Influence of woodland on the modification of the albedo and water distributions in an insular environment. Case study on Tenerife, Canary Islands, Spain

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Forests and abundance of water –focus on boreal forests and peatlands

Abstracts and Programme of the COST Action FP0601 FORMAN Workshop at the Finnish Environment Institute, Helsinki and Hyytiälä Forestry Field Station, Finland 6.–8.9.2010

Leena Finér, Pirkko Kortelainen, Elve Lode and Markus Lier (eds.)

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Title

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Abstract

This paper compiles the programme and abstracts of the international scientific workshop, Forests and abundance of water boreal forests and peatlands, organised in the premises of the Finnish Environment Institute, Helsinki and the Hyytiälä Forestry Field Station of the University of Helsinki from the 6th to 8th of September 2010. It is the 7th workshop of the COST Action FP0601 Forest management and water cycle (FORMAN). The main objectives of FORMAN are to enhance the knowledge on forest-water interactions in Europe and to elaborate science-based guidelines for the improvement of the management of forests predominantly designed for the production and storage of water. FORMAN will scientifically address the manifold aspects of managing forest-water interactions under rapidly changing environmental constraints.

The main organizers of this Workshop are the Finnish Forest Research Institute, the Finnish Environment Institute, together with the Institute of Ecology from the Tallinn University, the Department of Soil and Environment from the Swedish University of Agricultural Sciences and the COST Action FP0601. Over 50 scientists from 19 different countries attend the workshop.

Keywords

abundance of water, boreal forests, peatlands

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Other information

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Sponsors

Organizers

Welcome to the conference

Boreal forests are natural an essential element of the Northern European landscape. They cover 40–70% of the land area of the Nordic countries. With respect to abundant water conditions on that part of Europe, forests have an important stabilizer role both from water quality and quantity point of view, as well as from water basin and landscape point of view. The European boreal forest are important natural resource accompanied with intensive management, where forestry operations such as cutting, soil scarification and drainage have both internal and external forest and water impact interactions. The main concern is the increase in the export of elements after forestry operations. Changed element load will deteriorate surface water ecosystems and active measures are taken to mitigate these harmful effects on the watercourses. In the future one of the biggest challenges is to adapt forest management to the changing climatic and hydrological conditions.

The focus of this three-day international scientific workshop, Forests and abundance of water, is in the water relations of boreal forests and peatlands and it is the 7th workshop of the COST Action FP0601 Forest management and water cycle (FORMAN). The main objectives of FORMAN are to enhance the knowledge on forest-water interactions in Europe and to elaborate science-based guidelines for the improvement of the management of forests predominantly designed for the production and storage of water. FORMAN will scientifically address the manifold aspects of managing forest-water interactions under rapidly changing environmental constraints. The previous six workshops have been arranged in the Mediterranean or temperate parts of Europe and this is the first workshop in the cooler climatic conditions, rich of water and forests.

The workshop is organised in the premises of the Finnish Environment Institute (SYKE), Helsinki and the Hyytiälä Forestry Field Station of the University of Helsinki from the 6th to 8th of September 2010. The main organizers of this conference are the Finnish Forest Research Institute, Metla, SYKE, together with the Institute of Ecology from the Tallinn University, the Department of Soil and Environment from the Swedish University of Agricultural Sciences (SLU) and the COST Action FP0601. Over 50 scientists from 19 different countries attend the workshop.

Scientific Committee of the Conference

Michael Bredemeier, Leena Finér, Shabtai Cohen, Pirkko Kortelainen, Elve Lode,

Viliam Pichler, Patrick Schleppi and Markus Lier

Practical Information

The conference is organised in the premises of the Finnish Environment Institute (SYKE), Mechelininkatu 34a, Helsinki (on the 6.9.-7.9.2010) and the Hyytiälä Forestry Field Station (7.9.-8.9.2010), Finland.

Sunday 5.9.2010

19:00–21:00 Ice breaker and sauna, Finnish Environment Institute (SYKE).

Monday 6.9.2010

08:30–09:00 Registration
09:00–18:00 Conference day 1 (*see programme for more detailed information)*
19:30–22:00 Dinner at restaurant Savu, Tervasaarenkannas 3, 00170 Helsinki
(at 18:30 public transport with bus no 18 from SYKE to the restaurant)

Tuesday 7.9.2010

09:00–14:00 Conference day 2 *(see programme for more detailed information)*
14:30 Departure to Hyytiälä Forestry Field Station by bus in front of SYKE
17:30 Arrival to Hyytiälä, accommodation
18:00-19:30 Sauna (optional)
20:00 Dinner

Wednesday 8.9.2010

07:30–17:30 Scientific excursion *(see scientific excursion for more detailed information)*

Coffee and lunch break

Coffee and lunch is included in the participation fee. Coffee will be served during breaks in the lobby and lunches at SYKE restaurant.

Internet

A wireless Internet connection is available in the conference venue. Please ask for the password from the registration desk.

Important phone numbers:

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Programme

Sunday 5.9.2010 Arrival to Helsinki

18:30 Registration
19:00–21:00 Ice breaker and sauna, Finnish Environment Institute (SYKE)

Monday 6.9.2010

8:30–9:00 Registration
9:00–9:15 Opening of the workshop
Michael Bredemeier, chairman COST FORMAN

Session 1: Water relations in boreal forests and peatlands
Chair: Elve Lode, Tallinn University, Estonia & Swedish University of Agricultural Sciences, Sweden

9:15 **Keynote: Water relations in boreal forests and peatlands**
Leena Finér, Finnish Forest Research Institute, Metla, Finland

9:45 Managing erosion, sediment transport and water quality in drained peatland catchments
Hannu Marttila, University of Oulu, Finland

10:10 Forestry operations have a small impact on the groundwater quality in aquifers
Sirpa Piirainen, Finnish Forest Research Institute, Metla, Finland

10:35 Coffee break and posters *(see page 11)*

11:00 **Keynote: The role of water for carbon sequestration and GHG emissions in boreal forests**
Mats Olsson, SLU, Sweden

11:30 Drought-induced changes in Scots pine and Norway spruce stands estimated on the evidence to artificial drought experiments
Jurate Aleinikoviene, Lithuanian Research Centre for Agriculture and Forestry, Lithuania

11:55 The impact of drought on young spruce trees stem circumference changes and sap flow rate
Katarina Střelcová, Technical Univeristy of Zvolen, Slovakia

12:20 Forest and permanent excess of water – peatland forestry
Ari Laurén, Finnish Forest Research Institute, Metla, Finland

12:45 Use of natural and restored peatland buffers to reduce sediment and nutrient transport from forested catchments - Finnish experiences
Mika Nieminen, Finnish Forest Research Institute, Metla, Finland

13:05-13:45 Lunch

continue on the next page...

Session 2: Water fluxes at different scales (modeling, upscaling etc.)
Chair: Patrick Schleppi, WSL, Switzerland

13:45 Significance of tree roots to preferential flow in soil horizons with different degrees of hydromorphy
Benjamin Lange, WSL, Switzerland

14:10 FOREST stony soil: The contribution of rock fragments to soil water retention
Viliam Novák, Slovak Academy of Sciences, Slovakia

14:35 Development of a physic-based, dual-permeability model for subsurface stormflow and conservative transport and a forested hillslope
Hanne Laine-Kaulio, Aalto University, Finland

15:00 GIS analysis of peatland topo-hydrological features
Elve Lode, Tallinn University, Estonia & Swedish University of Agricultural Sciences, Sweden

15:25 Coffee break and posters *(see page 11)*

16:00–18:00 Meetings of COST Action FORMAN working groups

19:30 Dinner

Tuesday 7.9.2010

Session 3: Hydrological fluxes in different climatic conditions
Chair: Viliam Pichler, Slovak Academy of Sciences, Bratislava, Slovakia

9:00 Forest – Water Interactions: A Reply to the Water Yield Debate
David Ellison, Institute of World Economics, Hungary

9:30 Carbon and nitrogen pathways from boreal headwater catchments downstream to the coast along variable land use cover
Pirkko Kortelainen Finnish Environment Institute, SYKE, Finland

9:55 Stable isotopes studies to increase knowledge from the role of peatland in catchment hydrology
Anna-Kaisa Ronkainen, University of Oulu, Finland

10:20 Runoff generation across spatial and temporal scales following wildfire
Jan Jacob Keizer, CESAM, Dept. Environment, U. Aveiro, Portugal

10.45 Soil and water in managed forests - sustainable production and environmental quality. Final conference in Santiago de Compostela, 9.5.-13.5.2011
Agustín Merino, University of Santiago de Compostela, Lugo, Spain

11:00 Coffee break

11:15 Conclusions of COST Action FORMAN working groups

11:50 COST Action FORMAN MC meeting

13:00–14:00 Lunch

14:30 Departure to Hyytiälä Forestry Field Station

17:30 Arrival to Hyytiälä, accommodation

18:00-19:30 Sauna (optional)

20:00 Dinner

Wednesday 8.9.2010

Scientific excursion

7:30	Breakfast at Hyytiälä
9:00	SITE 1: Visiting at SMEAR- research station. Measuring the relationship of atmosphere and forest in boreal climate zone. *(Samuli Launiainen, Finnish Forest Research Institute, Metla)*
10:00	Bus transfer to Lakkasuo
10:20	SITE 2: Demonstration of Lakkasuo pristine and drained peatland. *(Sakari Sarkkola, Finnish Forest Research Institute, Metla)*
11:40	Bus transfer to lunch
12:00	Lunch at Hyytiälä
13:00	Bus transfer to Vilppula
13:30	SITE 3: Vilppula peatland water balance experiment site at Jaakkoinsuo experimental drainage area. *(Hannu Hökkä and Sakari Sarkkola, Finnish Forest Research Institute, Metla)*
14:30–17:30	Bus transfer to Helsinki-Vantaa airport and Helsinki city centre

Monday 6.9.2009, 10:35 and 15:25 during coffee break

Poster presentations

New methods to control acid sulfate and organic acid leaching from peatland forestry drainage areas
Kaisa Heikkinen, SYKE, Simo Tammela, Hannu Marttila, Tuomas Saarinen, University of Oulu, Finland, Kati Martinmäki, Raimo Ihme, Mika Visuri, Jaakko Saukkoriipi, SYKE, Jermi Tertsunen, Timo Yrjänä, Jukka Tuohino, Centre for Economic Development, Oulu, Finland and Bjørn Kløve, University of Oulu, Finland

Participation of aquatic fungi in litter decomposition in Lithuanian woodland streams
Svetlana Markovskaja and Jurga Motiejûnaité, Institute of Botany, Lithuania

Hydrological and protective services of forests –modeling on watershed level
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Stream ecohydrological surveys to evaluate the impacts of watershed land use
Semih Ediş Betűl Uygur and Ysuf Serengil, Turkey

Litterfall production in forests located at the pre-delta area of the Paraná River (Argentina)
Pablo G. Aceñolaza, CICyTTP-CONICET, Argentina,Lisandra P. Zamboni, Universidad Autónoma de Entre Ríos, Argentina, Estela E. Rodríguez, CICyTTP-CONICET, Argentina, Juan. F. Gallardo, C.S.I.C., IRNAS, Spain, and M. Isabel González, University of Salamanca, Spain

Ethylene and ABA responses to water stress in young Poplar, Alessio Fortunati
Emanuele Palozzi, Giovanni Marino and Mauro Centritto, Institute of AgroEnvironmental and Forest Biology, National Research Council, Italy

Upscaling water and carbon fluxes from leaf to canopy: role of stomatal control models
Samuli Launiainen, University of Helsinki and METLA

Carbon emission from bogs along a human-impact gradient in Estonia
Margus Pensa, University of Tallinn, Estonia and Helen Karu, University of Tartu, Estonia

Influence of woodland on the modification of the albedo and water distributions in an insular environment. Case study on Tenerife, Canary Islands, Spain
Juan Carlos Santamarta Cerezal, Universidad de La Laguna, Spain and Luis Santa Pérez, Agrocabildo technical advisor (Tenerife island Council), Spain

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Session 1

Water relations in boreal forests and peatlands

Chair: **Elve Lode, Tallinn University, Estonia & Swedish University of Agricultural Sciences, Sweden**

Keynote:

Water relations in boreal forests and peatlands

Leena Finér

Finnish Forest Research Institute, Metla, Finland

Boreal regions of Europe are characterized by coniferous forests growing on upland mineral soils or peatlands developed after the last Ice Age about 10 000 years ago. Towards the north, the climate gets increasingly colder and humid. The precipitation exceeds the evapotranspiration leading to the formation of runoff. The water flows to lakes and streams and further to the sea, in case of Finland, mainly the Baltic Sea. In central and northern parts of boreal region a significant part of the annual precipitation falls as snow, which melts in spring within a relatively short period of time leading to a runoff peak comprising 40–60% of the annual runoff. In winter the soils, if not protected by snow, will get frozen at the surface layer affecting on water pathways during the thawing periods. In the boreal forest regions surface and ground water resources are ample and the quality is mostly high for the human use due to the filtering capacity of forests and forest soils.

Boreal forests were earlier frequently disturbed by fire and had therefore an influence on forests and water. Nowadays the fire protection is effective in the Nordic countries, and the disturbances on forests are caused by forest management activities like cutting, soils scarification and forest drainage. These operations have mostly minor impacts on runoff, but can significantly increase the element export into the watercourses for a period of several years. Locally these impacts can deteriorate the water quality, and are of major concern, but on national scale the impacts are small compared to the diffuse load from the agricultural lands. Of the single forest management operations, forest drainage has probably had the most significant effects on the fresh water ecosystems by increasing dramatically the sediment load to the watercourses. In Finland the research on water and forests has mainly focused on the effects of forest management practices on water yield and quality, and for developing methods to mitigate the negative effects.

One of the biggest challenges in the future is to couple with the interactions of forests and water in changing climatic conditions. The climate change scenarios for the boreal regions of Europe predict and increase in the annual mean temperature up to 4–6 °C by the 2080s. The temperature will increase in all seasons, but more in wintertime. The amount of precipitation will increase and mostly in winter. In summer the total amount of precipitation changes very little or might even decrease. In the northern parts of the boreal region snow cover period will shorten, whereas in the south is becomes horter and most of the annual precipitation falls as rain. Warming and changes in snow cover affect also on soil frost and water pathways in soil. Climate change is expected to increase the occurrence of extreme weather phenomena. Increased number of storms and heavy rainfalls is forecasted. These changes can have many both positive and negative effects on the interactions between forests and water.

Managing erosion, sediment transport and water quality in drained peatland catchments

Hannu Marttila[1], Kari-Matti Vuori[2], Hannu Hökkä[3], Juha Jämsen[4] and Bjørn Kløve[1]

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Drainage-induced diffuse pollution and erosion are key water quality problems in peatland forestry. A major part of the pollutant load is transported during peak runoff periods after snowmelt or intense rainfall. This presentation represent possibilities to increase retention time of runoff waters in drained peatland catchments on purpose to diminish peak runoff and improve settling conditions of suspended solids (SS). To create retention, a peak runoff control (PRC) structure was developed and its functioning, dimensioning and practical applications were studied in seven partly or completely ditch-drained catchments in Central Finland. Also erosion and sediment transport processes were studied. Results clearly indicate that effective water quality management in drained peatland areas can be achieved using the PRC method in drainage areas. The main effect of PRC is on SS and SS-bound nutrients. The PRC structure is cheap and can easily be created with forest drainage machinery during the ditching and ditch network maintenance operations. Different issues relating to the sediment transport dynamics, structural design, water quality benefits, and impacts on forestry are discussed.

Forestry operations have a small impact on the groundwater quality in aquifers

Sirpa Piirainen[1], Leena Finér[1], Marja-Liisa Juntunen[1], Hannu Mannerkoski[2], Mirella Miettinen[2] and Michael Starr[3]

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[2] *University of Eastern Finland*

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Groundwater is the main source (60 %) of water distributed by waterworks to households and industry in Finland. Groundwater aquifers are mainly located on forest land, thus forest fertilization and intensive soil preparation are not allowed on groundwater aquifers to maintain the good quality of groundwater. High nitrate leaching to groundwater after clear-cuttings has been observed in studies done in N-rich soils in southern Sweden and central Europe (Wiklander et al. 1991, Weis et al. 2001). However, the effects of different forestry operations on groundwater quality are not systematically studied. A monitoring study on the effects of forest cutting on the quality of groundwater in large aquifers (5.2–15.4 km^2) showed that both thinning and clear-cutting (27–66 % of the recharge zone) increase nitrate concentrations for several years (Rusanen et al., 2004). However, even the maximum annual average concentrations remained very small < 2 mg L^{-1}, well below the upper level (50 mg L^{-1}) set for drinking water. The results from an other study (VALU) by Mannerkoski et al. (2005), on headwater catchments, where 10–30 % of the area were clear-cut and disc-plowed, showed also that influence of forestry to groundwater level and quality is small, although in some wells the maximum monthly concentration of nitrate increased to 6.3 mg L^{-1}. In the VALU study it was clearly shown that leaching of nitrate was delayed for some years after forestry operations and the effect seemed to be long-lasting.

In 2000 we started a new study to find out what is the effect of forest regeneration and soil harrowing on the quality of groundwater in the Class I groundwater recharge area. The area, called Silkunharju esker, locates in eastern Finland and the soil is glacial deposit with a texture of gravel. The main tree species was pine (Pinus sylvestris L.). 70 % of the area (2.47 km^2) was cut in 2001 and we have monitored the groundwater quality, groundwater table level and climatic variables in the area. We will show the results from the Silkunharju study, which indicate that the effects of forest operations are small on groundwater quality and short lasting. We will also introduce the latest measurements from the VALU study where the influences are longer.

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Keynote:

The role of water for carbon sequestration and GHG emissions in boreal forests

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The accumulation of SOC (soil organic carbon) is the result of the dynamic balance between litter production and heterotrophic respiration, both of being strongly affected by water availability. Water effects on long-term SOC sequestration is evident from SOC content in soil types with different hydrological regimes. Hiederer (2009) reported for 0–100cm, based on an European data base: Histosols (73.9 kg C m^{-2}) > Podzols (11.5 kg Cm^{-2}) > Cambisols (3.3 kg Cm^{-2}) > Chernozem (3.0 kg Cm^{-2}) > Xerosols (1.7 kg Cm^{-2}). This range is caused by differences in groundwater level and precipitation , but also in land use. Water saturation such as in the Histosol allows photosynthesis and litter production but retards decomposition resulting in peat accumulation. Dry conditions such as in Xerosols gives a very low litter production. Hiederer (2009) also showed that the drier soils has a higher proportion of total SOC in the lower part of the profile. Reasons to this may be a higher proportion of below-ground biomass, and forest floor carbon at dryer conditions may be lost through fires. Olsson et al. (2009) reported, based on the Swedish Forest Soil Inventory, a higher content of SOC to the depth of 50cm in well-drained Podzols at sites with high groundwater level (ca. 1m) than at sites with low groundwater level (> 2m). This difference was exclusively due to difference s in SOC stock in the O-horizons. Possible explanations for the higher stocks at slightly moist sites are lower decomposition losses due to occasional water saturation, production of litter from the field layer is higher, and that the litter quality is different. However, there are no major differences in tree-biomass production between slightly moist and fresh sites, and, presumably, no difference in tree-litter production. The deviating pattern in the O-horizon versus the mineral soil may be caused by the distribution of root litter. Berggren Kleja et al. (2008) showed that 0–2 mm root biomass in the O-horizon is higher at moist sites than at fresh and dry sites, whereas the root biomass in the mineral soil lower at moist sites. Callesen et al (2003) determined SOC pools in Nordic forest soils for forest floor and mineral soil to a depth of 100cm as functions of mean annual temperature and precipitation. They concluded that SOC stores in forest floor and forest floor+mineral soil were positively correlated with precipitation. Based on their regressions, an increase in precipitation with 50% from 600 to 900mm at 5ºC would increase SOC stock with 75%. The short term SOC sequestration may deviate from the long term resulting in CO_2 sinks or sources. Data from the Swedish Forest Soil Inventory did not show any net emissions for well-drained soils. Peatland, on the other hand, has been shown to emit large quantities of CO_2, CH_4 and N_2O. Ojanen et al (2010) showed for drained boreal peatland that groundwater level affects CO_2 and CH_4 emissions, and hypothesised that soil nitrogen availability would correlate with N_2O flux.

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Drought-induced changes in Scots pine and Norway spruce stands estimated on the evidence to artificial drought experiments

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Drought-induced changes on tree condition, ground vegetation cover, chemical and biological soil parameters were comparatively estimated in Scots pine (*Pinus sylvestris* L., 60 years old) and Norway spruce (*Picea abies* (L.) Karst., 40 years old) stands where the artificial drought was proceeded by installing the roof constructions below forest canopies. The artificial drought experiments were held permanently in *Pinetum vaccinio-myrtillosum* site in 2003–2005 and in *Piceetum oxalidosum* site in 2003–2004.

Although the artificial drought experiments were kept 3 and 2 vegetation periods, respectively, in Scots pine and in Norway spruce stands, there were estimated drought-induced changes in both stands. The mean crown defoliation under the drought condition in Scots pine stands was by 6.3–17.5% higher as compared with that in the control. Though, the mean crown defoliation was not extensively increasing in Norway spruce stands under the drought and was only by 2.2–2.4% higher as compared with the control plots. Even though the crown defoliation in pine stands was high in drought plots, the increase in the litterfall mass was not well-defined over the experiment. Thus, in spruce stands the litterfall mass increased after the introducing the drought and remained by 1.5–2.0 times higher than in the control. However, under the drought conditions the tendencies in decreasing of the mean mass of tree fine-roots remained for both pine and spruce stands.

In Scots pine stand as well as in Norway spruce stand under the drought conditions the ground vegetation cover significantly decreased. Thus, under the drought condition over the 3 years vegetation period in pine stands the cover of the mosses and vascular plants have decreased, respectively, from 89.5% to 0.5% and from 41.5% to 0.7%. In spruce stands, naturally with low ground vegetation cover, under the drought conditions over the 2 years vegetation period decrease in the cover of the mosses and vascular plants was estimated, respectively, from 7.2% to 0.1% and from 1.5% to 0.0%.

The artificial drought influenced the changes in chemical and biological properties of O-layers and in some extent only in mineral soil of 0–2 cm deep layers in Scots pine and in Norway spruce stands. If to compare with the control plots the drought induced the increase in the contents of organic carbon in the O-layer and mineral soil of 0-2 cm deep layer in both sites, even though, these differences were statistically not significant. Thus, significantly increase of the contents of nitrogen (by 2–3 times in O-layer and mineral soil of 0–2 cm deep layer of the pine plantations, while, by 2 times only in O-layer of the spruce plantations) was estimated. Also, the significantly increase in the abundance of the ammonifiers and nitrifiers in organic soil (by 2 times in both sites) was found.

The impact of drought on young spruce trees stem circumference changes and sap flow rate

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In connection with the global climatic change, a considerable increase of the drought-induced damages over many regions of the world (IPCC Third Assessment Report 2000) is expected. Water stress limits the potential range of many species by affecting plant production potential and thus establishment and competitive success. The anticipated changes in climate, including changes in precipitation patterns in certain regions on the background of increasing temperatures and atmospheric demand for water, make it imperative to understand species responses to water stress. Considering the sensitivity of *Picea abies* [L.] Karst (Norway spruce) to soil water supply, and its ecological and economical importance in both natural and planted stands of Europe, it is not surprising that observations of *P. abies* stands showing clear signs of drought stress cause a wide concern.

The contribution is aimed at identification of potential drought stress of spruce stand (30 years old) during vegetation period 2009. The response of stem circumference changes and sap flow rate were investigated in diurnal courses and seasonal courses in relation to meteorological parameters (global radiation, air temperature, potential evapotranspiration and soil water potential). During the second half of vegetation period the decrease of soil water potential was observed and irrigation was applied in control group of spruce trees (6 samples), while second group of 6 samples was treated under natural soil drought. The atmospheric parameters were measured continually using digital meteorological station, stem circumference using digital dendrometer DRL 26 and sap flow rate using thermal heat balance method (EMS Brno, CZ).

The decreasing sap flow rate was observed in tree samples treated under mild drought stress during noon and afternoon period. Diurnal courses of transpiration rate in these trees are different from those one in irrigated trees showing the noon depression of transpiration which continues afternoon. During drought stress conditions the decrease of dependency to global radiation, water pressure deficit and potential evapotranspiration has occurred. Under stress the determining factor of transpiration is soil water content.

Model trees growing under water stress showed circumference changes characterized mainly by diurnal and inter-daily shrinkage and swelling, which reflected particularly irradiation, air water potential deficit, soil water potential and precipitation regime. On the other hand circumference changes of irrigated trees were characterized by diurnal shrinkage and swelling, but continuous inter-daily increase of circumference were observed. The strong impact of meteorological parameters and soil moisture on stem circumference changes during the diurnal and seasonal level was found.

Forest and permanent excess of water – peatland forestry

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About one third of land surface area in Finland is peatland, where ground vegetation is characterized by mire species, or where the thickness of the peat layer on the mineral soil is more than 30 cm. Traditionally, peatlands have been considered as wastelands with inferior utilisation value, because they are not suitable for agricultural or forest production as such. The main problem that restricts plant production in peatlands is the excess water in rooting zone. When water content in soil is near saturation, soil water blocks the flux of atmospheric oxygen to the roots, and carbon dioxide flux from the root zone to the atmosphere. As a rule of thumb, excess water restricts gas transfer if air filled porosity is less than 10 % of volume. Growth conditions in peatlands can be improved by draining the rooting zone. In forestry, drainage is conducted using open ditch network with 60–100 cm depth and 30–60 m spacing.

In peatlands the excess water in the rooting zone is a result of climatic and soil related factors. In boreal zone the annual rainfall typically exceeds evapotranspiration and hence the drainage is an important component of water balance. Draining water accumulates to depressions in the topography promoting formation of peat, whose physical characteristics support retention of water in the soil. Peat profile typically consists of low-humified top layer and a well humified bottom peat layer, underlain by mineral soil. Both low-humified and well-humified peat materials have a high porosity, but saturated hydraulic conductivity in well-humified layer is several orders of magnitude lower than that in low-humified peat. Because of the low hydraulic conductivity, well-humified peat material typically remains wet throughout the growing season keeping the air filled porosity in the soil too low to support forest growth.

Ditching changes the physical conditions in the rooting zone which in peat soils typically extends ca. 10–20 cm below the surface. Water can be removed from the low-humified layer easily by ditch drainage, but the impact of the drainage on the humified layers is much smaller. Hydrologically the success of the drainage operations depends on the depth and spacing of the ditches, and on the depth of the permeable peat layer at the surface. During growing season, transpiring vegetation extracts the water from the rooting zone and air filled porosity increases accordingly. When transpiration and evaporation are strong, also the water content in well-humified layers may decrease. From the drainage viewpoint, it is crucial whether the excess water restrict s transpiration, which occurs in saturated soils. Field experiments have shown that if the volume of the growing stock exceeds 100 –150 m^3 ha^{-1}, the evapotranspiration can be more important for the results of drainage operations than the ditch flow.

About half of the peatland area in Finland has been ditched to enhance forest growth. In this respect, the ditching campaign has been a very successful: it has increased the annual forest growth in national scale by ca. 15 millions of cubic meters, while the total growth is presently ca. 100 millions of cubic meters. The length of forest ditches – ca. 1 300 000 km – reveals the scale of the Finnish ditching operation: the total length of natural rivers isonly 53 000 km. The large scale alteration of peatland hydrology has, however, caused several drawbacks including deterioration of water quality in the recipient water courses. Ditching and ditch network maintenance increase especially export load of suspended sediments and organic matter. Wood harvesting and water protection are the future challenges of peatland forestry in Finland.

Use of natural and restored peatland buffers to reduce sediment and nutrient transport from forested catchments – Finnish experiences

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Sediment and nutrient losses from forested catchments are typically low, but can increase especially in drained peatland-dominated catchments when forests are harvested or fertilized, or when the ditch networks are maintained. To prevent the increased sediment and nutrient transport to reach recipient water courses, use of sedimentation ponds was a subject of active research in the 1990s. Ponds were shown to efficiently remove coarse-textured sediment particles from discharge waters, but their effect on fine-textured materials, light organic particles and soluble nutrients was negligible. It is presently recommended that nutrient-rich drainage waters from forested catchments are conveyed to receiving surface waters through either natural or restored peatland buffer areas.

Buffer wetlands in operational peatland forestry are usually created by simply conducting discharge waters from drained peatlands to pristine mires or, occasionally, also to paludified mineral soils. However, because most peatlands in Finland have been drained for forestry, buffer wetlands are very often created by restoring and rewetting sections of drained peatlands by filling in or blocking the main drainage ditches. Buffer area size may vary considerably but rarely exceeds 1.0-1.5 hectares. If only productive forestry land is available for the construction of the buffer small areas are preferred.

The studies have indicated efficient sediment and nutrient removal, especially by large buffer areas (>1% of catchment area) and under low hydrological loading. Thus, the reduction of sediment and nutrient transport is likely governed by how much the water flow is slowed down in the buffer area to allow the sediments to settle down among ground vegetation and surface soil, and also to enable sufficient contact time between nutrient-rich through-flow waters and the vegetative and soil sinks of nutrients. In smaller buffer areas the formation of flow channels especially during the high flow episodes significantly decreases their retention capacity. A study with ^{32}P indicated that the effectiveness of buffer areas in retaining increased P loading may not be satisfactory during spring snow-melt period, when sparse vegetation restricts biological P accumulation and high flows reduce the capacity of deeper soil layers to retain P.

Although large peatland buffers are an efficient water protection method, a negative impact may be involved that the restoration and rewetting of drained peatlands for use as buffers initially increases the export of soluble nutrients, especially phosphorus. This is particularly true if a significant proportion of P under drained conditions was adsorped by iron hydroxides or oxides as this P is easily released upon water table rising and consequent redistribution and reduction of iron. Tree harvesting from buffer areas during construction operations and leaving cutting residues on site are also likely to increase P export. However, it should be noted that the buffer areas that initially release phosphorus during and after their restoration later can function as significant and sustainable P sinks.

Methane gas fluxes from the buffer areas constructed on undrained, pristine mires may be high, but revitalization of methane emissions after restoration may be a slow process, since the emissions from >10-year-old restored buffer areas were still low. Methanotroph communities between pristine and restored sites were nearly identical, indicating that peatland methanotrophs tolerate drainage well and/or recover rapidly after restoration. The low methane fluxes observed on restored peatlands may result from the poor establishment of methanogens. N_2O fluxes are low from both natural and restored buffers, but may increase after high N loading.

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Session 2

Water fluxes at different scales

Chair: **Patrick Schleppi, WSL, Switzerland**

Significance of tree roots to preferential flow in soil horizons with different degrees of hydromorphy

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The assumption that forests reduce discharge is in circulation for almost two centuries. Today we think that forest soils contain pores with higher hydrological efficiency when compared with soils carrying other types of vegetation. Tree roots are important factors for the generation and conservation of pores, also in deeper hydromorphic horizons. In this project we explored the influence of the root length distribution on preferential flow in soils with stagnic properties.

The study site is located in the Flysch region 30 km south of Bern (Switzerland) at an altitude of 1000 m. Soils were characterized by stagnic and gleyic properties. The experimental set up consisted of a 1 m x 1 m sprinkler device and TDR probes that were horizontally mounted from a trench into the centre of each horizon. Each plot was irrigated three times within a 24-hour interval with a volume flux density of 70 mm/h to obtain dates of varying initial soil moisture. After the sprinkling, soil cores (10 cm diameter) were sampled. The roots were extracted from the soil and digitally analysed with the program "winRHIZO".

The application of a rivulet approach to the water content data of the irrigations resulted in the contact length, L ($m\ m^{-2}$), per cross-sectional area and the film thickness, F (µm), between mobile water and soil. The volumetric water content, and therefore the amplitude of the infiltration, is given by the product of L and F. Our results indicated that, at high initial soil moisture, the contact length L was significantly positively correlated to the root length per soil volume ($R^2 = 0.71$) and the film thicknesses decreased with increasing root length, but this correlation was less pronounced ($R^2 = 0.25$).

To prove the hypotheses that the significance of tree roots to infiltrability is dependent on the degree of the horizon's hydromorphy, we grouped the investigated horizons according to the frequency of hydromorphic features. At high initial soil water content (third irrigation), the infiltration was positively affected by roots in topsoil layers and hydromorphic horizons. Cambic horizons did not benefit from the pore system created by the roots, since swelling clay particles had possibly decreased porosity which was effectively involved in infiltration.

FOREST stony soil: The contribution of rock fragments to soil water retention

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The water retention capacity of coarse rock fragments in forest soils are usually considered negligible. But the presence of rock fragments in a soil can play an important role in both water holding capacity and in hydraulic conductivity as well. Presence od stones in forest soils in hilly areas is frequent.

Rock fragments can hold water and act as an accumulation storage (source) during water movement in soil. There is a lot of studies devoted to the hydrophysical parameters of a fine fraction of soil, but a few only, are focused to study the influence of rock fragments on hydrophysical properties of stony soils.

The origin of the rock fragments has significant influence on the soil water holding capacity. Flint and Childs, (1984) measured the maximum contribution of rock fragments retention of available soil water for plants from 40 soil locations in southwest Oregon. They found their average contribution to the total available water as 0.15 volumetric water content, ranging from 0.016 to 0.52. This retention range is the result of the differences in quality of the above mentioned rock particles.

Rock fragments are changing their water content with changing water potential (as any other porou medium), the relationships between rock water content and rock water potential (retention curve) can be determined. The retention of water in this media can contribute to the available stony soil water capacity.

Soils containing rock fragments are strongly influencing even their hydrodynamic characteristics, quantitatively expressed by the soil hydraulic conductivities. The presence of rock fragments usually decrease hydraulic conductivity of soil saturated with water, but in some cases (existence of lacunar pores), it can increase saturated hydraulic conductivity of such soils .

This paper presents results of maximum water holding capacity (stone water content saturated with water) measured in coarse rock fragments in the soil classified as cobbly sandy loam sampled at High Tatra mountains. It is shown, that those coarse rock (granite) fragments have the maximum retention capacity up to 0.16 volumetric water content (see Fig.1). Retention curves of the four particular granite fragments have shown water capacity available for plants expressed in units of volumetric water content of 0.005 to 0.072 in the soil water potential range (0, 0.3 MPa). It can be shown, that stones water retention can be significant and available water capacity of stone fragments can contribute to the available water capacity of soil fine earth considerably and help plants to survive during dry spells (Novák, Šurda, 2010).

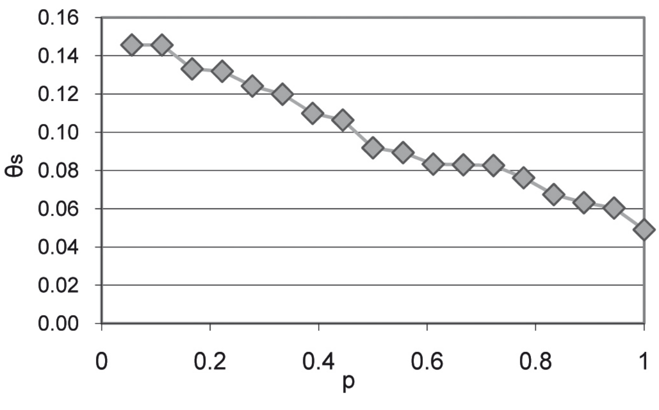

Fig. 1. Probability exceedance curve of saturated stones water content (θ_s) at site FIRE, High Tatras.

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Development of a physics-based, dual-permeability model for subsurface stormflow and solute transport in a forested hillslope

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Preferential flowpaths related to the soil structure have a decisive influence on subsurface flow and transport processes in forest soils in the boreal region. The pore space of the soil matrix functions mainly as a storage, whereas the macropore network constitutes preferential flow routes for water, enabling the generation of fast subsurface stormflow. Detailed, physics-based modelling provides a means to investigate the subsurface flow and transport processes in hillslopes that constitute the basic landscape elements of catchments (Troch et al. 2003). Traditional models that consider the soil pore space as one domain cannot, however, capture the non-linear flow pattern of heterogeneous forest soils. A separate, but parallel and coupled simulation of flow in the soil matrix and in the preferential flowpaths is suggested as a solution to the problem (e.g. Gerke and van Genuchten 1993). In the so-called dual-permeability models, the two pore domains are connected by a transfer term that delivers water and solutes between the domains. While several studies advocate the use of the dual-permeability models (e.g. Ray et al. 2004, Jansson 2005), applications of detailed, three-dimensional, Richard's equation -based, dual-permeability flow and solute transport models are not available for forested hillslopes. The main objective of this study was to produce a dataset that supports the development, parameterisation and testing of a dual-permeability model for simulating fast subsurface flow and conservative solute transport in a forested hillslope in Finland.

The collected dataset consists of soil analyses, field measurements and tracer experiments. Combined with inverse modelling, the dataset provide the basis for the model parameterisation. Water levels and tracer concentrations recorded at the tracer experiment provide data for simulating subsurface stormflow and solute transport. In the tracer experiment, intensive irrigation rates were applied to initiate fast lateral, preferential flow along the study slope. Chloride as a conservative tracer produced a direct indication of subsurface stormflow. When simulating the downslope travelling chloride plume first with a traditional, one pore domain model version, a correspondence between the observed and simulated flow velocity was only reached when the transport of water and solute was restricted to an effective fraction of the total pore space in the model. However, as a simplification of the dual domain model, the one pore domain model was not able to reproduce the observed strengthening and dilution of the chloride concentration with any parameterisation, since the exchange of water and solute between the pore domains was not included in the model. The parallel and coupled simulation of the matrix and the preferential flow domains was found to be essential in capturing the observed, dynamic changes in the moisture conditions, flow velocities and chloride concentrations during the initiation, steady-state and recession stages of the studied stormflow event.

A dual-permeability model was concluded to be suitable for describing subsurface stormflow and conservative transport in the study slope. Parameterisation of the model was however challenging since the soil matrix and the preferential flow routes need to be parameterised separately. In addition, as many parameters as possible need to be *a priori* fixed in order to reduce problems with equifinality and model identifiability. Parameterisation of the soil matrix was fixed based on the fact that fast subsurface stormflow is related to the preferential flow routes and is not sensitive to the slow matrix processes. For the same reason, only the water retention properties could be *a priori* fixed in the preferential flow domain. With respect to capturing the dynamics of the tracer plume, the model was sensitive to the remaining parameters, which include the saturated hydraulic conductivity of the preferential flow domain, the fractioning of the total porosity to soil matrix and preferential routes, and the exchange coefficient between the two pore domains. Identification of these parameters was based on the computational estimates of field-scale hydraulic conductivities and the tracer data along the slope. A further development and testing of the dual-permeability model calls for field data in dry conditions and advances in the measurement and parameterisation of the water retention properties.

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GIS analysis of peatland topo-hydrological features

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Currently, there are two main *Directives* which are regulating management of wetlands, including peatlands, in Europe – *Natura 2000* and *Guidance document n^o^.12* to the *Water Framework Directive* (WFD), i.e. "*The role of wetlands in the Water Framework Directive*".

During the last century mires have been declined in all bio-geographic regions of EU; Atlantic, Continental and Alpine regions, Boreal, Mediterranean and Macaronesian regions. From conservation point of view, afforestation is a major problem for mires, in particular for blanket and raised bogs, and aapa mires (Raeymaekers, 1998). In Boreal region (i.e. Estonia, Finland, Latvia, Lithuania and Sweden), which covers 18.8% of EU (Sundseth, 2009), fens were selected for woodland because of their better nutrient conditions and at these sites, forestry was successful. Later, afforestation of ombrotrophic mires took place, but because of the poor and acidic conditions, this didn't give the expected timber yields because of slow growth rate, poor timber quality and high harvesting costs (Raeymaekers, 1998). However, because of the ditches dug into the mire peat body, diverted or canalized streams and rivers to drain the mires, and "improved" mire surroundings to suit new functions (agriculture, forestry or urbanization) (*Ibid*), fragmented and often with intensive tree growth (Lode, 2005) mire landscapes were created; fragmented hydrologically, with differently lowered groundwater tables, and fragmented topologically, with artificially and mosaic changed surface heights (Lode et al., 2010).

Water is essential for all mire habitats. Therefore providing the mire with enough water with right quality is thus the first and foremost emergency action for conservation and restoration of mire complexes. Since Boreal mires often are integrated landscape complexes of bogs, transitional mires and fens, conservation and restoration can be successful only if the habitats, which share a common hydrological system with the mire biotopes, are included in management objectives (Raeymaekers, 1998). Hereby, the topographic features are important descriptors for water supply conditions of wetland or habitat (Wheeler et al., 2009).

The accurate digital nature, visualised usually via DEMs (digital elevation models), is the primary advance of the LiDAR (Laser Imaging Detection And Ranging) data for modelling of important *surface* and *hydrological* features of disturbed or managed mire landscapes. Although, according to our study, modelling of mire basins are resolution and algorithm sensitive, the LiDAR based DEMs are powerful tools for creation and visualisation of different (eco)hydrological scenarios for different mire landscape units, e.g. mire ecotopes or mire complexes.

Presentation will focus on following items: 1) Statistics of changed mire extensions in EU, and changes caused by forestry, 2) Soil-based re-identification of natural mire extension in its transformed conditions (examples from two Swedish and Estonian mires, statistics of their surface cover), 3) Presentation of LiDAR data based 3D modelling results of two Estonian mires – e.g. surface, water basin and tree coverage features, 4) Important outlets of 3D modelling of mire landscapes.

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Session 3

Hydrological fluxes in different climatic conditions

Chair: **Viliam Pichler, Slovak Academy of Sciences, Bratislava, Slovakia**

Forest – Water Interactions: A Reply to the Water Yield Debate

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Five major articles published in the past decade have all concluded that the impact of re- or af-forestation on water yield is negative: planting additional forests will reduce downstream water availability. Likewise, removing forests will result in higher downstream water availability. Even without climate change, such findings have powerful land use implications. In a period of increasing global warming, climate change and changing precipitation patterns, the implications are even more far-reaching—in increasingly *water-constrained* regions, re-, af-forestation and other land use strategies must be carefully considered. A second group of authors continue to argue that the opposite is true: planting additional forests should ultimately raise downstream water availability and improve the hydrologic cycle. Supporting evidence however has eluded these authors. We provide theoretical *and empirical* support for both sides of this debate, with the balance of the argument leaning in favor of the second set of authors. Forest cover is intimately and naturally linked to precipitation. Increasing forest cover has the effect of raising the likelihood of precipitation events and ultimately water yield. These two strands of the forest-water interaction literature argue (and measure) past each other because they fail to adequately understand and experimentally operationalize the problem of scale. We resolve this methodological and theoretical dilemma and illustrate the generally positive relationship between forest cover and water yield.

Carbon and nitrogen pathways from boreal headwater catchments downstream to the coast along variable land use cover

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Organic matter transported by streams and rivers from headwater catchments downstream to the coast is affected by processes in the river and by changing land use along the river basin. Hence, the concentrations of total organic nitrogen (TON) and total organic carbon (TOC) show significant variability during the riverine transport from first order catchments to the coast. The TON and TOC concentrations were studied in 42 unmanaged and 21 managed first order catchments covered by forests and peatlands with an area ranging from 0.07 to 56 km^2 and in 36 river catchments and their sub-catchments with mixed land use and an area of 73 to 56 500 km^2.

In small pristine headwater catchments, the proportion of organic nitrogen of the total N load was very high, on average 91% (Mattsson et al 2003, Kortelainen et al. 2006). In headwater catchments where forestry practices have annually affected about 2.4 % of the catchment area, comparable to average values in Finland, the proportion of organic nitrogen was somewhat smaller, on average 77% (Kortelainen et al. 1997). Downstream in the river basins, the proportion of organic nitrogen decreased and in the river mouths the proportion was 53% (Mattsson et al. 2005). Although the proportion of organic nitrogen decreased from headwaters downstream, TON concentrations increased from on average of 340 $\mu g\ l^{-1}$ in first order streams through 400 $\mu g\ l^{-1}$ in river sub-catchments to 550 $\mu g\ l^{-1}$ in river mouths. On the contrary, TOC concentration was on average highest in headwater streams (17 $mg\ l^{-1}$), whereas in river mouths, the average TOC concentration was lower (13 $mg\ l^{-1}$). These results indicate that land use gradient from headwaters to lowlands affects TON and TOC concentrations and has significant effect on the stoichiometry of our study rivers.

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Stable isotopes studies to increase knowledge from the role of peatlands in catchment hydrology

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After 1960 intensive draining of peatlands, hydrology in the catchment scale has drastically changed and decreased water storage capacity of uplands in Finland. This has inflicted on higher and narrower peaks, and decreased low flow in runoffs, which is followed by poorer ecological conditions for salmonid migrants and river pearl mussel. Nowadays, restoration operations have been initiated at large areas with poor forest growth aim to restore flow and ecological conditions. Runoff detention would also benefit hydroelectric power plants downstream locations. Potential locations for restoration have been studied by the Metsähallitus in the Iijoki catchment area located in the Northern Finland.

Two study sites have been chosen to study effects of peatland restoration on hydrology in the catchment scale. One peatland (Marjasuo) has been drained for forestry in around 1960, but the other is still a pristine peatland (Ryövänsuo) locating in the National park of Isosyöte. Both peatlands have their separate local catchment areas but are located at the same bigger catchment area and area part of the Iijoki catchment. Monitoring campaign in both areas includes automatic discharge, groundwater and precipitation measured continuously. Nutrient concentrations (nitrogen, phosphorus, suspended solids) of outflows and groundwater have been analysed once a month. Furthermore, vegetation and tree growth are monitored. The drained peatland are going to restore in the summer 2011.

Generally, stable isotopes are used as a tracer in studies of catchment hydrology (Kendall & MacDonnell, 1998). The method is also successfully adapted to peatlands in smaller scale (Ronkanen & Kløve, 2007 and 2008). A properly designed survey of stable isotope composition of water within a given catchment area should yield important information concerning the spatial heterogeneity of isotopic composition of water in this system, which can be linked to the structure of water flow, residence times and preferential flow paths. In order to study, how large peatland areas should be rewetted for sufficient water storage, impacts of restoration are going to study. Objective of the study is to use the stable isotope ratio $^{18}O/^{16}O$ to find out the effect of peatland restoration on catchment hydrology. Artificial tracer tests and the stable isotope ratio $^{18}O/^{16}O$ will be used to investigate the changes in flow paths and water balance in the area.

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Runoff generation across spatial and temporal scales following wildfire

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Through their effects on soil properties as well as on vegetation and litter cover, wildfires can lead to considerable changes in geomorphologic and hydrological processes. Previous studies in various parts of the world, including Portugal, have revealed strong and sometimes extreme responses in runoff generation and associated soil losses following wildfire, especially during the earlier stages of the so-called “window-of-disturbance”. Besides wildfire itself, also post-fire forestry practices can strongly influence overland flow and erosion in recently burned areas.

Following the catastrophic summer fire season of 2003, in which more than 400.000 ha of Portuguese forests and woodlands were burned, the EROSFIRE projects set out to address the need for a model-based tool for: (i) assessing soil erosion hazard following forest fires in Portugal; (ii) for predicting the effectiveness of selected erosion mitigation measures. To this end, the suitability of various existing erosion models is being compared. Whilst the (semi-)empirical models USLE and MMF are included in this comparison, the physically-based MEFIDIS model has been the focus of data collection efforts.

Data gathering for initial parameterization of MEFIDIS and its subsequent calibration and assessment involved as principal methods: (i) field rainfall simulation experiments (RSE’s); (ii) runoff/erosion plots, both bounded micro-plots (< $1m^2$) and unbounded slope-scale plots; (iii) catchment gauging station; (iv) regular monitoring of soil properties like ground cover, moisture content and water repellency. In the EROSFIRE-I project (POCI/AGR/60354/2004), six slopes covered by eucalypt plantations were intensively studied during the first one or two years following wildfire using a combination of RSE’s, plots and monitoring. In the follow-up project EROSFIRE-II (PTDC/AGR-CFL/70968/2006), continuous recordings of water level and turbidity at the outlet of an entirely burned micro-catchment are being combined with plot measurements at five nearby slopes covered by pine or eucalypt stands and the monitoring of selected soil properties at four pine and eucalypt slopes.

Analysis of the collected data is still ongoing and model assessment, in particular of MEFIDIS, has by and large been limited to some preliminary efforts. Therefore, a presentation is proposed that will focus on the following two aspects: (i) changes in overland flow generation with time-since-fire at the micro-plot scale; (ii) differences in overland flow generation at the micro-plot versus slope-scale.

Poster presentations

New methods to control acid sulfate and organic acid leaching from peatland forestry drainage areas

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Acid sulfate soils are common in the river drainage basins of the Gulf of Bothnia area (e.g. River Sanginjoki). Intensive peatland drainage, among other factors, has increased acid sulfate leaching from these soils under the peat layers. Temporal low pH values (< 4) can appear during flood peaks particularly after dry seasons when soil sulfites have been oxidized. Flooding can also increase leaching of organic acids from forested and peatland dominated areas to the river, causing lowered pH values in the river water. These low pH pulses are harmful to stream biota and may decimate e.g. fish populations.

In order to be able to control and decrease the emergence of these low pH values different management methods are tested and studied in the River Sanginjoki basin: Controlled outflow, which slows down the sudden formation of acid peaks in the streams and can also be supposed to prevent their formation by increasing the buffering capacity of the runoff water. Also the effect of limestone weirs at drainage ditches and streams during different hydrological periods is tested in the project with encouraging preliminary results. The project includes also studies on the runoff water acidity decreasing effect of grained ash in a ditched, nitrogen-lacking peatland forest.

Localizing of the acidity deposits in the river basin is done with the existing GIS and other geologic soil data and by water quality monitoring. These measures are indicating also whether acidity is sulfate soils or organic acid originated. The project has over 20 continuous and 40 monthly pH-measuring points all over the river channel network. They are completed by bi-weekly water sampling from 16 locations.

The project "City and Water – Ecological enhancement and improvement of recreational value of river Sanginjoki" is a cooperation project of University of Oulu, SYKE and Centre for Economic Development, Transport and the Environment for North Ostrobothnia. It is financed by the European Regional Development Fund (ERDF), municipalities of Oulu, Muhos and Utajärvi, Turveruukki Oy, Oulu Golf club and local fishery collectives of the River Sanginjoki area.

Participation of aquatic fungi in litter decomposition in Lithuanian woodland streams

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About 30 % of the Lithuanian territory is covered by forests of various types and up to 1,5 % is occupied by running and stagnant freshwater basins. Submerged litter of riparian vegetation is an important habitat and food source for many aquatic organisms, including fungi. Aquatic fungi are the major decomposers of such submerged substrates; they produce various enzymes degrading cellulose, hemicellulose, lignin, starch and pectin into usable intermediate compounds. In temperate streams located in forested areas of Lithuania with riparian vegetation characterized by a rich species composition (*Alnus, Acer, Betula, Corylus, Quercus*, *Salix, Tilia, Ulmus* and other) the fungal communities reach a maximum peak in overall metabolic activity and species richness in autumn (October-November). After autumn fall, some terrestrial fungi species also may be introduced to streams and lakes from terrestrial litter or phylloplane. The main aim was to study fungal diversity of various taxonomical groups occurring on different submerged substrates (leaves, wood and needles) in the two different woodland streams. Our study indicates that substantial differences exist in species richness and composition of fungal communities established on a particular substrate. We established that aquatic hyphomycetes are the most frequent early decomposers of submerged forest leaf litter in investigated streams. Majority of the fungus species found on wood were aero-aquatic and terrestrial hyphomycetes, which have a slower growth rate and lower density. The results also suggested that diversity and structure of fungal communities depend on diversity of riparian vegetation bordering the streams, seasonal temperature changes and fresh input of litter fall into a stream.

Hydrological and protective services of forests – modelling on watershed level

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The water and soil regime in this research is dealt at the level of forestry needs and knowledge, from the aspect of both water discharge and erosion, with an emphasis on considering the natural capacity and practical employability of the selected model. Model was developed for the purpose of evaluation and allocation of forest areas with hydrological and protective services. Within the framework of this research, the two effects of the forest have been merged, owing to their close relationship and comparable forest management measures for their consolidation. The model was tested in the alpine watershed and in lowland watershed on alluvial plain. First is characterized by a substantial proportion of forestland (83%) and rather low proportions of other types of land, second has only 42% of forest cover. Both lie on sensible, porous and erodible limestone parent material.

The development of the decision support GIS model required first to determine the demands and contemporary the capacity of forest sites for providing hydrological and protective services. We aimed to underline the significance of a suitable stand structure, canopy cover and suitability of tree species for optimal water cycle in the forest ecosystems.

Demands are expressed by external-ecological factors (terrain slope and forest soil types, distinguished by their erodibility and water permeability). A forest's capacity to assure hydrological and protective services is expressed by internal-forest stand factors (stand structure, stand density, degree of stand naturalness). The model was designed to confront the external factors (which in view of their natural features dictate the manner of management) with the stand factors (upon which one can exert certain influence and reach the desired result). Although the basic factors are integrated into several steps, the impacts of separate factors are still visible in the overall results. These characteristics were decisive in the selection of this model, considering that the multicriteria evaluation methods would not have provided for it to such a great extent. In the latter, the impact of a separate factor on the overall result is not clearly visible, owing to the intermediate standardisation and subsequent classification (Ferreira 2000).

The joint map of the demands and the needs represented a good basis for determining the most suitable silvicultural actions. We took into account the natural conditions and assist in the process of shaping and directing silvicultural actions in areas where they are most needed. In the prepared model we emphasized critical areas (16% in managed forests, 33% in protection forests). We can maintain, in compliance with needs, existing conditions, or enhance the capacity of a forest to carry out its hydrological and protective service.

The idea of multifunctionality in Slovenia's forestry practice lacks guided measures for the preservation and promotion of the forests' certain service. This can provide an equivalent management in the entire region, in spite of the different local needs for the functions and services of forests.

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Stream ecohydrologic surveys to evaluate the impacts of watershed land use

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Urban and peri-urban watersheds are affected from human activities and streams draining them are modified in most cases. Therefore, it may be possible to connect stream properties with land use. Streams draining forestlands generally posses functional riparian corridors while the ones passing through settlement areas are less healthy.

This study was carried out in Balaban and Kilyos watersheds in Istanbul. The objective was to estimate land use impacts based on the results of stream surveys performed on 2 main streams.

Physographic factors were determined and evaluated by using ArcGIS program and watersheds were evaluated with spatial data collected from orthophotos. Stream surveys were performed according to a procedure developed at the department of watershed management.

Nine sampling points were selected along the main stream within different land uses. Physical and chemical analyses were done on water samples that were collected from the sampling points. Water quality data were also revealed and compared. For example, Balabandere creek was better in water quality (use and ecologic water quality) than Kilyos creek. But on the other hand the last sampling point of Balabandere creek was poor with its stream habitat because of channelization.

Litterfall Production in Forests located at the Pre-delta Area of the Paraná River (Argentina)

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The objectives of this study were to measure litterfall production of the four floodplain forest types and to analyze the relationship between litterfall (forest type, dominant species, and organic fractions) and flood pulses.

Litterfall production was measured in two mono-specific stands of Salix humboldtiana or Tessaria integrifolia, respectively, and two mixed forests dominated by A. inundata or Nectandra angustifolia, during 1998 and the 2000–2002 periods.

Mono-specific stands presented similar productivities (6.8 and 6.5 Mg dry matter ha−1 y−1, respectively), but differed significantly from the two other. The highest litterfall production was obtained during the large flood that occurred during 1998, decreasing later throughout the study period. Leaves were the dominant fraction of litterfall, followed by branches, flowers, and fruits. Only S. humboldtiana, T. integrifolia and A. inundata forests showed distinct patterns of litterfall production, depending on the flooding pulse. N. angustifolia did not show a distinctive litterfall pattern.

The forests studied here presented patterns of litter production associated with the flood pulse according to its location along a topographic gradient that controls the litter productivity of these forests.

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Ethylene and ABA responses to water stress in young Poplar

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Water stress induces various biochemical and physiological responses which are mostly mediated by hormones. ABA is a major component of plant's long-distance signaling system, which plays an important role in the regulation of stomatal behavior and in preventing the development of the physiological effects associated with severe water deficits. It has been recently shown that stomatal sensitivity to ABA is reduced by ethylene synthesis in leaves. This in turn may affect plant response to water stress. We conducted a number of independent experiments using plant-growth-promoting rhizobacteria to improve water use efficiency and tolerance against drought. These rhizobacteria produce an enzyme, 1-aminocyclopropane-1-carboxylate (ACC)-deaminase, that hydrolyzes roots' ACC (an immediate precursor of ethylene) to ammonia and α-ketobutyrate decreasing ethylene production in roots as well as ACC translocation from root to shoot where it is then converted to ethylene gas by ACC oxidase. This results is the promotion of root growth (i.e. better root length, weight and root surface area) and, in turn, in improved drought tolerance. The purpose of this paper is to review how water stress can influence the physiology of carbon exchange by leaves, specifically focussing on the the impact of these novel bioinoculants on physiological processes, i.e. synthesis of leaf ethylene, stress-induced ABA and stomata opening regulation.

Upscaling water and carbon fluxes from leaf to canopy: role of stomatal control models

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At leaf scale, the aggregated behavior of stomata to microclimatic variations is rather well-behaved inviting the interpretation of stomatal conductance (g_s) in the context of a big 'stoma' with an effective aperture (Mott and Peak, 2007). Response of g_s to environmental stimuli is described by several models that can be divided into two broad classes: The first describes g_s as an empirical response to changes in radiation, atmospheric vapor pressure deficit, air temperature, leaf water potential, and the rate of leaf carbon assimilation (Jarvis, 1976; Ball et al., 1987) and are routinely used in climate models. The second approach is based on '*economics of gas exchange*' and assumes that the stomata operate to autonomously maximize the carbon gains while minimizing water losses (e.g. Cowan and Farquhar, 1977; see Katul et al., 2009 for a review). How various leaf-scale stomatal formulations influence up-scaled canopy fluxes of H_2O and CO_2 and scalar profiles was studied (Launiainen et al., 2010). Two versions of the widely used semi-empirical Ball-Berry –model and two modifications of the optimality hypothesis for g_s of autonomous leaves were parameterized against shoot-scale data measured in a Scots pine forest at the SMEAR II-station in Hyytiälä, Southern Finland in summer 2006. The g_s models were then combined with a leaf-scale photosynthesis model (Farquhar et al, 1981), a layer-resolving light attenuation model, and a turbulent closure scheme for scalar fluxes within the canopy air space. These multi-layer model (MLM) predictions of water vapor and CO_2 exchange were compared against eddy-covariance (EC) fluxes within and above the canopy and against measured scalar concentration profiles hence retaining full scale-independency.

The MLM results showed that g_s schemes, although parameterized against same shoot gas-exchange data, can alone have about ~15% influence on canopy scale CO_2 and ~30% influence on water fluxes. Concurrently, the vertical source/sink profiles indicated that the contribution of a single layer to the upscaled fluxes differs somewhat among models but the scalar concentration profiles are only marginally affected. The comparison to EC fluxes showed that all four versions of MLM predicted the measured net carbon exchange to within 15% and latent heat fluxes to within 25% accuracy. The optimality model based on a linearized photosynthetic demand function predicted significantly larger CO_2 uptake and transpiration than the other models while original Ball-Berry –model (Ball et al., 1987) gave the smallest fluxes. Moreover, within each g_s model, the CO_2 fluxes were insensitive to the model parameter variability but the transpiration rate estimates were notably more affected because of linear proportionality between g_s and transpiration when leaf is well coupled to the atmosphere.

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Carbon emissions from bogs along a human-impact gradient in Estonia

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Water-logged soil conditions are suitable for the growth of *Sphagnum* mosses, which act as ecosystem engineers by amplifying soil water holding capacity and ombrotorphy. By doing so, *Sphagnum* mosses create bog ecosystems with unique flora and fauna.

Being waterlogged ombrotrophic ecosystems, boreal bogs are important sinks of atmospheric carbon, which accumulates as peat. In the oldest Estonian bogs, the peat layer is more than 7 m thick. Two main human-induced factors may affect the peat accumulation in bog ecosystems. Firstly, drainage, widely used in forestry, lowers water level in bogs and initiates peat mineralization. Secondly, deposition of nutrients suppresses growth of *Sphagnum* mosses and enhances growth of vascular plants, which also may initiate soil mineralization.

In this study, we measured soil carbon (C) emissions in three bogs along the human-impact gradient. Human impact consists from peat mining, underground oil-shale mining, alkaline air pollution, and drainage. The most badly affected Kalina bog (affected by underground mining, drainage, and alkaline pollution), and moderately affected Selisoo bog (peat mining and drainage) were located in Northeast Estonia, while non-affected Selli bog was located in East Estonia (in Alam-Pedja Nature Reserve Area). In Kalina and Selli bog, we selected two sites, and in Selisoo bog we had four sites for measurements of C emissions. Carbon emissions were measured from April to December 2009 by applying soda-lime method. In each measurement site, seven chambers were installed (two control chambers and five measurements chambers). Carbon emissions were measured monthly on the same days in each site. The duration of measurements was 24 hours.

The average C emission of eight months ranged from 0.30 to 1.80 g C m^{-2} per day. However, the variation in C emissions within bogs was rather high, so the differences among bogs were not statistically significant (ANOVA, $F = 2.2$, $P = 0.051$). In most of the sites, the maximum C emission occurred in July, except in Selli bog, where both sites had maximum C emission in May. The highest within-site variation in C emissions was observed in Selisoo bog, in sites that were located in former peat mining area. The lowest variation in C emissions was in Selli bog. The maximum C emission in July correlated negatively with the soil water level measured in the same month. Carbon emissions from peat were positively related to the LAI of tree layer.

Our results indicate that although human impact may cause severe changes in the vegetation in bogs, the C emissions due to soil mineralization are rather variable within bogs. Thus, even in sites where human impact was very strong, the C emissions differed from other sites only at the height of vegetation period. The human impact tends to increase both the spatial and temporal variability of C emissions.

Influence of woodland on the modification of the albedo and water distributions in an insular environment. Case study on Tenerife, Canary Islands, Spain

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The island of Tenerife has a remarkable ecological diversity in spite of its small surface area, which is a consequence of the special environmental conditions on the island, where its distinct orography modifies the general climatic conditions at a local level, producing a significant variety of microclimates. The vegetation of Tenerife can be divided into zones that are directly related to altitude and the direction in which they face. The most important forest species of the island is the Canary Island pine el Canary Island pine (Pinus canariensis), it grows between levels 800–2000 m. This kind of pine is of vital importance to the Canary Islands in gathering water. It grows in the cloud forest belt, where rainfall is typically around 50 cm; under the trees, this increase to 200 cm with fog drip off the leaves. This twofold and a half increase in precipitation supplies the irrigation water essential for the Islands' economy.

There are three temporal stages in the history of the woodlands, on the Tenerife island , from 1496-1800, from 1800 to 1940 and from 1940 to present. The initial stage with 50,000 hectares of Pinus canariensis, characterized by massive destruction of forests to be transformed in agricultural crops, reduces the spread of pine forest in a half. The second stage is the period of greatest decline in the woodland, around 25,000 hectares, although at this stage, some recovery starts. In the last stage, began the restoration of forest cover, in 1940-1995, 15,352 hectares of the woodland have restored reaching of which 82% correspond to the Pinus canariensis. This has brought a great impact in two ways, first of them, change the *albedo* in midlands areas of the island (400–1,200 m), Who is defined as the ratio of total-reflective to incident electromagnetic radiation. It is a unitless measure indicative of a surface's or body's diffuse reflectivity. The other change noted is increasing clouds and horizontal rain, and this, will benefit the island water resources. This paper provides an explanation how the increase of forest in the midlands area (400–1200 m) there is a change in albedo as opposed to coastal areas (400 – sea level), without woodlands, and in the other hand change in rainfall pattern, which affects virtually the whole island.

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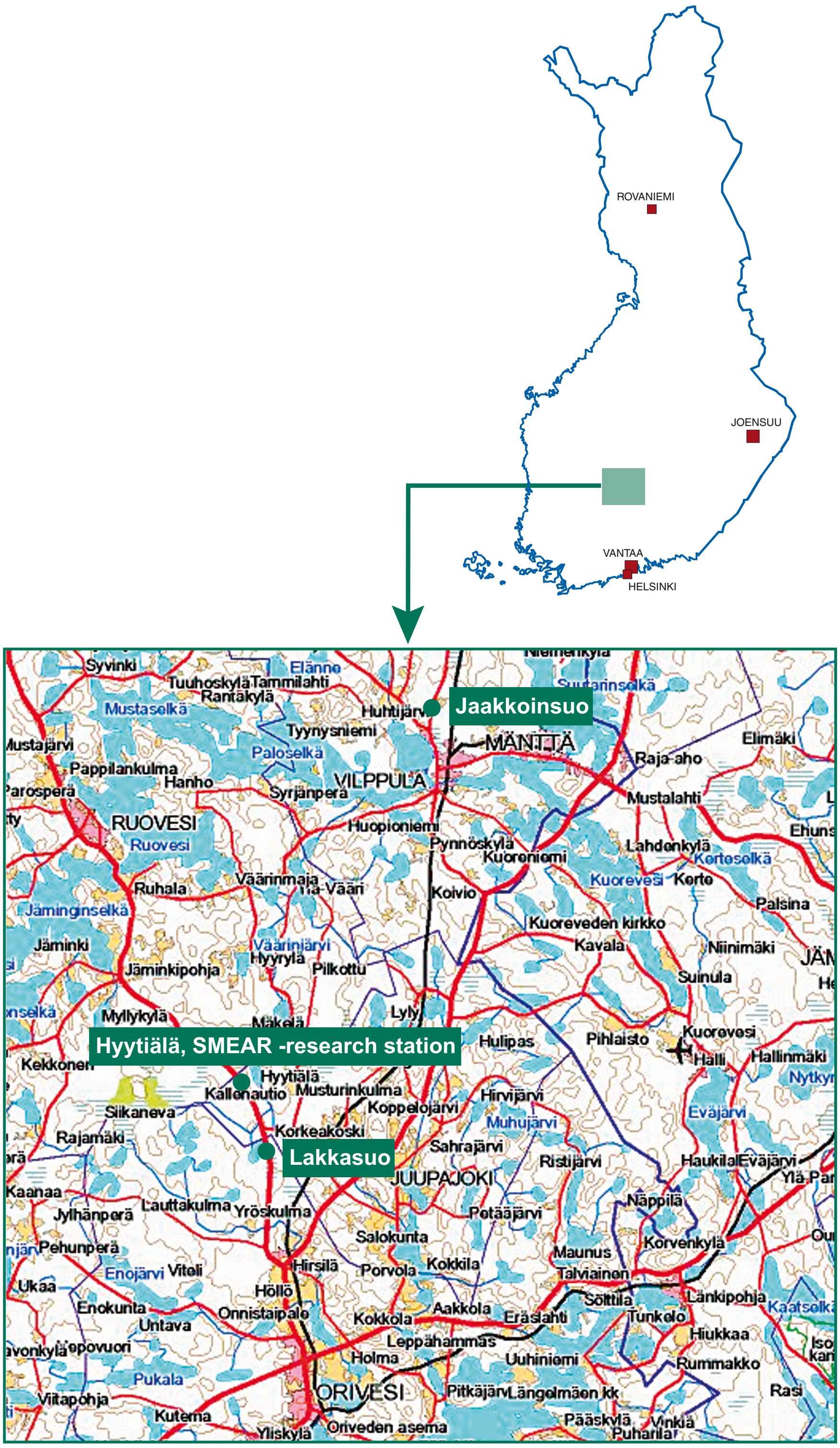
Scientific excursion, Wednesday 8th September 2010



EXCURSION SITE 1

SMEAR II – research station in Hyytiälä, Finland

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The SMEAR II (Station for Measuring Ecosystem – Atmosphere Relations, http://www.atm.helsinki.fi/SMEAR) station of University of Helsinki is located next to the Hyytiälä forest station in Juupajoki, southern Finland (61° 51'N, 24° 17'E, 181 m above sea level). SMEAR II was founded in 1995 in a relatively homogenous Scots pine stand (*Pinus sylvestris* L.), sown in 1962, and designed for continuous and comprehensive measurements of fluxes, storages and concentrations at forest –atmosphere continuum. The site is one of the most intensively studied in the boreal region and represents a boreal coniferous forest that covers about 8 % of the Earth's surface. The measurements at SMEAR II can be divided to four main components: 1) an instrumented 73 m tall mast for measuring ecosystem – atmosphere fluxes and basic meteorological parameters, 2) systems to monitor aerosols, their growth and properties, 3) instrumentation to monitor tree functions such and 4) two instrumented mini catchments to measure soil parameters and hydrology (Hari and Kulmala, 2005).

The atmospheric variables continuously monitored at several levels include wind speed, temperature, H_2O, CO_2, O_3, SO_2, NO and NO_2 and several volatile organic compounds. In addition the properties of solar and terrestrial radiation are measured above and below the canopy. The whole-ecosystem fluxes of momentum, heat and mass (CO_2, H_2O, O_3 and aerosol particles) are measured using micrometeorological eddy-covariance (EC) method above the canopy. The time EC flux time series measured at Hyytiälä date back to April 1996 and is thus one of the longest available. Since 2003, EC measurements have been conducted also in sub-canopy to separate the understory and overstory contribution on energy and carbon exchange. One of the main focuses of the research coalition lead by Prof. Markku Kulmala (University of Helsinki) is on aerosol dynamics, the formation and subsequent growth of fresh atmospheric aerosols in particular. Hence, the number of different aerosol measurements at SMEAR II is large and include aerosol and ion distributions, measures of composition of aerosol mass, dry deposition and wet scavenging. Tree processes and component fluxes are measured using chamber techniques. The processes receiving most attention include photosynthesis, respiration components, transpiration, NO_x emissions/deposition, O_3 deposition and emissions of volatile organic compounds. Also sap flow, trunk diameter change measurements and phenology are monitored continuously (Hari and Kulmala, 2008). The soil properties and processes such as temperature and moisture profiles and soil respiration are measured at several locations. At SMEAR II there is two mini catchments (900 and 300 m^2) close the measurement cottage which are closed with a dam and the runoff and leakage of substances are monitored continuously.

The measurements at SMEAR II hence offer an excellent possibility to study the variability and environmental responses of different processes taking place at the forest- atmosphere continuum at various temporal and spatial scales. For instance, carbon, energy and water cycles and their components can be assessed either on short-term or inter-annually (e.g. Kolari et al., 2009; Launiainen. 2010; Ilvesniemi et al., 2010). The international collaboration related to carbon and water cycles has been conducted, for example, in EUROFLUX, FLUXNET and CARBOEUROPE projects. The site is also part of European long-term carbon and greenhouse gas monitoring program ICOS (http://www.icos-infrastructure.eu/) recently initiated. The data from SMEAR II is flexibly available for research purposes.

Close to SMEAR II, there is also the Siikaneva wetland (fen) site (Rinne et al., 2007). It includes micrometeorological flux measurements of CO_2, sensible and latent heat and methane. The basic meteorological and radiation parameters are monitored together with the peat temperature and oxygen profiles and water table depth. The methane flux record from Siikaneva is one of the longest available and the site is involved in several EU projects.

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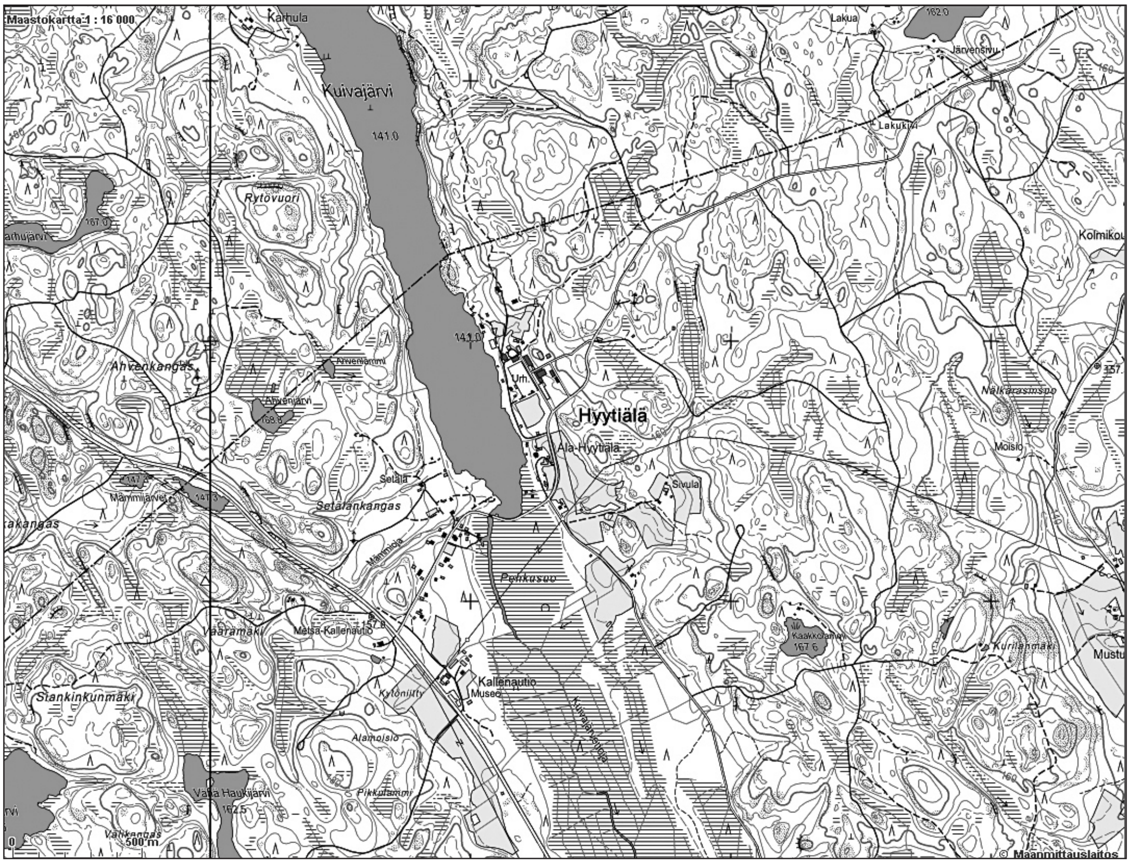

EXCURSION SITE 2

Lakkasuo - A diverse mire nature and research area in Central Finland

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Lakkasuo mire

Lakkasuo (*"Cloudberry mire"*) is an eccentric raised bog, It is located ca 18 km north of Orivesi town (61º 47' N; 24º 18' E) at about 150 m a.s.l. The annual rainfall is about 700 mm of which about one third falls as snow. The annual average temperature sum is 1160 d.d. and average temperatures for January is -8.9 ºC and for July 15.3 ºC (long term average 1961–1990). The area of Lakkasuo is about 120 ha, which about ca half is in natural state and protected. The other half of the Lakkasuo has been drained for forestry purposes in 1960´s. Ombrotrophic raised bogs are the dominant mire complex type in Southern and Central Finland. Instead, in Northern Finland, minerotrophic aapa mires are the typical feature in the landscape.

About the History of Lakkasuo

The initiation and development of the mire have been shaped by geomorphology and climate for thousands of years. The history of Lakkasuo starts at around 10000 B.P. in the beginning of Holocene when the glaciers retreated. At those times, the area of Lakkasuo mire was covered by the Yoldia Sea. Based on the radiocarbon and pollen dating, the oldest parts of the mire are about 9200 years old situated on the eastern margin of the east side esker, which formed during the smelting of the glacier. Gradually, during the past millenniums, the mire area has been widened and the peat thickness has been increased due to the growth and slow decomposition of mire plants -especially Sphagnum mosses. Lakkasuo mire was mainly formed through paludification of forest soils. Before the mire phase and following deglaciation, the land was covered with forests for 1500-6000 years.

There have been numerous fires in Lakkasuo during its history and left charcoal layers in the peat. In southern part of the mire, evidence of at least 21 separate fires has been discovered in period 1020–1845. However, most of the fires have stayed within the narrow margin and even today the wetter and minerotrophic parts of the mire in the north have not burned since the early paludification phase. It has been estimated that the carbon loss in one fire might have been 2500 g C m^{-2}.

Ecohydrology has created diversity

Ecohydrology, i.e. the temporal and spatial patterns of variation in the quantity and quality of water that mire receives, is the key driver, which regulates the initiation, development and all functions of the mire. The mire ecohydrology is further regulated by the properties of the catchment area. Ombrotrophic mires receive nutrients only from atmospheric deposition (very low amounts in Finland), whereas minerotrophic mires receive nutrients from runoff or seepage from the catchment or as groundwater influence. The most commonly observed feature in the vegetation of mires is the connection between the variability of mire vegetation and the variability of nutrient content and moisture. In Lakkasuo, as a result of the exceptional large variation in ecohydrology, almost all mire site type variability found in Finland can be found; only the clearly rich fens are not represented. The site types are ranged from fertile eutrophic rich fens (LN) and Herb-rich sedge hardwood-spruce swamps (RhK) to highly poor *Sphagnum fuscum* pine bogs (RaR) and from wet flark fens to drier forested fens and bogs. The dominant site type in northern parts of the mire are tall-sedge pine fens (VSR, RhSR) and in the southern area ridge-hollow pine bogs (KeR). In these sites, the main and usually the only tree species if occurs at all is Scots pine (*Pinus sylvestris*). Lagg areas in Lakkasuo are mostly surrounded by more fertile site types such as *Vaccinium myrtillus* spruce mires (MK), *Vaccinium vitis-idaea* spruce mires (PK) and herb-rich hardwood-spruce mires (RhK). The dominant tree species on these sites is Norway spruce (*Picea abies*) with pubescent birch (*Betula pubescens*) as admixtural tree species.

Based on the peat resource inventories of the Geological Survey Finland, the largest measured peat thickness is 3.7 m and the mean peat thickness is 1.8 m. Most of the peat (75%) is Sphagnum peat, with *Eriophorum vaginatum* as an abundant additional component. Sedge (*Carex* species) dominated and woody peats are concentrated in the northern parts and margin parts of the mire.

Mired important in carbon cycle

Mires are very important storages of carbon and carbon gas dynamics of mires have significant climatic impacts. Generally, the pristine mires stores carbon dioxide (CO_2) effectively from air, but on the other hand, they are also significant sources of methane (CH_4), particularly the minerotrophic sedge dominated sites. In Lakkasuo, based on radiocarbon dating and related mass measurements, the long-term carbon accumulation rate ranges 8.3–24.4 g C m^{-2} a^{-1} and is on average 16 g C m^{-2} a^{-1}. The highest accumulation rates have been measured from the fens and pine bogs and the lowest from the spruce mires in the western margin of the mire, from where the mire initiated. It has been estimated that in surface peat (7–58 cm) the accumulation rate is 40–81 C g m^{-2} a^{-1} and about half of that in deeper peat. Global warming has expected to decrease the net carbon accumulation, because of increased peat decomposition and reducing growth and cover of mire vegetation due to the water table draw down. On the other hand, the recent study results obtained among others from Lakkasuo, show that because of increased growth of woody biomass and decreased methane production, drainage may even result in cooling climate effect in mires. This effect, however, largely varies between the site types, and it is likely, that at least in nutrient rich sites, the global warming may change the mire to the source of greenhouse gases.

Teaching and research at Lakkasuo

University of Helsinki has for decades used the Lakkasuo area for teaching during the summer field courses and also for research during the latest decennia. By the 1930´s the area was already being used to demonstrate the Finnish mire site type classification created by A.K. Cajander. Since the days of S.E. Multamäki, who was the professor in peatland forestry (1944–1957), some parts of Lakkasuo were used for teaching every summer. In 1958 were established the first permanent sample plots both on natural and drained parts of the peatland in order to monitor the long-term stand growth and temporal changes in vegetation. This sample plot network has been still frequently followed. As teaching in the area increased, boardwalks were built there for increased accessibility and to minimise damage to the vulnerable mire vegetation. The routes in Lakkasuo are freely open to the public.

Lakkasuo is one of the most intensively studied mire in the world. Study materials collected from Lakkasuo is utilised in over 200 scientific studies during the latest decades including studies on mire ecohydrology, nutrient balances, carbon gas dynamics, climate change impacts, plant ecology, vegetation succession, site type formation, drainage, forest stand dynamics and wood quality as well as forest growth and yield studies. This laborious work has involved wide cooperation between different work groups and research consortia. New results have significantly deepened the understanding of the functioning of boreal mire and peatland ecosystems.

Further reading

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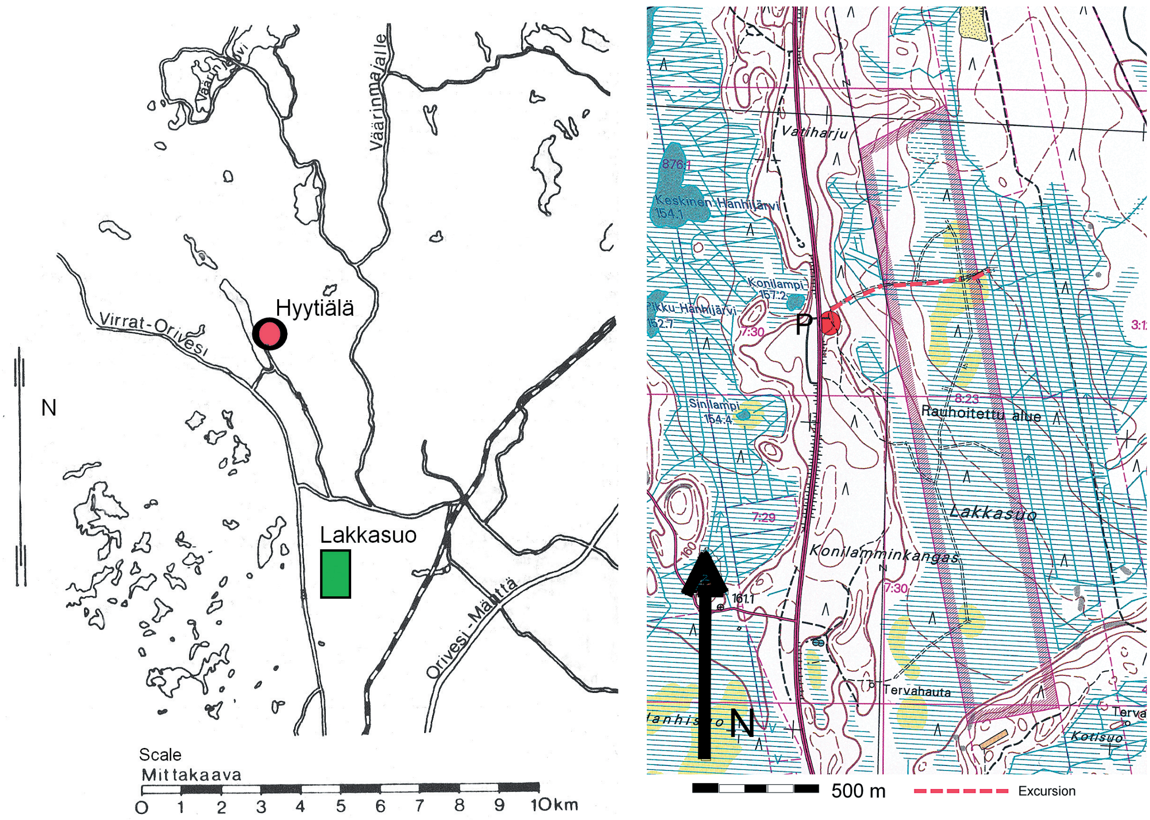

General and detailed maps of Lakkasuo mire in Central Finland.

EXCURSION SITE 3, a

Peatland water balance experiment in Jaakkoinsuo, Vilppula

Hannu Hökkä[1], Sakari Sarkkola[1], Harri Koivusalo[2], Eero Nikinmaa[3], and Mika Nieminen[1]

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Background

In Finland, drained peatlands cover about one fourth (ca. 5 mill. ha) of the total forest land area and the growth of peatland forests is ca. one fourth (24 mill. m^3a^{-1}) of the total forest growth in Finland. In a majority of these areas ditches need maintenance operations during stand rotation (70-90 years). However, ditch network maintenance is regarded as the most harmful forestry operation for the water quality of recipient water courses.

In operational forestry, only visual condition of the ditches is used as the decision criterion for the need of ditch network maintenance, although the condition of ditches does not necessarily reveal whether soil drainage condition is affecting tree growth or not. An important component in the forest water balance is the contribution of tree stand water use on site drainage, but this is neglected in management and has been not assessed in research. This study aims at determining the water balance components for a drained peatland stand in order to determine the role of tree stand transpiration. Based on this information, the possibility to avoid unnecessary ditching operations would give a chance to decrease loads from forestry to surface waters.

Study site

The study site is a drained pine bog located about 250 km north of Helsinki (62º04’ N, 24º34’ E, 120 m.a.s.l.). The annual temperature sum is 1220 ddºC (+5 ºC as the threshold value) and the annual precipitation is 640 mm, of which 180 mm falls as snow (average during period 1974-2004). According to the Finnish site type classification for drained peatlands the site type is dwarf-shrub drained peatland site. The site was originally drained in 1925 with 120 m ditch spacing. The peat layer is 1.5 – 2 m thick and it is mostly composed of poorly decomposed *Sphagnum* peat with wood residues. The experiment was set up in 2003 as an artificial catchment of 1.0 ha and isolated from its surroundings by ditches.

The tree stand is a premature Scots pine (*Pinus sylvestris* L.) thinning stand naturally established in 1935. In 2006, the living stem volume was 152 m^3ha^{-1}, with mean diameter of 17.5 cm and dominant height of 17.5 m. The field layer is dominated by *Vacciniun vitis-idaea*, *Ledum palustre* and *Vaccinium uliginosum* shrubs with scattered coverage and height of 0.2 – 0.4 m. The forest moss species (e.g. *Pleurozium schreberi, Dicranum spp.*) with scattered patches of Sphagnum-moss species are dominant in the ground layer.

Measurements

In situ measurements included monitoring of throughfall, snow depth, snow water equivalent, depth to water table, tree transpiration and runoff starting from year 2007.

Runoff measurements are based a Thompson weir, which was installed in 2006 with an excavator in the outlet ditch. The height of the water level in the weir is measured continuously with TruTrack WT-HR500 water level logger, and calibrated with weekly manual control measurements.

Depth to water table is manually monitored in an intensive sampling grid where 50 perforated plastic tubes were inserted into the peat down to 1 m depth below soil surface. Additionally, a TruTrack WT-HR1000 water level logger was installed in one tube in order to continuously monitor the water table during frost-free periods.

Throughfall is measured with 20 rain gauges, installed regularly under the canopy. Throughfall and water table depth are manually recorded weekly during the frost-free period.

Tree-level water use is studied by Granier type sap flow sensors installed in 8 sample trees, which are representing the whole diameter and height distribution of the stand.

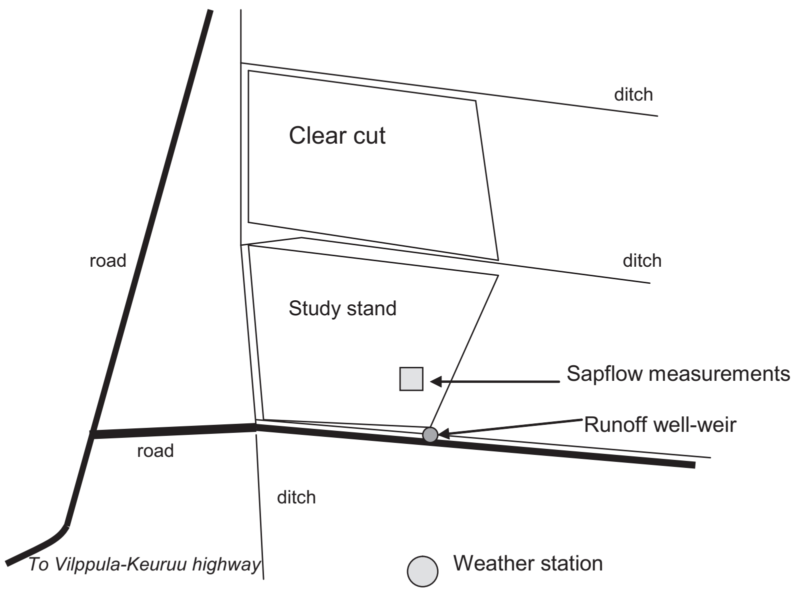
The meteorological data (radiation, precipitation, temperature, wind, and air humidity) is obtained from a weather station established nearby in 2007.

For determining stand characteristics of the 1.0 ha study area, diameter at 1.3 m height and location of every tree (> 4.5 cm in diameter) was measured in fall 2006. As well, a representative number of height sample trees was measured.

Estimating water balance components

Water level measurements at the weir are transformed to run-off on the basis of the stage-runoff relationship. Monthly water balance components were determined on the basis of measured precipitation, throughfall, runoff , and calculated change in soil water storage. Evapotranspiration was determined as the residual term of the water balance equation. For comparison, transpiration based on sap flow measurements is calculated.

The setup of the water balance experiment on drained peatland at Jaakkoinsuo-mire, Vilppula, Finland.



EXCURSION SITE 3, b

Jaakkoinsuo experimental drainage area

Hannu Hökkä[1] and Sakari Sarkkola[2]

[1] *Finnish Forest Research Institute, Rovaniemi Research Unit*
[2] *Finnish Forest Research Institute, Vantaa Research Unit*

An experimental forestry drainage area was established in Jaakkoinsuo mire in 1909 following an authorization issued by the Senate of Finland. Good connections via railway and roads and variety of different sites were the criteria for selection. Its initial area of 190 ha has diminished to the present size of 100 ha. Since 1923 the area was governed by the Finnish Forest Research Institute, but in 2008 it was moved under the governance of Finnish State Forests (Metsähallitus).

In 1909 the area was drained for the first time with the principal aim to investigate the effect of different ditch types, sizes, and distances on tree growth. The peat thickness varied between 0.5m and 3 m. At the time of drainage, the peatland was mostly sparsely forested and partly treeless. After drainage, the tree growth considerably increased and the treeless areas were regenerated naturally. Thus, without any afforestation actions the whole area is now growing productive forests. Part of those are young stands representing already the second tree generation after drainage.

The first permanent sample plots were established in 1915. During the following four decades, several growth and yield plots were established to study the effect of ditching intensity, species mixture, site quality, and different stand treatments on timber production.

Site nutrition experiments were started in 1926. In the beginning, the use of lime and sand as a way to improve site productivity was studied. Ash fertilization experiments date back to 1937 and the first trials with N, P and K are from 1946.

Forest ecological studies started in 1956 and were focused on the effect of soil water, nutrients and temperature on development of trees. An important subject was the water conditions in soil, which was studied with experiments where ditch water levels were controlled to different depths (10–70 cm) or by creating flood during the growing season. Water uptake of trees from frozen soil was also studied. In 1970–1980 several experiments were established to study the nutrient conditions in peat soils and the use of commercial fertilizer to improve the nutrient imbalances in trees. Important research topics were also the variation of berry and mushroom crops, and the effect of acidifying air deposition on the soils. In 1990's, forest regeneration studies with new field experiments were started.

Presently, 11 permanent stand growth plots and numerous other plots are followed by regular measurements. A couple of new experiments have been set up to study, e.g. peatland forest water balance and the effect of tree biomass harvesting as well as the water table rise (peatland restoration) on runoff water quality.

The experiences obtained from Jaakkoinsuo formed the basis for the large practical forest drainage work that was carried out in Finland during 1960's and 1970's.

Visitors can make a walk on the area by following a marked trail and read summaries of studies on posters next to the study plots.


Maastokartta 1 : 16 000
Hallamäki
Kaakkosuo
Kettukangas
Kettumäki
Jaakkola
Anttila
Kulmala
122.1
Kulmalanniittu
Metsäntutkimuslaitoksen koealue
Jaakkoinsuo
Latumäki
Ylisenlammi
110.7
112.4
Autio
Ronikko
Marjala
Metsämäki
Mantila
Kotiniemi
Vankila
Ahosenpelto
109.2
Heinämäki
Kangasmoisio
Suojala
Uutela
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