tropical peatlands.

Secondly, we conducted a study to unravel the consequences of drying and wetting on peat carbon decomposition. We show from both controlled microcosms and field studies, that anoxic decomposition from water-saturated peat accounts for nearly 70-80% of emissions. The mechanistic basis of the continued peat decomposition even in the wet period, which results in high anoxia, was linked with increased nutrient availability (of both carbon and nitrogen) due to 'priming' affect. The solubilization of nutrients due to priming resulted in extensive changes in >360 different organic molecules from carbon and nitrogen metabolism in a coupled manner. This coupled carbon-nitrogen metabolism is also explained from high N₂O and CO₂ emissions that emerged from anoxic zones in the field. The overall findings of this study will be useful in peatland management by providing a basis to focus early efforts on hydrological interventions and improving sustainability of oil palm plantations by adopting mixed cropping practices. By adopting these microbial-driven technological solutions, we aim to perform socio-economic analysis in future that can reveal the benefits for the livelihood of people affected by the land-use change in the region."

Sun Room 3: 9:30 - 9:45

1.4.3 A Tale of Two Bogs: Biodiversity, Budgets and Bunds

Lydia Cole

Lydia Cole, lydcole@gmail.com University of Liverpool, Liverpool, United Kingdom

Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

tropical peatlands, temperate peatlands, restoration, biodiversity, hydrology, responsible management

Within the last few years, Indonesia and the United Kingdom have set ambitious targets: Indonesia committed to restoring two million hectares of peatlands by 2020 and the UK to having one million hectares “in good condition, under restoration agreements and being sustainably managed” by the same time. These targets offer great opportunities for each nation, and for the international (peatland) community: to raise awareness of the importance of these climate stabilising ecosystems and raise funds for their responsible management; to reduce carbon emissions, enhance carbon sequestration and contribute to the conservation of biodiversity and human well-being. They also represent significant challenges. Where does each peatland hydrological unit start and end? What state of degradation is each in? What funds are available for restoration in each locality? What interventions are appropriate for restoring hydrological integrity and functional biodiversity? What constitutes “good condition”? And is “sustainable management” possible? Through a brief summary of the historical and contemporary dynamics of the UK’s and Indonesia’s peatland ecosystems, this talk will provide a critical review of each nation’s restoration goals. To end, it will consider whether a greater exchange of experiences and wisdom between practitioners and policy makers managing the UK’s barren bogs and Indonesia’s sweaty swamps would be useful. Though each nation faces unique challenges resulting from their political and geographical contexts, there are opportunities for the exchange of knowledge and support across the two countries that could help such ambitious, international significant restoration goals to become more tangible.

1.4.4 Factors affecting the carbon dynamics in blanket peatland – Irish case study

Mariya Radomski, Alan Gilmer, Vivienne Byers, John Cassidy & Eugene McGovern

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Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

peatland, water, carbon

The fluvial carbon cycling in Irish upland blanket peatlands is highly variable spatially. In blanket peatlands, macropores and peat pipes are well connected with the pools and hummocks and this connectivity leads to significant variations in outflows of carbon from these microforms. The primary source, transport pathway and concentration of dissolved CO₂ are poorly understood in Ireland. The excess CO₂ in the peatland catchments could originate from peatland soils where it is derived from the respiration and soil organic matter decomposition. Dissolved CO₂ is transported out of the peatland soil into the pools via surface run-off and via lateral throughflow. Peatland pools are typically supersaturated in CO₂ with respect to the atmosphere. Conditions such as negative net ecosystem production, photochemical degradation of dissolved organic carbon (DOC) or high dissolved inorganic carbon (DIC) inflow from the peatland soil surface are among conditions responsible for supersaturation. The losses of CO₂ could be enhanced as a result of disequilibrium between air and water gas concentrations. Freshwater mediated CO₂ evasion may represent an important pathway for the carbon losses to the atmosphere. This project investigates the role of spatial (based on microtopography) and seasonal (temperature, atmospheric pressure, precipitation and wind speed) variables on carbon production and fluxing. The methods employed in the study include a continuous in-situ monitoring of carbon dioxide (CO₂) using NDIR sensors in the peatland pools and the adjacent soils, monitoring of meteorological parameters, routine hydrochemical sampling (quantification and the analysis of dissolved organic carbon, ions and nutrients) and physical analysis (pH, conductivity, peat characterisation). Sensors were maintained at a constant depth in both conditions (peat water and the pool) by a protective floating housing mechanism. Three monitoring stations were established to allow spatial comparison and replication to get more accurate results. The results of this project to date were indicative of a strong seasonal, diurnal and spatial influences on the CO₂ dynamics. The findings derived from this study will provide substantial knowledge regarding the carbon cycling in these types of environment in Ireland. The quantitative data produced from this project could be potentially useful for estimation of carbon emissions from mountain blanket peatlands in Ireland.

1.4.5 The water footprint of peat from tropical and boreal locations

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Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

Peat; Water footprint

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Abstract

Peat used for energy or for horticulture, is a form of biomass that develops in mires and peatlands over a period of thousands of years. Recent studies have shown the large water footprints of bioenergy. The concept of the water footprint (WF) uses a life cycle approach by taking water use in production chains into account and distinguishes between direct and indirect water use in production chains. This study adopts the WF life cycle approach for the assessment of indirect water use for peat from tropical and boreal climates. In this way, it estimates the WF related to the accumulation of peat. The study shows that WFs of peat are comparable to WFs of presently available bioenergy (m³ per GJ). Counterintuitively, the indirect blue WFs that are related to evaporation are smallest for peat from tropical locations in Indonesia, where evaporation rates are high, and largest for locations in the boreal areas with relatively small evaporation rates. For Indonesia, the blue WF was 8 m³ per kg dry mass; for boreal areas, blue WFs ranged between 11 (western Canada) and 15 m³ per kg dry mass. The blue WFs are determined by evaporation on the one hand and peat growth rates on the other. In the boreal areas, both evaporation and growth rates are smaller than in tropical areas, but peat growth is relatively smaller than evaporation rates resulting in relatively large blue WFs. When the WF of total annual peat production is compared to the WF of the global economy of 9087 Gm³ per year, the WF of peat has a small contribution.

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1.4.6 Sphagnum farming on strongly decomposed peat in Lower Saxony, Germany

Martha D. Graf, Amanda Grobe, Jan Felix Köbbing, Dorothea Rammes, Michael Reich, Lotta Zoch

Martha D. Graf, graf@umwelt.uni-hannover.de Leibniz Universität Hannover, Hannover, Germany

Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

Sphagnum farming, Paludiculture, Experimental Site, Sphagnum productivity

In Germany, peat resources used in growing substrates are dwindling. Annually, 9.5 million m³ of peat are needed for the production of growing substrates in Germany (Schmatzler 2012). Currently, the demand that cannot be met is being imported, mainly from the Baltic States. In 2012, 1 million m³ of the raw materials for growing media came from peat alternatives, i.e. wood chips, green compost, coconut fibres (Schmatzler 2012). However, Germany would like to increase the amount of peat alternatives to compensate for its dwindling peat resource. Sphagnum fibres are an excellent alternative to peat as they show similar chemical and physical attributes to peat (Emmel, 2008; Jobin et al. 2014). Additionally, Germany has very high greenhouse gas emissions coming from drained peatlands (Tiemeyer et al. 2016). Cultivating Sphagnum is currently the only sustainable use option (paludiculture) for ombrotrophic peat (bog) sites.

From 2015 to 2019 the cultivation of peat mosses (Sphagnum) is being tested and scientifically monitored on two industrially harvested and strongly decomposed peat fields, in Lower Saxony, Germany. The study sites were inoculated with peat mosses (in particular *Sphagnum papillosum*, *S. palustre*, *S. magellanicum*, *S. fimbriatum*) from three donor sites. The economic efficiency of peat moss cultivation and the suitability of peat mosses as constituent for growing media were tested by the substrate manufacturer Klasmann-Deilmann GmbH. The Institute of Environmental Planning at the Leibniz Universität Hannover is assessing and evaluating the growth rate of the different peat moss species and the suitability of the cultivation sites as habitats for characteristic plant and animal species of raised bogs. We observed the successful establishment of Sphagnum moss on both experimental sites. Covering the mosses with straw resulted in higher establishment rates than covering them with a geotextile. Research on improving the irrigation and drainage of the fields would improve the growth of the tested species. Unfortunately, economic analysis showed that cultivating Sphagnum on these sites was not profitable. The mechanization of 'seeding' and harvesting would greatly improve the economic efficiency of Sphagnum farming. Additionally, adding Sphagnum to the list of EU cultivated species would allow farmers to receive the standard subsidies for farming this environmentally-friendly product.

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Chair Budi Indra Setiawan
Peatlands and Climate Change

Sun Room 7: 11:00 - 11:15

1.4.7 Changes in the carbon stock and areal distribution of Finnish peatlands
1950-2015 Turunen Jukka, Valpola Samu

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Peatlands and Climate Change
peat, peatland, carbon balance, carbon stock, Finland

Since 1970's the Geological Survey of Finland (GTK) has investigated ca. 2.2 million hectares of mires and peatlands throughout the Finland. These investigations had been done using the most up-to-date mapping and data storage methods. Data has been stored directly to the database format, checked and eventually stored in the vast GTK peat database. This database is a unique and world record peat database: it consists totally ~1.8 M peat study points, comprising totally 17 700 peatlands. Altogether the peat database has over 234 M data enquiries related to peat thickness and peat quality, mire types, information on vegetation, bottom soil material, chemical and physical properties etc. This data is one of the key elements in evaluating the carbon balance and stock both in Finnish peatlands but also at the national level, approximately 2/3 of the Finnish carbon being stored in the peat. The first evaluation of the carbon stock and areal distribution of Finnish peatlands 1950-2000 was done in GTK by Turunen (2008) and the re-evaluation is now possible by substantially widened and more precise peat data set and data sets related to forestry and peatland agriculture (provided by Natural Resource Institute Finland), artificial reservoirs on peatland (Finnish Environment Centre) and horticultural and energy peat production (the Bioenergy Association of Finland). Also several papers with new results on evaluating the GHG-balance of different land use practices on peatlands, especially forestry drained peatlands has been published since 2008, bringing new possibilities on the field.

This work will provide one of the most important pieces of scientific data for governance and decision making in European but especially national level climate change mitigation work. Representing national data and results from Finland this work is a good basis in evaluation of the development of Boreal region, where the major part peat and peatlands of Europe is locating. An unbiased data is the only tool in estimating the trends of carbon binding capacity development, expected changes in carbon stock and possibilities to use these for example in evaluating the LULUCF sector role, possibilities for emission trade and the future of forestry, agriculture and the use of peat in securing the food production in the future.

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Sun Room 8: 11:15 - 11:30

Berry production in extracted and abandoned peatlands: first year results of CO₂ and CH₄ emissions
Ainars Lupikis, Andis Lazdins, Kaido Soosaar, Ülo Mander

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Peatlands and Climate Change

1.4.8 Berry production, CO₂, CH₄, extracted peatland

Abandoned and unmanaged peat extraction sites loses carbon through CO₂ and CH₄ and is one of the sources to the atmospheric greenhouse gases. At the same time, those sites are also excluded from production and have low ecological value. One of the after use options for abandoned peat extraction sites is berry production and, contrary to the peatland restoration, can be profitable for land owners. It may have also positive effect on reducing the carbon losses from peat compared to abandoned and unmanaged peat extraction sites. The aim of this study is to compare one year CO₂ and CH₄ flux measurements between unmanaged former peat extraction sites and sites used for cranberry and blueberry production.

Closed chamber method from December of 2016 to November 2017 was used to measure autotrophic CO₂ and CH₄ respiration (air sampling) and CO₂ net ecosystem exchange (CO₂ gas analyzer) once in a month in 4 sites for abandoned peat extraction sites with bare peat (BP), 3 sites for abandoned peat extraction sites with ground vegetation cover (VP), 3 cranberry production sites and 3 blueberry production sites.

There were no significant differences between land uses on both net CO₂ and CH₄ emissions.

However, the smallest net emissions were from cranberry sites (0.5 Mg CO₂-C ha⁻¹ year⁻¹), but in bare peat, peat with ground vegetation and blueberry sites net emissions were 1.3, 1.8 and 1.4 Mg CO₂-C ha⁻¹ year⁻¹. Results doesn't include C uptake in root and woody biomass for blueberry sites, only autotrophic respiration and NEE of ground vegetation. The smallest CH₄ emissions were in cranberry and bare peat sites (5.2 and 2.3 Kg CO₂-C ha⁻¹ year⁻¹), but in peat with ground vegetation and blueberries emissions were 56.7 and 33.0 Kg CO₂-C ha⁻¹ year⁻¹. If the carbon uptake in woody and root biomass for blueberry will be included in calculations, then it is expected, that after two year measurements both, cranberry and blueberry sites, will be significantly smaller sources of CO₂ than abandoned and unmanaged peat extraction sites."

1.4.9 Monitoring concept for tropical peat swamp forests with airborne and spaceborne sensors applied in the Mawas area, Kalimantan

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Peatlands and Climate Change

tropical PSF, airborne and spaceborne sensors, Mawas, Kalimantan

Monitoring concept for tropical peat swamp forests with airborne and spaceborne sensors applied in the Mawas area, Kalimantan

Michael Schlund 1.) & Viktor Boehm 2.)

1.) University of Goettingen, Goettingen, Germany 2.) Kalteng Consultants, Munich, Germany,

Tropical peat swamp forests are of high significance for climate and environmental studies due to their large carbon stock and rich biodiversity. Therefore, the key importance of peat swamp forests for ecological processes, their resilience to forest degradation and logging highlights the need for a comprehensive forest monitoring in which LiDAR (Light Detection and Ranging), UAV (unmanned aerial vehicle) and SAR (Synthetic Aperture Radar) technology may play an important role in these inaccessible areas.

SAR (Synthetic Aperture Radar) sensors are independent of weather and light conditions and ESA's Sentinel-1 satellites flying in a constellation enable temporally dense and consistent global coverage. Consequently, Sentinel-1 has high potential in forest monitoring especially in the tropics where clouds hinder spatially and timely consistent acquisition of optical data. Changes of forests were detected on basis of multi-looked complex covariance matrixes of a dense Sentinel-1 time series acquired between April 2015 and September 2016 in the Mawas area, Central Kalimantan. The accuracy of this change detection was over 90%.

Peat swamp forests covered 74% of the study area at the beginning of the monitoring period, where 1/3 of the forest area was deforested or degraded at the end of the monitoring period. First, only subtle changes were detected at forest edges due to logging activities. Severe changes in the forest were detected between July and October 2015, which can be related to forest fires. Between the acquisition dates of October 07, 2015 and October 31, 2015 as well as October 31, 2015 and November 24, 2015 occurred most changes and 27% of the forest area was already deforested or degraded due to forest fires. The analysis revealed that trees close to canals were especially affected, whereas trees in more intact forest were less affected. This indicates the significance of intact forest (without the influence of drainage) for the resilience of peat swamp forests to forest fires.

However, the interpretation of changes is not trivial. A combined use of satellite sensors detecting changes timely and spatially consistent together with airborne high-resolution systems will support the monitoring of peat swamp forests and especially the interpretation of detected changes with spaceborne systems. For instance, small-footprint LiDAR has high potential in biomass estimation. Consequently, the biomass estimated with LiDAR can be combined with the change detection in order to assess the emitted carbon from changed peat swamp forest. Further, UAVs with high-resolution cameras could support the interpretation of changes, because it is often difficult to separate anthropogenic and natural changes. The satellite based change detection may support the focusing of the UAV flights on areas with high interest like severely changed forests.

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1.4.10 CHANGES OF PEAT PROPERTIES UNDER NATURAL CONDITIONS AND HUMAN IMPACT

Laimdota KALNIŅA, Jānis DREIMANIS, Reinis BITENIEKS, Inārs DREIMANIS, Jānis KRŪMIŅŠ, Ingrīda KRĪGERE

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Peatlands and Climate Change

Peatland, Burtnieks, Lubāns, the Stone Age

Changes of palaeogeographical conditions have influenced locations of the Stone Age settlements and affected human life conditions as they were lived near the water bodies and used water ways for getting around.

Records of the Late Paleolithic Age sites in Latvia usually have been found in mineral soils because of cool climate and scanty vegetation during that time. The Mesolithic and the Neolithic man also lived at the water bodies, but during that time paleogeographical conditions and climate have been changed. More settlements were at the lake shores of glacial origin with complicated shoreline containing number of shallow bays.

Large lakes (Lubāns, Burtnieks) and occupy the deepest depressions of glacial plains characterized by a complicated geological structure, a peculiar hydrographic network. The territory of these ancient lakes at the end of the Late Glacial was two or three times larger than nowadays. These area become bogged and cover number of the Stone Age settlements.

Multidisciplinary studies, including palaeobiological and sediment composition analysis were performed with aim to find out the environmental conditions the plant and animal kingdom that have existed during that time in the immediate vicinity of the lakes and its surroundings where ancient settlements were located.

Especial attention was given to the records of human presense. Open landscape areas considerably decrease in the surroundings of Lake Burtnieks during the end of the Early Holocene due to spread of pine forests with significant admixture of birch and alder in the moist places. Pollen of the anthropogenic indicators like *Plantago major/media*, *Rumex acetosa/acetosella*, *Chenopodium alba*, *Urtica* has been found in several sites investigated in the northern part of the ancient Burtnieks area, which point on the presence of the man in the area.

One of the most interesting site from archaeological and palaeogeographical aspect is Pantene ancient island, which nowadays is surrounded by bog. Investigation results show that the number of former settlement areas from ancient Lake Burtnieks and Lake Lubāns area which nowadays is located in the bogs, during the Mesolithic and the Neolithic were located at the shores of lakes. The largest amount of carbonates in sediments is in the lower part of sections below the cultural layer in many settlement sites of Lake Lubāns indicates that sediments before the appearance of settlements, have accumulated in the aquatic environment. At the beginning of the Late Holocene water level decrease and sediment accumulation took place under dryland conditions. Lake level fluctuations caused also erosion of sediments, therefore in some settlement areas has remained incomplete section - as the water level has risen, and the meandering of the river, part of the settlements has not survived. According to analyses of sediment composition and pollen diagrams the cultural layer sediments at the Lake Lubans accumulated in the Holocene Climatic Optimum and the first part of the Late Holocene.

Investigation data concludes that the most essential reasons why the Stone Age people changed location of their settlements are lake water level fluctuations, lake shore and shallow bay overgrowing and bogging."

1.4.11 Carbon dioxide production and emissions from blanket peatlands in Co. Wicklow, Ireland

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Peatlands and Climate Change

Peatlands, Carbon, Greenhouse Gas emissions, Land-use

Peatlands are recognised as both a sink and source of CO₂, therefore understanding factors that influence either sequestration or emission of CO₂ is important in the management of peatland areas. Although CO₂ fluxes are recognised as occurring throughout the peat profile, national emission inventories typically measure only the Net Ecosystem Exchange (NEE) which tends to reflect surface fluxes. However, using only surface fluxes we are unable to account for the several potentially important processes. For instance, using only surface fluxes, we are unable to account for the partitioning of the rates of production and transport occurring in lower peat profiles. In longer term monitoring studies (1-3 years) the annual rates of production and storage of CO₂ are equal to the annual surface efflux of CO₂. However, in shorter-term studies, CO₂ produced within the sub surface may be stored temporarily in various temporary sinks (e.g. root exudates, soil pores) or alternatively CO₂ fluxes measured in chambers may exceed CO₂ diffusion within the soil profile. Therefore, the rate of transport and diffusion may not accurately reflect the CO₂ efflux from peatlands. This may result in a failure to recognise important parameters, leading to an incomplete understanding of peatland carbon dynamics. This study proposes to investigate sub-surface CO₂ effluxes in a blanket peatland site located in Sally Gap, Co. Wicklow in Ireland. This will involve accounting for the production of CO₂ at different soil depths and assessing drivers such as decomposition rates and nutrient status. The project also will quantify the rates and factors influencing CO₂ transport such as diffusion, advection and pressure pumping. This will enable the investigation of the importance of including sub-surface processes in the quantification of the peatland Net Ecosystem Exchange (NEE) as it relates to the (1) national reporting of greenhouse gas emissions, (2) modelling future CO₂ emissions and (3) assessment of the impact of climate change and land use management. Outputs will include the development of new methods to calculate CO₂ emissions at a high spatial and temporal resolution (hourly), investigation into the drivers of CO₂ emissions (e.g. Chemical, Microbial, Physical parameters) and the development of a model capable of representing CO₂ dynamics in peat and therefore provide information regarding future CO₂ emissions under climate change and a range of land-use scenarios.

1.4.12 Double trouble: subsidence and CO₂ respiration due to 1,000 years of Dutch coastal peatlands cultivation

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Peatlands and Climate Change

subsidence, CO₂ respiration, Netherlands, peat

Coastal plains are amongst the most densely populated areas in the world. Many coastal peatlands are drained to create arable land. This is not without consequences; physical compaction of peat and its degradation by oxidation lead to subsidence, and oxidation also leads to emissions of carbon dioxide (CO₂). This study (Erkens et al., 2016 in Hydrogeology Journal) complements existing studies by quantifying total land subsidence and associated CO₂ respiration over the past millennium in the Dutch coastal peatlands, to gain insight into the consequences of cultivating coastal peatlands over longer timescales. Results show that the peat volume loss was 19.8 km³, which lowered the Dutch coastal plain by 1.9 m on average, bringing most of it below sea level. At least 66% of the volume reduction is the result of drainage, and 34 % was caused by the excavation and subsequent combustion of peat. The associated CO₂ respiration is equivalent to a global atmospheric CO₂ concentration increase of ~0.39 ppmv. Cultivation of coastal peatlands can turn a carbon sink into a carbon source. If the path taken by the Dutch would be followed worldwide, there will be double trouble: globally significant carbon emissions and increased flood risk in a globally important human habitat. The effects would be larger than the historic ones because most of the cumulative Dutch subsidence and peat loss was accomplished with much less efficient techniques than those available now. Meanwhile, for the Dutch, CO₂ respiration from drained peatlands still is a considerable contribution to the national CO₂ emission values (~2-3 %) and drained peatlands continue to subside with 5-10 mm per year. Most of the structural damage, however, occurs in urban areas, where land subsidence causes houses to subside and crack, and where roads are continuously in need of reparation, at large costs. Cities such as Gouda spend considerably more money to sustain the urban area at an acceptable level of maintenance. Because of the high costs, and in the light of global climate warming and associated absolute sea level rise, both peatland subsidence and CO₂ respiration are now increasingly challenged by policymakers and the general public. The current land subsidence rates in the Dutch coastal peatlands, the associated damage, and the future developments, both from a technical viewpoint and a policy viewpoint, will additionally be discussed.

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2 Poster presentations

P1

2.1.1 Assessing the condition of the Flow Country peatlands to support their future protection

Sterk, Henk Pieter., Payne, Richard., McIlvenny, Jason., Cowie, Neil., Marshall, Chris., Andersen, Roxane.

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Peatland Restoration

Blanket bog; Plant functional types; GIS RS InSAR

Peatland condition monitoring utilising both field surveys and remote sensing techniques is well established in Scotland. However, each has its associated strengths and weaknesses. Many of these weaknesses can be resolved if a more synergistic approach is considered between the two data collection methodologies. If realised this has great potential for the management and restoration of peatlands at the landscape scale. The aim of the project is to gather data from both in-situ greenhouse gas flux measurements, unmanned aerial vehicle (UAV)-derived imagery and ground motion from ISBAS InSAR to assess peatland condition in a range of settings. Target areas are located within the Flow Country: the largest blanket bog area in Europe. Two sites were selected: a peatland classified to be in good condition - Plantlife Munsary peatlands - and an upland peatland in a degraded state, at RSPB Knockfin Heights. Sites are surveyed at monthly intervals over the growing season with gas flux, UAV and InSAR measurements. These are supplemented by lower intensity sampling over the winter period to ensure measurements were representative. Measured variables include soil temperature, photosynthetic active radiation (PAR), water table depth and moisture content. Vegetation cover (-change), micro-topographic features and spectral signatures of different plant functional groups are also mapped using field techniques and GIS and remote sensing tools. This set of environmental and topographic parameters are then combined with remote sensing data to upscale the technique over the whole Flow Country. The development of this tool shows great potential in the identification of sites with the greatest potential for restoration within what is Europe's largest area of blanket peatland.

2.1.2 Study on necessities and strategies of revegetation in Indonesian peatlands: Focused on Jambi province, Indonesia

Jong-Kyu Lee, Su-Young Woo, Myeong-Ja Kwak, Ji-Eun Kim, Sang-Hee Park, Han-Dong Kim, Ho-Sang Kang

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Peatland Restoration

Revegetation, Peatland, Jambi, Indonesia, Species

Peatlands are globally substantial carbon pools and have been formed by accumulation of organic matter under waterlogged conditions over a long period of time. Peatlands and their role are becoming important in the world since recognition of carbon storage and emissions is growing. 20-21 Mha of tropical peatlands cover in Indonesia including 7 Mha in Sumatra. Indonesia possesses the largest area of tropical peat which is about 50% of total tropical peatland. The most rapid degradation of peatlands recently occurs in Southeast Asia due to the agriculture and plantations of oil palm and rubber trees. Degradation of peatlands occurs substantial carbon emissions and loss of biodiversity. Degraded peatland is needed to establish a vegetation cover to sustain wet condition and decrease fire risk. Revegetation is the important activity of peatland restoration. This research aimed to study necessities and strategies of revegetation in Indonesian peatlands located in Jambi province. The strategies of revegetation plan should be selected appropriate to the characteristics of the peatland. Furthermore, the selection of species for revegetation should be considered depending on needs of local community. According to field survey, it was found that local community prefer socialforestry with *Dyera lowii*, *Alstonia scholaris* and *Nothophoebe coriacea* for peatland restoration.

Acknowledgment: This study was carried out with the support of 'R&D Program for Forest Science Technology (Project No. 2017047B10-1818-BB01)' provided by Korea Forest Service (Korea Forestry Promotion Institute)."

2.1.3 Climate-smart Sphagnum in rewetted extracted peatlands in Sweden

Sabine Jordan, Örjan Berglund, Jan Fiedler, Elve Lode, Monika Strömngren, Torbjörn Nilsson, Lars Lundin

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Peatland Restoration

automated chambers, CO₂, CH₄, greenhouse gases, mire restoration, shallow lake, vegetation development

Carbon emitter sites, such as peat extraction areas, can be turned into carbon sinks after termination by rewetting with following vegetation development. Two extracted peatlands have been rewetted in the late 1990's and functioning wetland ecosystems with stable hydrology and characteristic peatland vegetation have been established. Some parts of the restored wetlands are covered by almost 100 % of Sphagnum and terrestrialization by Sphagnum of the newly established shallow lakes is proceeding rapidly. Simultaneously, bare peat areas are decreasing. To monitor the Sphagnum's climate impact, sites with dense Sphagnum lawns were investigated with transparent automated and manual chambers for methane (CH₄) and carbon dioxide (CO₂) fluxes. As a result, depending on temperature, soil moisture or height of water table and light, ecotopes with vegetation (fen sites and Sphagnum sites) can be sinks or sources for carbon whereas bare peat sites are carbon sources only.

2.1.4 Slowing-the-flows: Post-forestry blanket bog restoration on the North York Moors, UK

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Peatland Restoration

peatland, restoration, water table, evapotranspiration

Peat moorlands are known to form a significant component of the upland hydrological cycle, with the capacity to alleviate flooding during high intensity rainfall events. The development of effective methods for post-forestry peat moorland restoration has so far been limited by a lack of empirical models that assess the hydrological changes associated with restoration and a lack of long-term, high resolution data to derive such models. The upland ombrotrophic mire, May Moss (Yorkshire, UK), at 150 ha, is the largest intact blanket bog in eastern England, with peat in excess of 5 metres in thickness. In 2006-8, the Forestry Commission facilitated the large-scale removal of forestry from the eastern third of the mire and since 2008, hourly data have been collected on the hydrology and micrometeorology of the adjacent intact and restoring sites, offering a rare insight into the hydrology of intact and restoring blanket bogs, crucial to understanding the long-term effects of drainage, ditch blocking and climate change on these ecosystems. These data are used to assess the controls over changes in the peatland water balance, particularly evapotranspiration, outflow and intra-annual water table variability. The monitoring enables a post-forestry bog to be compared with the adjacent intact site to test hypotheses about 'slow-the-flow' in the context of managed peat moorlands. Strong intra-annual climate control over peatland hydrology includes high winter water tables driven by minimal evapotranspiration losses and higher rainfall. Summer water table draw-down, governed by evapotranspiration, varies between years largely reflecting the frequency and magnitude of summer rainfall events. This work links to, and complements, on-going practical research on best restorative methods, but will also provide a more holistic analysis of the environmental factors affecting peat moorland restoration.

2.1.5 Natural revegetation of bog pools post-restoration on UK southern moorland: discussing the typical timescales for botanical community and hydrological recovery on degraded blanket bogs.

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Peatland Restoration

Peatland restoration, Sphagnum, blanket mire.

This poster provides an analysis of change in mire vegetation for a restored blanket mire on Dartmoor, reporting on four years' monitoring of recovery after hydrological restoration (2013-2018). An overview of both the current and future programme of research for the site is also described.

Hydrological restoration measures (gully blocking) were applied to part of the North Dartmoor SSSI blanket bog macrotope at South Tavy Head in autumn 2013, as part of the Dartmoor Mires Restoration Project (2010-2018). This resulted in the re-wetting of extensive areas of damaged peatland and the creation of hundreds of new bog pools. The main aim of the project was to re-establish ecosystem services whilst also investigating the feasibility and impacts of restoring degraded blanket mires. The project provided an invaluable opportunity to compare pre- and post-restoration vegetation in order to further understanding with regards to timescales involved for recovery of mire vegetation. At South Tavy Head, seventy bog pools were identified via stratified sampling in 2015. Vegetation composition of bog pools was assessed in the summers of 2015-2017 by recording all plant species within the pool margins, together with visual estimates of cover using the Domin Scale. As of 2017, 96% of the bog pools studied had been colonised by *Sphagnum*, indicating that the site is undergoing the typical succession from bare peat and standing water to *Sphagnum* pool and lawn communities. There was considerable variation in the abundance and species composition of pool surface vegetation, however the primary colonising species were *Eriophorum augustifolium* and *Sphagnum*. Preliminary data pertaining to *Sphagnum* productivity at the site was promising, with aquatic *Sphagnum* in particular demonstrating rapid growth and colonisation of bog pools within two years of restoration.

The findings of the previous study indicate that the restoration of degraded blanket mire can successfully recover hydrological conditions and vegetation within five years. The current programme of research focuses on investigating the ameliorating effects of *Sphagnum* on the peatland environment, specifically on changes to decomposition rates and pore water quality, in response to hydrological restoration. There is growing interest in the role that peatland vegetation plays within the narrow tolerances afforded to them by changing hydrological and chemical changes. Therefore detailed research into both the response and effects of *Sphagnum* reestablishment to restoration will have critical implications for international peatland management in light of present and predicted climate change. The main objective of this research is to contribute to the understanding of the vegetation-driven mechanisms supporting the stability and resilience of restored mires, both within-site and at a landscape scale. The key methods and experimental designs will be discussed. "

2.1.6 Sustainable Sundew (*Drosera rotundifolia*) cultivation for high value products on drained nutrient-poor peat bogs in Northern Satakunta, Finland

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Peatland Restoration

Round-leaved sundew, Drosera rotundifolia, naphthoquinones, 7-methyljuglone, sundew collection, sundew cultivation, nutrient poor peat-bogs, drained mires, mire vegetation

Round-leaved sundew (*Drosera rotundifolia*) is a small, carnivorous perennial plant growing mainly on nutrient-poor peat bogs. It uses insects as a source of nitrogen and phosphorus. Sundews have been used traditionally as cough medicine. Round-leaved sundews are not presently endangered in Finland and they are collected from natural mires and sent e.g. to Switzerland for medical purposes. Sundew cultivation method was developed already ca. 20 years ago (Galambosi & Galambosi 2000) in Finland. Nowadays it's known to be implemented in paludiculture in Germany (Baranyai & Hoosten 2016). Cultivation of sundew on drained nutrient poor (low productive) peatlands in Finland would further improve it's availability and would boost commercialization and development of new high-value products locally.

Sundews contain naphthoquinones which are pharmaceutically active compounds. The dominant naphthoquinone in *D. rotundifolia* is 7-methyljuglone (5-hydroxy-7-methyl-1,4-naphthoquinone). They contain also flavonoids, such as quercetin. We have applied HPLC-method to analyze 7-methyljuglone from sundew extracts. There is no commercial standard for pure 7-methyljuglone, so we need to fractionate it from the extracts of living plant. We have also developed a method to reproduce sundews vegetatively in lab to accelerate the cultivation process of this perennial plant.

In field cultivation (from seeds) experiment we use the new Sphagnum –moss harvested areas in Western Finland. Our aim is also to find out the suitability of the drained nutrient poor peatland areas for sundew collection and landowners interest even in cultivation in the area Northern Satakunta in Western Finland. This has done by mapping the presence of *D. rotundifolia* in the bogs and by sending questionnaires to the local land owners.

By improving the growing methods and availability of *D. rotundifolia* together with the information of the naphthoquinone content of the biomass we hope to create better possibilities to commercial utilization of sundews in Finland. Cultivation would also lower the pressure on natural populations due to collection.

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2.1.7 Measuring Canal Blocking Impact on Surface and Ground Water Levels Dynamics

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Peatland Restoration

peatland, peatland rewetting, canal blocking, ground water level

The utilization of peatland for agriculture and plantation activities in Indonesia have drained peatland due to massive drainage canal constructions that increase water run-off and lowered water retention in peatland ecosystem. As a result, surface and ground water levels decrease significantly and create high vulnerability of peatland dry out as well as prone to fires during dry season. In order to avoid these continuously degradations and its associated negative impacts, hence hydrological peatland restoration measures, notably canal blocking is a fundamental way to reestablish and stabilize disturbed hydrological condition in peatland. Canal blocking aims at reducing water outflows and increase water retention within blocked canal and its surrounding area. This study aims to investigate the impact of canal blocking on peatland hydrological dynamics, namely ground and surface water level fluctuations and stabilization. This study was conducted in Garung Village, Pulang Pisau District, Central Kalimantan Province, where massive peatland fire occurred during the El-Nino in 2015. Two canals in Garung Village, namely Jejangkit and Ulin, were selected to monitor both ground and surface water levels. The Jejangkit Canal was blocked in 2017 (five dams), meanwhile, the Ulin canal has no canal blocking intervention. In addition, these two canals were located in the same peatland hydrological unit with similar characteristic in terms of water-flow and elevation. The primary data collected for this study consists of ground-water level (GWL) and surface water level (SWL). To monitor GWL, about 55 and 40 monitoring wells were installed in Jejangkit Canal and Ulin Canal respectively. The distance between each monitoring well was arranged between 50 - 100 meters. Meanwhile, to monitor SWL, each canal was equipped with two water level meters located at the up and downstream. Monitoring and data collecting were carried out in March 2018 during the rainy season. The GWL and SWL data measurement were taken within 5 days, starts from 08.00am – 04.00pm with 2 hour interval. All collected data from both canals were classified, processed and analyzed by using Microsoft Excel. The analysis shows that the GWL fluctuations in Jejangkit and Ulin Canals were between 4 – 12 cm and 4 – 29 cm respectively. The difference in GWL fluctuations indicates that the restored area has a higher ability to hold ground-water compared to the unrestored area. In the meantime, the SWL fluctuations of Jejangkit Canal were between 0.44 – 0.60 meter (upstream) and 0.45 – 0.70 meter (downstream), meanwhile at Ulin Canal were 0.52 – 0.75 meter (upstream) and 0.70 - 0.95 meter (downstream). It is clear that SWL in restored site is less dynamic compared to unrestored. In addition, the correlation between GWL and SWL in both sites indicates that every 10 cm increased of SWL would potentially result in 1.2 cm and 0.8 cm increase of GWL in the restored and unrestored sites respectively. This investigative study concludes that there is a positive correlation between canal blocks and the stabilization of ground and surface water level dynamics in restored. However, in order to come up with obvious correlation between hydrological restoration measures and the stabilization of hydrological dynamics, further study with a longer period of monitoring time-span is needed.

2.1.8 The diversity of peatland fish of Sabangau, Central Kalimantan (Indonesia)

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Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

fish, peat-swamp forests, Borneo

Due to their unique characteristics including acidic waters, peat-swamp forest (PSF) and peatland rivers are important fish habitats that often have a higher degree of endemism than other waterways. Fishing is one of the main sources of livelihood in villages surrounding the Sabangau Forest, and therefore assessments of the fish biodiversity and monitoring of water quality along with projections of future fish population trends are of high relevance and necessity. In the Sabangau catchment of Central Kalimantan, Indonesia, we completed the first detailed spatial and temporal assessments of local fish biodiversity of PSF and blackwater river habitats. Monthly environmental and fish data were collected over a 15-month period in both riverine and forest habitats. This resulted in a species list of 55 species from 16 different families. Species richness in the river was almost 1.5 times higher than in the forest which is likely due to the sampling methods and trap selectivity. River fish catches were negatively correlated with river depth and positively correlated with water turbidity (i.e. the clearer the water, the fewer fish catches), but not with other environmental variables measured (including pH, water temperature and dissolved oxygen levels). River fish surveys were conducted pre- and post- fire in 2015, with results showing increased river acidity and reduced fish catches post-fire. These data form a baseline for future monitoring projects and further highlight a previously overlooked potential impact of fire on local biodiversity in Indonesia, which has likely direct implications for the human communities dependent on fishing for their livelihoods. With peatlands and their rivers facing continued human disturbance and degradation, such assessments of fish biodiversity and water quality are of high priority. The results of these surveys form the baseline for future monitoring projects. In the long-term this information will be vital to improved understanding of these wetland habitats, their importance for community livelihoods, and ultimately to finding ways of promoting conservation alongside community development. We lastly present plans for developing fish research networks to support future fish research and conservation in Kalimantan.

2.1.9 Peat and peatlands research and peat data management in the Geological Survey of Finland

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Peatlands and Biodiversity, (Ecology, Hydrology and Geology)
peat, peatland, Finland

The Geological Survey of Finland (GTK) is the leading research institute in systematic peat and peatland investigations, mapping ca. 20 000 hectares of peatland yearly. Overall ca. 2.2 million hectares of mires and peatlands has been investigated throughout the Finland since 1970's. During these investigations GTK has used the most up-to-date mapping and data storage methods and has continually made improvements to the mapping processes. Nowadays our mapping is a mixture of traditional and modern methods: peat sample is obtained traditionally with Russian corer and data collection is made in modern GIS environment. Also Ground Penetrating Radar (GRP) and drone measurements are used in detailed mapping. During fieldwork the data is stored with field tablets directly to the database format and the transferred with web-based data transfer services. After management and validation the data is stored to the vast GTK peat database and distributed via web service at www.gtk.fi/turvevarat.

The database is a unique world record peat database: it consists totally ~1.8 M peat study points, comprising totally 17 900 peatlands. Altogether the peat database has over 234 M data enquiries related to peat thickness and peat quality, mire types, information on vegetation, bottom soil material, chemical and physical properties etc. Traditional this kind of data has been used for evaluating the possibilities of using peat as a resource for energy, horticultural purposes, litter and other environmental uses. However, during last decades the utilization of widening set of ecosystem services has been gaining substantial added value by using this data. At this very moment, the applied use of peat data and GTK expertise provides solid base and tools for decision making and governance needed in tackling the climate change through evaluation of the carbon stock and balance. At the same time, unbiased use of peat and peatland data provides possibilities for responsible use of peat for e.g. in securing global food production. "

2.1.10 The scheme of distribution of peatlands in the directions of use

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Peatlands and Biodiversity, (Ecology, Hydrology and Geology)
peatland, peat fund, environmental protection

The data of all peat deposits in the Republic of Belarus have been refined and their current state has been determined with the aim of the deposits redistributing in new areas of using.

The work was carried out on the basis of analysis of the collected data for each object including general technical, physical-chemical, geomorphological and stratigraphic characteristics.

The evaluation of the peat fund made it possible to develop a new normative document ""The scheme of distribution of peatland in the directions of use for the period till 2030"".

The project was realized by The Institute for Nature Management of the National Academy of Sciences of Belarus jointly with the The Scientific and Practical Center for Bioresources of the National Academy of Sciences of Belarus. Peat fund of the Republic of Belarus is divided into trust funds: especially valuable, protected, developed and land peat species.

1. The Fund of particularly valuable peat species includes peatlands, containing raw materials for bituminous production, raw materials for hydrolysis production, mud treatment materials. The total area of peat deposits of this fund is 19.6 thousand hectares (0.8%) with reserves of 43.7 million tons (1.1%).

2. The Fund of peatlands which comes under special protection has been significantly expanded in the new Scheme. It is planned that this fund will amount about 684.2 thousand hectares (28.6 %) with total reserves of 1,555.5 million tons (38.5%) by 2030. The peatlands of this fund carry out important biospheric functions in nature. Peatlands are important for conserving landscape and biological diversity, cleaning atmospheric air from excess carbon dioxide and enriching it with oxygen. Ecological tourism is developing on some peatlands.

3. The Developed Fund includes 99.1 thousand hectares (4.1%) with peat reserves of 302.1 million tons (7.5%), which will ensure the work of peat processing plants at the current production level for 100 years. This Fund includes raw materials bases specialized on the production of multi-purpose and fuel products. A wide range of products has been patented in the Republic of Belarus. The technologies and corresponding equipment for the production of these products have been developed.

4. The Land fund makes 1592.6 thousand hectares (66.5%) and 2135.4 million tons (52.9%) of peat. It is supposed to use peat deposits in agriculture, forestry and under water. The Specialists of the Institute study the methods of preserving and improving peatlands for agricultural use. It will reduce the annual loss of organic matter and the emission of carbon dioxide into the atmosphere, improve the agrophysical properties of soils, improve the agronomic, economic and environmental effectiveness of their agricultural use.

The Scheme is aimed at balancing the national interests in the environmental and industrial spheres, as well as the fulfilment of the International obligations related to protection of peat deposits, wild flora and fauna by the Republic of Belarus.

The Implementation of the Scheme will increase the efficiency of peat using in agriculture, expand the range of products through biothermochemical peat processing and provide environmental protection."

2.1.11 Epigeic invertebrates on Sphagnum farming sites

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Peatlands and Biodiversity, (Ecology, Hydrology and Geology)

Sphagnum farming, biodiversity, Coleoptera, Lower Saxony

Restoring the hydrology and establishing peat mosses on cultivation sites for Sphagnum farming can provide potential habitat for characteristic raised bog species. Two experimental sites for Sphagnum farming were established on industrially harvested and strongly-decomposed peat fields in Lower Saxony, Germany. On these sites a total of 5 ha were inoculated with peat moss from four donor sites. In 2017 and 2018 invertebrates living in and on the upper moss layer were studied in six areas. Four different parts of the experimental sites (with different origins of donor material and different ages) and two sites in near-natural peatlands (one donor site and one reference site) were assessed. The invertebrates were collected by manual extraction of 100 peat moss samples (30 cm x 30 cm x 5 cm) per area.

In 2017 a total of 4357 individuals were collected. Among them were mainly spiders (Aranae), bugs (Hemiptera) and beetles (Coleoptera). Ants (Hymenoptera: Formicidae) were also dominant in the near-natural areas, but were missing on the cultivation sites. Most arthropods were found on the near-natural reference area. It is notable that the number of individuals is lower in the older parts of the cultivation areas compared to the newer parts. On the cultivation sites, the number of beetle species varied according to age and shape of the areas. In addition, some characteristic and endangered beetle species (e.g. *Myllaena kraatzi*) could already be found.

"

2.1.12 Implementation of GEST method to estimate GHG emissions from peatlands

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Peatlands and Climate Change

GEST, EU-LIFE project, GHG emissions, Restoration

The EU-LIFE project "PEAT RESTORE" aims to restore 5,300 ha of degraded peatlands across five countries: Estonia, Germany, Latvia, Lithuania and Poland, and to reduce Greenhouse Gas (GHG) Emissions from the targeted peatlands. For estimation of the climate effect of the restoration measures we are using the GEST method (Greenhouse Gas Emission Site Type - COUWENBERG et al. 2011). According to the water table level and vegetation composition, these GESTs show different emission characteristics. Based on the vegetation mapping, additional water level measurements and chemical analysis of the trophy level, we were able to identify different GESTs on the project sites, which already exist or were published, in addition to identifying GESTs with a probable different emission character. First results will be presented in the poster.

2.1.13 The importance of methane ebullition in floodplain fens

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Peatlands and Climate Change
methane, ebullition, floodplain, fen

The contemporary global warming or cooling effect of peatlands is influenced disproportionately by recent emissions of the potent but short-lived greenhouse gas, methane, leading to concern about the potential for peatland management to unintentionally increase methane emissions and exacerbate radiative forcing. Uncertainty in estimates of methane emissions from peatlands arise, in part, due to difficulties in quantifying the importance of ebullition, a mechanism by which methane is rapidly transported from sub-surface peat to the atmosphere, bypassing consumption by methane oxidation. This is a particular concern in temperate lowland floodplain fens in which total methane emissions to the atmosphere (often measured as the sum of diffusive and plant-mediated fluxes) are known to be high, but few direct measurements of methane ebullition fluxes have been made. Our study quantified methane fluxes (by diffusive, plant-mediated and ebullitive transport) from two temperate floodplain fens under conservation management (Norfolk, UK) over six months using funnels and static chambers. Methane ebullition was a major component (> 38 %) of total emissions over spring and summer. Ebullition was both steady and episodic in nature, and we show that ignoring episodic ebullition could lead to major under-estimation of total methane emissions from these landscapes. Seasonal methane ebullition fluxes varied over five orders of magnitude owing primarily to changes in soil temperature, but also in water level, plant phenology and air pressure. Methane ebullition fluxes increased markedly at a distinct threshold as water level rose to within 10 cm of the peat surface. In contrast, methane ebullition flux decreased steadily with increasing green area of vascular plants. Management practices such as reed-cutting, which reduce vascular plant biomass for a number of years, have the potential to reduce plant-mediated transport of methane but also to increase methane ebullition by limiting the magnitude of rhizospheric methane oxidation. Quantifying the importance of different methane transport pathways remains a significant challenge, but is vital to understanding the effect of such management practices on methane emissions from lowland fens.

2.1.14 Greenhouse gas fluxes from organic soils in Germany – synthesis and derivation of emission factors for the national greenhouse gas inventory

Bärbel Tiemeyer, Annette Freibauer, Elisa Albiac Borraz, Jürgen Augustin, Michel Bechtold, Sascha Beetz, Colja Beyer, Matthias Drösler, Martin Ebli, Tim Eickenscheidt, Sabine Fiedler, Christoph Förster, Andreas Gensior, Michael Giebels, Stephan Glatzel, Jan Heinichen, Mathias Hoffmann, Heinrich Höper, Gerald Jurasinski, Andreas Laggner, Katharina Leiber-Sauheitl, Mandy Peichl-Brak, Thomas Riedel, Wolfgang Stümer

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Peatlands and Climate Change

emission inventories, regionalisation, carbon dioxide, methane, nitrous oxide

Drained organic soils are large sources of anthropogenic greenhouse gases (GHG) in many European and Asian countries including Germany. Therefore, they urgently need to be considered and adequately be accounted for when attempting to increase the carbon sequestration in agricultural soils. Here, we synthesise a large data set of GHG fluxes from organic soils and describe the detailed methodology for reporting anthropogenic GHG emissions from drained organic soils developed for, and applied in, the German GHG inventory under the UNFCCC and the Kyoto Protocol. The approach is based on national data and offers the potential for tracking changes in land-use and water management associated with intensification, peatland restoration or GHG mitigation measures in case time series of relevant activity data are available.

Drained organic soils were defined as soils with a mean annual water level of -0.1 m below surface or drier. Activity data comprise high resolution maps of climate, land-use, the type of organic soil and the mean annual groundwater level. The groundwater map was derived by a boosted regressions trees model from data from > 1000 dipwells.

Carbon dioxide and methane emissions were synthesized from a unique national data set comprising more than 200 GHG balances in most land-use categories and types of organic soils. The measurements were performed with fully harmonized protocols. Non-linear response functions describe the dependency of carbon dioxide and methane fluxes on the mean annual groundwater level, stratified by land-use and organic soil type where appropriate. Resulting "implied emission factors" for each land-use category take into account both the uncertainty of the response functions and the distribution of the groundwater levels within each land-use category. No functional relationships were found for nitrous oxide emissions. Emission factors for nitrous oxide were thus calculated as the mean observed flux by land-use category. IPCC default emission factors were used for minor GHG sources such as methane emissions from ditches and the losses of dissolved organic carbon (DOC). In Germany, drained organic soils annually emit nearly 50 million tons of GHGs, equivalent to 5% of the national GHG emissions. They are the largest GHG source from German agriculture and forestry. The described methodology is applicable as well to the project scale as to other countries where similar data is available.

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2.1.15 Impact of wildfire on methane emissions and dissolved organic carbon at a boreal fen, Alberta, Canada

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Peatlands and Climate Change

wildfire peatlands methane dissolved organic carbon

Boreal peatlands represent a globally important store of carbon, and disturbances such as wildfire can have a significant positive feedback to the climate. Understanding how carbon cycling and greenhouse gas (GHG) dynamics are impacted after a wildfire is important, especially as boreal peatlands may be vulnerable to changes in wildfire regime under a rapidly changing climate.

The study was undertaken in a forested fen near Fort McMurray, Alberta, Canada which was partially burned by the Horse River Wildfire in 2016. We investigated the impact of fire on both DOC concentration and quality (SUVA₂₅₄, E2:E3 and E4:E6) and methane (CH₄) emissions across a burn severity gradient (unburned, moderately burned and severely burned) in 2017 and 2018.

DOC concentration at the unburned site increased from 25.1 mg/L to 60.1 mg/L between May and July 2017. The moderately burned site followed a similar pattern. The severely burned site showed a much smaller increase between May and June (unfortunately no July measurements were able to be collected) from 42.9 mg/L to 44.3 mg/L. Preliminary results indicate there are significant differences in DOC concentration and quality between the three sites. Overall, DOC concentration increased post fire, to levels similar to previous years. There was no significant difference in DOC concentration or quality found between microform types (hummock versus hollow) at any of the sites.

However, microform type did affect variation in CH₄ emissions, with hollows in the unburned site having higher fluxes than hummocks. The opposite was found at the burn sites, where the hummocks had a higher flux. These initial results highlight the sensitivity of hollows to fire, removing labile organic material for potential methanogenesis. The previously demonstrated resilience of hummocks to fire also results in limited impact to carbon exchange and likely faster recovery to pre-fire rates.

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2.1.16 Impact of wildfires burning on peatland environment in Latvia

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Peatlands and Climate Change

peatland, wildfires, climate change, Latvia

Peatlands including bogs and fens are ecosystems existing on peat that is rich in decayed organic matter. It is assumed that in their healthy, natural state, peatlands are quite fire resistant. However, the number of peatland wildfires has increased over the recent decades. It is usually caused by reckless human activity, but also by natural ignition, which can be partly explained by the climate change. Air temperatures soar during summer seasons, and are usually accompanied by very low volume of precipitation. Dry and hot spells like this are becoming longer, causing lowering of groundwater level in peatlands. Wildfires have occurred both in natural mires including protected nature areas and in peat fields, in different places in Latvia.

The aim of the study was to identify the location of sites where the fires occurred and determine the level of influence the fires had left on the peatland environment, as well as how quickly the nature ecosystem had recovered. Usually wildfires happened in the areas with the dominance of raised bogs or raised bog peat type, mainly Sphagnum. Large areas that are affected by fires are in several specially protected territories, Bazhi Mire in Slitere National Park, Teichi Bog in Teichi Nature Reserve, Kemeru Bog in Kemeru National Park. Wildfires damaged Valdgale Mire and Ramata Mire in this year. Fires change the vegetation of mire, but their rehabilitation depends on many factors. It is known that the bare peat field was colonized first by dwarf shrubs and only then by trees, predominately birches. The same scenario of succession is evident after fire in mires. Burning of fens or wet grasslands are rare in Latvia. Survey of these places (Apsuciems, Kanieris) revealed that fire left no adverse effects on the composition of plant species.

The study also observed the fire-affected areas of peat fields with aim to determine how differently they were affected in comparison to nature bogs, as well as to what extent the peat characteristics had changed, also affecting the change in peat quality.

The results of study provide suggestions in the future management of bog ecosystems and peatlands in the light of climate warming.

"

2.1.17 Riverine CO₂ emissions in a peatland catchment

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Peatlands and Climate Change

Carbon, Rivers, CO₂, fluxes

The peatlands of northern Scotland are the largest reserve of organic carbon in Europe. However, many areas are subject to degradation, erosion, and loss of carbon, of which a large portion enters the draining river systems. Only a fraction of terrestrial organic carbon lost to river networks is exported to the oceans, yet as to whether the remaining portion is deposited within sediments, or remobilised to the atmosphere is as yet unknown. Rivers act as a centre for degradation and remobilisation of DOM and are a source of CO₂ to the atmosphere, but the extent of seasonal variations and within catchment variations is as yet unknown. // This study focuses on CO₂ fluxes from the River Halladale and its tributaries in northern Scotland. The River Halladale, which has one of the highest DOC concentrations in the UK, has a predominantly peatland catchment, but in varying conditions. Set to run throughout 2018/19, monthly sampling of the river and tributaries will provide seasonal and spatial variations as to the extent of CO₂ fluxes across varying sub-catchments. // This study is run as part of the NERC funded project, LOCATE, which sees a national collaboration among the Centre for Ecology and Hydrology (CEH), British Geological Society (BGS), Plymouth Marine Laboratories (PML) and the National Oceanography Centre (NOC), with the aim of identifying the key processes relevant to decomposition of terrigenous carbon, particularly in peatlands.

2.1.18 Agricultural drainage effect on Dissolved Organic Carbon of Boreal Peatland

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Peatlands for Agriculture

Peatland, Drainage, Dissolved Organic Carbon (DOC)

Peatlands are an important terrestrial carbon store which are particularly unbalanced ecosystems in which the rate of production and accumulation of organic material exceeds its degradation and export rate. Consequently, peatlands can hold approximately 200-450 Pg C. Peatlands with the carbon-rich soils are a principal source of dissolved organic carbon (DOC) to the fluvial environment, the transportation of which constitutes a significant link in the global carbon cycle. Estimated global land surface covered by peatlands is about 2-5% . Northern peatlands, storing about one-third of the global soil carbon (C), play a key role in the global C cycle. In other ecosystems, the influence of DOC pools and fluxes is small, but in the peatlands, DOC influence on the terrestrial and aquatic C cycles is significant. DOC consists of a variety of molecules that range in size and structure from simple non-humic acids and sugars to complex humic substances, and therefore contains both biologically available (labile) and more recalcitrant components, so concentration and composition of DOC can be varied in soil water according to changing conditions.

For centuries, the artificial drainage of the peatlands has been carried out to satisfy the demands of the agriculture, forestry, energy, and industries. Agricultural drainage of peatland has led to changing both in concentration and composition of DOC. The full effects of drainage on DOC are difficult to assess and are likely to be extremely complex. A reduction or loss of natural carbon sinks represents a significant problem from the standpoint of global climate change, so such study is therefore imperative that we improve our understanding of how peatlands respond to drainage.

In this study it has been made an attempt to investigate the principal differences in DOC concentrations between drained boreal peatland-pasture site and natural peatland site to have a qualitative assessment of DOC along with the initial assessment of aromaticity of DOC by using Specific UV absorbance (SUVA), which gives an "average" molar absorptivity for all the molecules contributing to the DOC in a sample. The temporal dynamic of DOC concentration was monitored in order to know how DOC concentrations vary over the time period of research.

DOC concentration measured using TOC-V analyzer. Also samples were analyzed for UV-Vis absorption using a spectrophotometer. SUVA was determined by dividing UV-Vis absorbance at $\lambda = 254$ nm by the sample DOC concentration multiplied by 100.

The results showed that DOC concentration was higher in drainage site than natural one. By drainage, and lowering water table, more aerobic decomposition is occurred and by likely increasing of biodegradation, so higher SUVA in drained peatland was seen in comparison to intact. So, Drainage can effect both on DOC concentration and aromaticity; it is found that DOC concentration showed variation during growing season.

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2.1.19 Peatland subsidence through agricultural activities in Sarobetsu Peatland, northern Hokkaido, Japan

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Peatlands for Agriculture
subsidence, agricultural land use, laser survey

Agricultural land use in peatlands unavoidably causes ongoing land surface subsidence due to consolidation, shrinkage, and decomposition of the peat substrate. Peatland subsidence intensely affects local agricultural productivity, regional environment, and global carbon balance issues. Knowing the situation of peat subsidence, particularly the rate of subsidence, is important for appropriate land use management, flood control, and carbon dynamics accounting.

Sarobetsu Peatland is the third largest peatland in Japan (approx. 14,000 ha) and located in the northernmost region of Hokkaido. More than half of its area (approx. 7,300 ha) has been developed for grassland since the late 20th century, and the intact rest area is conserved as a national park. We analyzed peatland subsidence through agricultural land use employing a contour map described in 1956 and two digital elevation models (1 m resolution) based on aerial laser survey in 2003 and 2013.

As a result, a recent (2003 to 2013) and a past (1956 to 2003) regional-scale subsidence map were generated. The average rate of subsidence at the grassland on peat was 18 mm/y for the period of 2003 to 2013, which was smaller than the rate of 27 mm/y for the past period of 1956 to 2003. The rate also depended on the time of the opening of grassland; in the decade of 2003 to 2013, the subsidence rates of the old grassland opened in the early 1960s and the new grassland opened in the late 1980s was 15 mm/y and 23 mm/y respectively. These values suggest that the rate of subsidence reduced through the time from the reclamation and well agree with previous studies. Spatial variation of those values was relatively high with the standard deviation of 6.8 mm/y depending on the several factors such as the distance from drainage ditches and presence of subsurface drainage. Maintenance such as deepening of the ditches and soil dressing on the top of each farm plot accelerated the rate of subsidence even after 50 years from grassland reclamation. Our result shows that the history of the land use management has had a significant impact on the subsidence and peat subsided at different rates under different conditions."

2.1.20 Peat for Food and Quality of Life: developments in China

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Peat for Growing Media and Energy
China, peat industry

Peat for Food and Quality of Life; Observations of Chinese Growing Media Market: Peat for Food and
Quality of Life; Observations of Chinese Growing Media Market:

In terms of volume, China can be considered as a leader in horticulture production in the world. The Chinese agriculture sector's focus is shifting its focus from yield optimization towards more sustainable growth. Chinese growers are slowly beginning to mimic agriculture practices from renowned European nations. As a result from this, the demand for growing media in China has experienced an increased growth. The International Peatland Society (IPS) has therefore commissioned an explorative study carried out by two students to examine current and future demand for growing media in China and the role of peat therein. During a period of three weeks in November 2017, data was obtained by firsthand experiences from the trips made in China, but also the many interviews we conducted with stakeholders in the Chinese growing media market to create an overview of the current situation. Although, qualitative data regarding the amount of peat used in China was complicated to come by, the excursion did give us a proper indication to what degree peat is used and how the Chinese growing media market in general is put together. From this observation, key factors were indicated one has to pay attention to when examining or infiltrating the substrate and growing media market in China."

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