Changing ecosystems - Opportunities and challenges in integrated research

The first INAR RI Ecosystems Scientific meeting at Oulanka Research station 20.-22.8.2018.

Abstracts

Needs and challenges in scaling up from local to regional

KEYNOTE: Needs and challenges in scaling up from local to regional

Dr Tarmo Virtanen

Ecosystems and Environment Research Programme, Department of Environmental Sciences, University of Helsinki, Finland

To understand and quantify soil, vegetation and climate – mediated ecosystem processes, it is crucial to know how different vegetation and land cover types varies in the landscape. The Arctic tundra and boreal peatland ecosystems consist of a mosaic of vegetation and other land cover units, and they seem to be more fragmented than any other ecosystems. This fragmentation is a consequence of several different factors, like water flow, wind and snow erosion, and permafrost dynamics impacts. All these factors lead to small scale variation in soil properties, vegetation and land cover. Existing large area covering land cover maps in the Arctic are still typically produced in such a coarse resolution, that they can't pick up the level of actual vegetation patterns. In recent years there has been considerable development in the satellite image analysis methods, and several new satellites are taking very high resolution images (pixel size 0.5 – 2 m) allowing realistic separation of land cover types, and drones are taken even cm pixel size images. However, higher the used pixel size, smaller is the possible study area. Spectral resolution of the images has also improved. If target is to produce thematically detailed classifications, they allow new possibilities, but also bring methodological challenges. I'll present some very high spatial resolution land cover, biomass, and leaf area index mappings from several Arctic and Northern boreal study sites in Finland, Russia, and Canada. In addition, I'll give some examples, how they can be utilized when carbon flux measurements are generalized and carbon dynamics are modelled.

Mapping vegetation in a north-boreal fen in very-high and ultra-high spatial resolution

Aleksi Räsänen, Sari Juutinen & Tarmo Virtanen

Ecosystems and Environment Research Programme, Faculty of Biological and Environmental Sciences, and Helsinki Institute of Sustainability Science (HELSUS), University of Helsinki, Finland

Very-high spatial resolution (VHSR) and ultra-high spatial resolution (UHSR) remote sensing data allow detailed mapping of vegetation, which can be utilized when analyzing ecosystem-atmosphere exchange of carbon and water. We mapped land cover, plant communities, biomass and leaf area index (LAI) at two spatial scales in Kaamanen, northern Finland (69° 08´ 25´´ N, 27° 16´ 11´´ E). In a 0.4 km^2 fen, we combined 5 cm UHSR drone image, vegetation height model and digital elevation model (DEM) with VHSR (0.5-3 m resolution) optical images and airborne laser scanning point cloud, canopy height model and DEM. We mapped a 33 km^2 catchment in 2 m resolution with VHSR data. We utilized combined full lambda schedule segmentation with random forest classification and regression. In land cover type classification, accuracy was 72% at both scales. We used species and plant functional type specific presence-absence data in configuring plant communities with fuzzy c-means clustering and modeled spatial patterns of the clusters with varying success (R^2 values from 0.25 to 0.67). In the regression models for estimating biomass and LAI, the R^2 values in the fen were 0.52 for both biomass and LAI. In the whole catchment, we mapped also tree biomass and LAI, with R^2 values ranging between 0.29 and 0.47 for different biomass and LAI components. UHSR data allowed detailed mapping of vegetation patterns which could not be distinguished with VHSR data in a patchy fen. Optical data should be combined with data about topography and vegetation height both in UHSR and VHSR.

Long-term trends and mass budgets for N and S compounds at European LTER-sites

Martin Forsius et al.

Finnish Environment Institute SYKE

We evaluated long-term trends and mass budgets for N and S compounds at sites belonging to the LTER-Europe and ICP IM networks. A significant decrease of SO_4, NO_3 and NH_4 deposition resulted in decreases in concentrations and fluxes of SO_4 and NO_3 in runoff. The catchments retained SO_4 in the early and mid-1990s, but this shifted towards a net release in the late 1990s, which may be due to the mobilization of legacy S pools accumulated during times of high atmospheric SO_4 deposition. Thus, the LTER/ICP IM network confirms the positive effects of the emission reductions in Europe. The site-specific variation of SO_4 concentrations in runoff was most strongly explained by deposition. Climatic variables and deposition explained the variation of inorganic N concentrations in runoff at single sites poorly.

Vuorenmaa, J., Augustaitis, A., Beudert, B., Bochenek, W., Clarke, N., de Wit, H., Dirnböck, T., Frey, J., Hakola, H., Indriksone, I., Kleemola, S., Kobler, J., Krám, P., Lindroos, A.-J., Lundin, L., Löfgren, S., Marchetto, A., Pecka, T., Schulte-Bisping, H., Skotak, K., Srybny, A., Szpikowski, J., Ukonmaanaho, L., VáÇna, M., Åkerblom, S. and Forsius, M. (2018). Long-term changes (1990-2015) in the atmospheric deposition and runoff water chemistry of sulphate, inorganic nitrogen and acidity for forested catchments in Europe in relation to changes in emissions and hydrometeorological conditions. Science of the Total Environment 625: 1129-1145. https://doi.org/10.1016/j.scitotenv.2017.12.245.

Vuorenmaa, J., et al. (2017). Long-term sulphate and inorganic nitrogen mass balance budgets in European ICP Integrated Monitoring catchments (19902012). Ecological Indicators 76: 15-29. http://dx.doi.org/10.1016/j.ecolind.2016.12.040.

PäijänneLTER - research and education environment in the lake landscape of Central Finland

Pauliina Salmi, Jonna Kuha & Juha Karjalainen

Department of Biological and Environmental Science, University of Jyväskylä

PäijänneLTER site in Central Finland focuses on high-frequency monitoring of physical and chemical conditions of boreal water bodies and effects of weather variations on them. PäijänneLTER site (www.paijanne.org) consists of two automatic water quality monitoring stations (AWQMs): a year round measurement station *Aino* in urban Lake Jyväsjärvi and open-water seasonally deployed station *Matti* in oligotrophic Lake Konnevesi, both equipped with profiling underwater CTD probes and weather observation units. As a part of international networks, data collected by the floats have been recently utilized in collaborative studies such as: “Geographic and temporal variations in turbulent heat loss from lakes: a global analysis across 45 lakes“ (Woolway *et al*. 2018) and “Response of boreal lakes to episodic weather-induced events” (Kuha *et al.* 2016). In addition to research, automatic monitoring data has intensively utilized by open online visualization in the basic level courses at the University of Jyväskylä. The aim is to offer concrete insights in seasonal variation and phenology of limnological phenomena. Advanced level teaching has more focus on analysis of time series and comparison to other stations across the world. Familiarizing university students to data sharing, interpretation and management via international networks such as LTER and INAR could facilitate the development of positive prospects for the established infrastructure. We search collaboration in scientific research but also in education.

References :

Kuha J. *et al.* (2016) *Inland waters* 6(4): 523

Woolway I. *et al.* (2018) *Limnology and Oceanography*. (In Press)

Upscaling greenhouse gas fluxes on adjacent peatland, lake and forest ecosystems within a subarctic catchment

Lauri Heiskanen[1], Mika Aurela[1], Juha-Pekka Tuovinen[1], Aleksi Räsänen[2], Tarmo Virtanen[2], Sari Juutinen[2], Timo Penttilä[3] & Tuomas Laurila[1]

[1]Finnish Meteorological Institute, Helsinki, Finland, [2]Department of Environmental Sciences, University of Helsinki, Finland, [3]Natural Resources Institute Finland (LUKE), Helsinki, Finland

The Finnish Meteorological Institute has been running a micrometeorological measurement station at Kaamanen in northern Finland since 1997. These measurements of the ecosystem-atmosphere exchange of energy and greenhouse gases (GHGs) have been conducted at a peatland site using the eddy covariance (EC) method. In 2017, EC flux measurements were also started at adjacent lake and forest sites. In addition, GHG fluxes were measured with the chamber technique.

The ecosystem-atmosphere exchange of CO_2 and CH_4 were measured during 2017 and 2018 on adjacent peatland, lake and forest ecosystems as part of the CAPTURE –project (Carbon dynamics across Arctic landscape gradients: past, present and future) funded by the Academy of Finland. The objective of these particular measurements were to observe the growing season carbon fluxes on these ecosystems and habitat types, e.g. on different land cover classes (LCCs) of the peatland. Using these data, the annual ecosystem-level GHG balances will be determined and upscaled to a catchment scale and further to a regional scale. This will be achieved by combining the EC flux measurements with the LCC specific fluxes from the chamber measurements and a detailed vegetation mapping based on satellite data and field measurements.

The Kaamanen peatland is a mesotrophic flark fen comprising dry strings and wet flarks. The lake within the catchment is shallow clear water lake and it is located 200 m southwest of the peatland site. The Scots pine forest, located 300 m west of the peatland site, has a mean tree height of 11 m. Vegetation and land cover classes were mapped in detail around the EC towers during summer 2017. The mapping consisted of plant species coverage observations and soil sample collection along transects.

Long-term monitoring of boreal forest ecosystems serves science and policy

Päivi Merilä, Kirsti Derome, Antti-Jussi Lindroos, Seppo Nevalainen, Tiina M Nieminen, Pentti Niemistö, Pekka Nöjd, Mikko Peltoniemi, Pasi Rautio, Maija Salemaa & Liisa Ukonmaanaho

Natural Resources Institute Finland (Luke)

The Natural Resources Institute Finland monitors the condition and functioning of forest ecosystems on 8-14 sites. The plots are located in Norway spruce and Scots pine stands within latitudinal range of 60.6-69.9 N°. The network includes both managed forests and stands in conservation areas. The monitoring is based on the UN-ECE ICP Forests Level II monitoring programme (http://icp-forests.net). The programme also feeds into the Forest Europe process (http://foresteurope.org/).

In Finland, the monitoring began in mid-1990s and has thus currently resulted in time series of >20 years. Continuous monitoring activities are based on methods developed and harmonized across Europe. They provide data and information required in several both politically and scientifically timely issues, including topics such as carbon sequestration, climate change, biodiversity, sustainable forest management, as well as the the impact of air pollution on forest ecosystems. The programme supports implementation of a consistent quality assurance approach, including e.g. cross-calibrations and ring-tests.

In this presentation we will review the most recent results of the programme (Johnson et al. 2018, Neumann et al. 2018, van der Linde et al. 2018).

References:

van der Linde, S. et al. 2018. Environment and host as large-scale controls of ectomycorrhizal fungi. *Nature* 558: 243-248.

Johnson J. et al. 2018. The response of soil chemistry in European forests to decreasing acid deposition. *Global Change Biology* 24:3603-3619. http://dx.doi.org/10.1111/gcb.14156

Neumann, M. et al. 2018. Regional and species-related variations of carbon and nutrient input by litterfall in European forests. *Biogeochemical Cycles* 32. https://doi.org/10.1029/2017GB005825

Lateral Carbon Transport

KEYNOTE: Lateral Carbon Transport: Combining long-term monitoring with process research

Hjalmar Laudon

Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, Umeå, Sweden

Most of our understanding on the mechanisms that regulate the lateral transport of carbon - dissolved organic carbon (DOC), dissolved inorganic carbon (DIC) and methane (CH_4) - is based either on individual well-studied catchments, or geographically distributed monitoring datasets. While studies based in research catchments often is powerful because of the large amount of ancillary information that can provide mechanistic explanations, the results are often difficult to extrapolate because of limited statistical and geographic representation. Conversely, environmental monitoring sites often lack the process-based designed data collection, which instead makes it difficult to infer causal relationships. Here I will discuss the value of combining long-term monitoring time-series with the exclusivity of process-based research across multiple spatial and temporal scales. The basis for this presentation will be on the Krycklan Catchment Study (www.slu.se/Krycklan) located in northern Sweden that provides a unique field experimental platform for hillslope to landscape-scale research on long-term ecosystem dynamics in the boreal landscape. The site is designed for processes-based research needed to assess the role of external drivers such as forest management, climate change, and long-range transport of pollutants on forests, mires, soils, streams, lakes and groundwater. In my presentation I will discuss some examples of how Krycklan has developed into a state-of-the-art field infrastructure for experimental and hypothesis driven research, maintained the long-term climatic, biogeochemical, hydrological and environmental data collection of highest quality, and how this has supported the development of new models and guidelines for research, policy and management.

Seepage from peatland influencing groundwater patterns and DOC processes in river-side esker

Hannu Marttila, Aurela M, Rossi P, Lohila A, Postila H, Saari M, Penttilä T, Klöve B.

We investigated how hydrogeological setting influences connection from peatland to aquifer in an aapa mire complex at northern Finland. Steady-stage groundwater model (Modflow) with combination of stable isotopes, water chemistry, detailed field investigations, and ground penetrating radar (GPR) were used to quantify groundwater flow volumes and directions. Recharge from aapa mire towards sandy riverside aquifer was enable by sandy pipe which connected peatland and aquifer, and thus produced surface water inflow to the surface aquifer. Seepage volume were rather constant and dominated esker hydrology at base flow events. Stable isotopes of water and DOC/DIC analysis from groundwater wells verified this seepage patterns. Our results indicate that groundwater seepage from peatland transport organic carbon to the river side esker formation, where it transforms to DIC and generate additional measurable CO2 input, likely contributing to the ecosystem-scale eddy covariance measurements done above the pine forest growing on the esker. In this presentation, we document this unique connection between peatland and esker formation and discuss its potential effects on local biogeochemical cycles.

Transport and transformation of soil-derived CO_2, CH_4 and DOC sustain CO_2 supersaturation in small boreal streams

Terhi Rasilo[1], Paul del Giorgio[2]

[1]INAR RI/Forest, University of Helsinki;, [2]Groupe de Recherche Interuniversitaire en Limnologie (GRIL), Département des sciences biologiques, Université du Quebéc à Montréal, Québec, Canada

Streams are typically supersaturated in carbon dioxide (CO_2) and methane (CH_4), and are recognized as important components of regional carbon (C) emissions in northern landscapes. Whereas there is consensus that in most of the systems the CO_2 emitted by streams represents C fixed in the terrestrial ecosystem, the pathways delivering this C to streams are still not well understood. We assessed the contribution of direct soil CO_2 injection versus the oxidation of soil-derived dissolved organic C (DOC) and CH_4 in supporting CO_2 supersaturation in boreal streams in Québec. We measured the concentrations of CO_2, CH_4 and DOC in 43 streams and adjacent soil waters during summer base-flow period. A mass balance approach revealed that all three pathways are significant, and that the mineralization of soil-derived DOC and CH_4 accounted for most of the estimated stream CO_2 emissions (average 75% and 10%, respectively), and that these estimated contributions did not change significantly between the studied low order (≤3) streams. Whereas some of these transformations take place in the channel proper, our results suggest that they mainly occur in the hyporheic zones of the streams. Our results further show that stream CH_4 emissions can be fully explained by soil CH_4 inputs. This study confirms that these boreal streams, and in particular their hyporheic zones, are extremely active processors of soil derived DOC and CH_4, not just vents for soil produced CO_2.

Integrated aquatic studies based on a continuously operated measuring platform: Visionary path to bring future or random walk into the unknown

Anne Ojala et al.

Institute for Atmospheric and Earth System Research, University of Helsinki, Finland

There are more than a million lakes in Europe alone where on average 5-10 % of the surface area is covered by lakes. However, there are limited activities in integrative research, where lakes in the landscape are studied as a nexus of fluxes of energy and material. Thus, there is a need of well-established, high-quality research infrastructures with continuous measurements encompassing major components of lake ecosystems, including processes of lateral carbon transport. Here we present a continuously operated platform on Lake Kuivajärvi, southern Finland, to measure fluxes and concentrations of elements of biogeochemical importance in aquatic environment using state-of-the art techniques. The aim is to study a boreal lake as a part of the peatland-forest-lake-atmosphere continuum in the context of climate change. Scientific approaches range from molecular biology to mathematical modelling. The measuring platform is part of the SMEAR station as well as ICOS network and it belongs to INAR. The methods are adopted from atmospheric physics and forest sciences to enhance synergy and ensure smooth integration of results. Lateral carbon transport has been studied over several years with differing weather conditions by collecting data from the inflowing streams as well as outflow. As a spin-off, research on lateral carbon processes are now being extended to sub-Arctic streams. Knowledge on ecosystem effects of later carbon load is also utilized in applied algology, where focus is in attempts to use mixotrophic algae as a high value raw material by culturing them with the principles of circular economy.

New technologies and their possibilities in ecosystem research

KEYNOTE: Researcher wearing glasses: seeing better or seeing different?

Mikhail Mastepanov

Aarhus University, Denmark Lund University, Sweden

New technologies and new instruments become available every year. How beneficial is to follow them? Can similar results be obtained using more conservative techniques? How much following the technology development can bias the direction of our studies? A number of examples from our field and lab studies as an attempt to discuss these questions.

Novel Stable Isotope Approaches in Tree Ring Research for Climate Change Studies

Katja Rinne-Garmston[1], Yu Tang[1], Elina Sahlstedt[1], Petri Kilpeläinen[1], Bartosz Adamczyk[1], Imane Karmoun[1]

[1]Natural Resources Institute Finland (Luke), Helsinki, Finland

Stable isotopes in tree rings (e.g. $\delta^{13}C$ and $\delta^{18}O$) have been proven to be a powerful tool to study the impact of climate change on boreal forests, as they can sensitively respond to the changing environment where the tree lives. Our project ISOBOREAL applies novel stable isotope analytical methods, specifically Compound-Specific Isotope Analysis (CSIA) on $\delta^{13}C$ and Position-Specific Isotope Analysis (PSIA) on $\delta^{18}O$, to reveal the response of larch and pine trees in European boreal forests to climate change. CSIA enables better mechanistic understanding of how climate signal is imprinted in sugars during photosynthesis and modified in post-photosynthetic processes prior to tree ring formation. PSIA will provide the first separation of leaf water $\delta^{18}O$ and source water $\delta^{18}O$ signals in tree ring cellulose. The project will improve interpretation of the climate signal in stable isotopes of tree rings, which can help to decipher environmental conditions in retrospect more reliably. The results will also expand current knowledge of temporal variability in C allocation and water cycle in ecosystems. Besides, the data will be valuable for climate change projections as well as forest growth projections, contributing to decision making in climate mitigation and adaptation strategies.

Root lab facility for studying tree responses to abiotic stresses

Timo Repo[1], Timo Domisch[1], Jouni Kilpeläinen[1], Sirpa Piirainen[1], Leena Finér[1], Tarja Lehto[2]

[1]Natural Resources Institute Finland (Luke), Joensuu; [2]University of Eastern Finland, School of Forest Sciences, Joensuu

The root lab facility with independent control of soil and air conditions allows studies of drivers of physiology, phenology and growth of roots and shoots and their interaction in trees. In the facility, the phase of annual cycle can be considered when exposing the trees to stress. In addition, annual cycle of trees can be speed up whereupon detailed information of tree responses to changes in environmental factors can be obtained faster than in the field experiments. The experiments have dealt with the effects of soil freezing, waterlogging and soil temperature on trees.

High-resolution Arctic water isotope ($\delta^{18}O$ and $\delta^{2}H$) cycle measurements of water vapor and stream water in N Finland

Kaisa-Riikka Mustonen[1], Hannah Bailey[1], Eric Klein[2], Hannu Marttila[3], Björn Klöve[3], Annalea Lohila[4], Antti Lipponen[4] & Jeffrey Welker[1,2]

[1]Department of Ecology and Genetics, University of Oulu; [2]University of Alaska Anchorage, USA; [3]Water Resources and Environmental Engineering Research Group, University of Oulu; [4]Finnish Meteorological Institute

The Arctic water cycle is changing dramatically as climate change is affecting its individual components such as Arctic sea ice conditions, atmospheric processes, and hydrological characteristics, and their interactions. To fully understand the behavior of the modern Arctic water cycle, we are continuously measuring in real time, water isotope ($\delta^{18}O$, $\delta^{2}H$, and *d-excess*) traits in water vapor, precipitation and stream water in Arctic Finland, Pallas-Yllästunturi National Park. The integrative nature of our studies are designed to for instance; understand how sea ice and synoptic weather patterns are effecting moisture sources in Fennoscandia, which may reflect in part the "Atlantification" of the Barents region and increases in Arctic Vortex phases. In addition, our coupling of vapor, precipitation and stream water isotopes provide a means to quantify basin-scale residence times and stream water isotope seasonality that can be used to delineate water sources of riparian species and provide a base-line on which to understand patterns of invertebrate life history characteristics. Developing a high-resolution perspective of the Arctic water isotope cycles is essential for understanding the ecohydrological changes in these highly seasonal catchments. In addition, a better understanding of the Arctic water cycle will help people adapt to changing local conditions such as flooding, water quality, and also improve our food and drinking water security. Linking event-based precipitation with continuous vapor and surface water isotope measurements at high temporal resolution will provide one of the greatest improvements this decade in our understanding the behavior and interactions in the Arctic water cycle.

Imaging spectroscopy in environmental monitoring

Markku Keinänen

Department of Environmental and Biological Science, University of Eastern Finland

In imaging spectroscopy (or hyperspectral imaging) spatially coregistered images are acquired in many spectrally contiguous bands, forming an image cube with spectral information as the third dimension. Thus, each pixel of an image contains typically hundreds of narrow bands of light intensity instead of just three broad bands of human vision or color cameras. Furthermore, it is not limited to visible range of radiation. In plant and environmental research, it is used in remote sensing and in the lab scale, and in recent years also from drones and with portable cameras for field use. Typical applications are, for example, vegetation studies (e.g., phenology, differentiation of plant species), estimation of chlorophyll, water and mineral nutrient contents or deficiencies, and detection and monitoring of plant diseased and pest invasions. In the presentation, I will give a short overview of the technique and its applications and introduce our Spectromics laboratory at the UEF, focusing on plant hyperspectral imaging. Examples of our studies on estimation of lichen water content, peat profiling and silver birch genetic variation will be presented.

Mitigation of climate change through ecosystems

KEYNOTE: Trade-offs and synergies between biodiversity, climate change mitigation and environmental loading in peatland ecosystems

Anne Tolvanen[1,2], Miia Saarimaa[1], Artti Juutinen[1,3]

[1]Natural Resources Institute Finland, Oulu, Finland; [2]Department of Ecology and Genetics, University of Oulu, Finland; [3]Oulu Business School, University of Oulu, Finland

Besides raw material timber and peat, peatlands provide a variety of valuable services, such as biodiversity, C sequestration and hydrological control. High pressure is targeted to these ecosystems by e.g. forest, bioenergy and peat industries. In Finland, a country with the highest percentage cover of peatlands in the world (30% of total land area, almost 10 mill. ha), about 60% of peatland area has been drained for forestry. This had led to the degradation of biodiversity, environmental loading to watercourses, and emission of greenhouse gases (GHG). There is a need to optimize the use of peatlands to simultaneously reach the biodiversity, environmental goals and the economic needs. We used empirical country-wide spatial data 1) to estimate and predict the impact of seven peatland uses on the biodiversity, GHG balances and environmental loading to watercourses, and 2) to numerically optimize cost efficient land uses so that benefits from biodiversity and ecosystem services are safeguarded. We show that there is no simple answer to the optimization of peatland uses due to the numerous trade-offs between biodiversity, ecosystem services and monetary value. The outcome depends on the level of environmental constraints, set monetary targets and the time frame of evaluation. Selection between multitude of options requires continuous contact between research, administration, planning, and other relevant stakeholders. We will demonstrate a multicriteria decision support tool that visualises the trade-offs and was piloted in a real planning case concerning peatland use.

Mitigation of climate change: sustainability and multi-functionality of European forests

Jaana Bäck, Tahvonen, O. & Vesala, T.

The interaction of forests with climate change is complex. The function given the highest priority in the 2015 Paris Agreement of the UNFCCC is to manage forests sustainably, so as to enhance forest carbon stocks in order to help mitigate climate change. The overall impacts of forests on the atmospheric carbon budget depend heavily on the uses of the harvested forest products (wood). In addition, forests influence climate by biophysical and biogeochemical processes, such as e.g., cloud formation processes and albedo, which depend on tree species diversity, stand density, types of forest management, and location. Depending on the combination of the above factors, the impacts of forests on global average temperatures can be positive or negative. This presentation examines aspects related to the net effect of forests on climate, including the net effects on climate of using forest biomass as a source of fuel and its comparison with fossil fuels.

Recent scientific analyses show tensions between some of the objectives in the current forest management schemes – especially between demands for increased extraction of biomass from forests and the contributions made by the same biomass in situ to soil fertility, biodiversity and protective functions. Other synergies and trade-offs exist in the way in which forests' interaction with climate change mitigation is managed.

Overall, the current scientific evidence on forests' role in climate change and on the current status of both biodiversity and forest vitality has significant implications for future forest policies and management. Policies should better account for the multi-functionality of forests and should better optimize the balance between

social, economic and ecological contributions. To find a better balance between the competing demands on Europe's forests may require different management approaches. For instance, depending on location, forest management strategies such as continuous cover silviculture and the enhancement of native tree species diversity and of landscape heterogeneity may simultaneously contribute to the maintenance of forest cover, the conservation of carbon stocks and biodiversity, whilst improving the social and cultural values of forests.

Continuous cover management as a tool to mitigate emissions from peatland forestry – a case study from Southern Finland

Annalea Lohila[1], Mika Korkiakoski[1], Timo Penttilä[2], Juha-Pekka Tuovinen[1], Paavo Ojanen[2], Kari Minkkinen[3], Sakari Sarkkola[2], Mika Nieminen[2], Juuso Rainne[1] & Tuomas Laurila[1]

[1]Finnish Meteorological Institute, Helsinki, Finland; [2]Natural Resources Institute Finland, Helsinki, Finland; [3]Dept. of Forest Sciences, University of Helsinki, Finland

Drained peatland forests represent about 25% of the total forest area in Finland. Even-aged management (EM), including clear-cut and ditch network maintenance (DNM), has been the prevailing management option in forestry so far. Soon after the clear-cut, high emissions of carbon and nitrogen into water bodies and atmosphere have been observed. Here we studied to what extent the adverse environmental impacts of peatland forestry could be mitigated by means of continuous cover forestry (CCF), where significant canopy cover is continuously retained in a stand and no DNM treatments are needed. The experiment was conducted at a nutrient-rich peatland forest (Lettosuo in Tammela, Southern Finland), which was originally drained in 1969. At the CCF plot, ca. 75% of the tree biomass was removed in spring 2016. For comparison, we also retained an uncut control and set up a clear-cut plot with 100% tree biomass removal. The effects of CCF and EM harvestings and the subsequent moderate or more dramatic water table level (WTL) rise on greenhouse gas (GHG) fluxes and evapotranspiration were studied using the data collected with the eddy covariance method before (2009–2015) and after (2016–) the harvestings. In addition, the discharge water quality was monitored at each of the three management plots. Significant differences between the EM and CCF plots were observed in water table level, GHG fluxes and nutrient exports. Differences between the CCF and control plots were minor.

Links between biodiversity and climate change

KEYNOTE: Climate as driver of long-term trends in freshwater invertebrate communities

Peter Haase, Viktor Baranov, Jonas Jourdan, Francesca Pilotto

Long-term observations on riverine invertebrate communities are crucial to assess potential impacts of climate change on stream ecosystems. In my talk I will present results from three recent studies: In the first study we examined LTER data (1032 years) of 26 streams and rivers from four European ecoregions, to investigate invertebrate community responses to changing climatic conditions. In a second study we analyzed long-term data (1969-2010) of aquatic insects from a nature reserve. In a third study, we analyzed the changes in the temperature signature (i.e., weighted temperature preferences of species within a community) and community composition of invertebrate communities over 25 years, based on 3,782 samples over large elevational, latitudinal and longitudinal gradients in central Europe. All three studies provide evidence that climate change already induce changes in abundance, richness, turnover and trophic structure, which could be regarded as early indicators of an ongoing process towards a homogenization of freshwater communities. Besides, the need to further explore the interactive effects of climate change variables with other local stressors to develop appropriate conservation measures became evident.

Interactions of Polyporales fungi in decomposition of dead coniferous wood

Tuulia Mali[1], Mari Mäki[2,3], Heidi Hellén[4], Jussi Heinonsalo[2,4], Jaana Bäck[2,3], **Taina Lundell**[1]

[1]Department of Microbiology, and [2]Department of Forest Sciences, Faculty of Agriculture and Forestry, and [3]Institute for Atmospheric and Earth System Research (3), University of Helsinki; [4]Finnish Meteorological Institute, Helsinki, Finland

In boreal forests, amount of dead wood may equal the amount of living tree biomass. Dead wood serves as a sink for organic carbon as well as an important habitat for animals, plants and microbes. Most of all, the wood-inhabiting saprotrophic, tree-pathogenic and ectomycorrhizal fungi act as primary decomposers of composite wood and thereby, as significant circulators of organic carbon in the forest ecosystems. In dead wood and woody debris, the decay-fungal communities are dynamic featuring mutualistic to antagonistic interactions. We have studied these interactions under controlled conditions by introducing *Fomitopsis pinicola*, a common brown rot Polyporales species encountered throughout the temperate Northern Hemisphere and attacking both coniferous and deciduous trees, on hyphal growth and enzyme activity patterns of white rot Polyporales fungi including *Phlebia radiata* and *Trichaptum abietinum*. In fungal combinations, *F. pinicola* turned out to be a supreme colonizer advancing over hyphae of the white rot species, with substantial production of oxalic acid in co-cultures and on wood as substrate. Evidence of Fenton reaction-type biochemistry was obtained for *F. pinicola* explaining its brown rot combative attack. However, the white rot species displayed tolerance for co-existence, and promoted oxidoreductive enzyme activities particularly against wood lignin. Analyses on profiles of emitted VOCs (volatile organic compounds) from combinatory fungal cultures on spruce and pine wood demonstrate a distinct effect of white rot decay pattern compared to the brown rot strategy for wood decomposition. We aim at characterizing the compounds, and have extended the experimental set-up and monitoring to a forest site.

The impacts of drought, nutrient enrichment and riparian canopy removal on stream invertebrate communities – preliminary results from a mesocosm study

Jussi Jyväsjärvi[1], Emma Göthe[2], Kaisa Lehosmaa[1], Ari Huusko[3], Timo Muotka[1], Brendan G. McKie[2]

[1]Ecology and Genetics Research Unit, University of Oulu, Finland; [2]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences Uppsala, Sweden; [3]Natural Resources Institute Finland (Luke)

Agriculture and forestry degrade stream ecosystems by removing riparian canopy cover and intensifying nutrient runoff from the catchment. In addition, hydromorphological impairment alters natural hydrological regime of streams and can result in drought periods of varying duration and severity. These three stress factors have been showed to induce considerable individual impacts on the structure and functioning of stream ecosystems, while their combined effects are poorly understood. We assessed the individual and combined impacts of these stressors using 24 stream mesocosms. We mimicked nutrient enrichment by increasing NO-3 and PO3-4 concentrations of the treatment flumes ca. 10-fold compared to the control levels. Impact of canopy removal was studied by covering the control streams with a shading fabric. Hydrological stress had three treatment levels: constant flow throughout the experiment, pulse-type drought (90% reduction in flow during nighttime for 9 d) and press-type drought (9 d). In my presentation, I will present the overall design of our mesocosm experiment and report the preliminary results of the impacts of our stress treatments on benthic macroinvertebrate communities. The stress treatments showed mainly individual effects on the species composition, abundance and diversity of invertebrate assemblages. Immediately after the drought treatments, canopy removal and pulse and press drought, in particular, altered the macroinvertebrate species composition, whereas nutrient enrichment had no effect on the community structure or diversity. After 21 d recovery period, the species compositional differences among the control and drought treatments were still detectable and also species abundance in drought treatments was lower relative to the control. Further data analyses will give us more comprehensive picture of how the studied stressors will affect central ecosystem functions and composition and diversity of other stream biota.

The plant-microbial impacts on soil processes with direct climate feedbacks: conclusions from studies on CO_2, CH_4, N_2O, VOCs and amines

Jussi Heinonsalo[1,2,3], Elisa Halmeenmäki[2,4], Antti-Jussi Kieloaho[5], Liisa Kulmala[2,3], Mari Mäki[2], Mari Pihlatie[2,4], Jukka Pumpanen[6], Anuliina Putkinen[2,4], Kira Ryhti[2], Minna Santalahti[1,2,4], Outi-Maaria Sietiö[1] & Jaana Bäck[2]

[1]Department of Microbiology, University of Helsinki, Finland; [2]Institute for Atmospheric and Earth System Research, University of Helsinki, Finland; [3]Finnish Meteorological Institute FMI, Helsinki, Finland; [4]Department of Agricultural sciences, University of Helsinki, Finland; [5]Finnish Natural Resource Institute; [6]Department of Environmental and Biological Sciences, University of Eastern Finland, Finland

We have conducted a series of experiments in boreal Scots pine forest ecosystem where the aim was to discover in which ways plants and their root-associated microbes affect the atmosphere through greenhouse gases (GHGs) or various volatile organic compounds (VOCs). In the laboratory, we identified VOCs produced and quantified the amine content of different soil-inhabiting fungi. We have mathematically estimated whether boreal soil is a source or sink of two amines that are known to affect aerosol and cloud formation processes. In the greenhouse experiments we studied how the roots and shoots of different boreal forest plant species, Calluna vulgaris, Vaccinium myrtillus, V. vitis-idaea and Pinus

sylvestris, affect the CH_4 production or consumption, and how these plant species differ in their CO_2 dynamics. In the field, where the below-ground C allocation of plants was restricted using trenching and ground vegetation removal, we studied how C flow to soil affects soil CO_2 fluxes but also VOC, CH_4 and N_2O production or consumption. Finally, we studied if there are biogenic components in the atmospheric aerosols by quantifying their DNA content and performed qPCR to estimate fungal and bacterial presence.

We have found several direct climate-feedback that are of plant-microbial origin. Soil fungi actively produce or their biomass contain climatically important volatile organic compounds. Belowground C flux did not play a significant role in CH_4, N_2O or VOC fluxes whereas plant-derived C compounds affect soil processes through priming. Ground vegetation has also an important contribution to soil C cycling and CO_2 fluxes.

Changes in treeline ecosystem and its herbivore assemblage in a changing world

Otso Suominen, Piippa Wäli, Anna Liisa Ruotsalainen, Karita Saravesi, Maarit Kaukonen, Karoliina Huusko, Heini Koivuniemi & Annamari Markkola

University of Turku, Finland

Many plant, animal, and pathogen species expand their range northwards due to global change. The abundance of the existing species may change as well. These range and abundance changes lead to changes in biotic interactions in ecosystems. This will have an impact on natural resources and people in the arctic. We give an example where the invasion of a new insect herbivore changes the whole ecosystem. The first known outbreak of winter moth in Finnish Lapland occurred in 2005-2009. It killed the birches from large areas, and led to drastic changes in vegetation, berry and mushroom production, as well as vertebrate populations.

The amount of alive birches and the coverage of dwarf shrubs declined dramatically during the outbreak. In areas where the outbreak continued for two or more consecutive summers, the death of birch trees was often total, grasses took over the field vegetation and the recovery of the dwarf shrubs was very slow. By 2015 it seemed evident that large parts of the damaged areas will turn from forest to treeless tundra. Despite a measurable increase in temperature and length of the growing season during the last 55 years, the area of treeless tundra has increased 20 % in the northernmost Finland thanks to moth outbreaks and reindeer summer grazing on birch trees. Berry production of Empetrum and Vaccinium shrubs ceased after the moth outbreak and it took several years to recover. Fruitbodies of ectomycorrhizal fungi of birch were virtually absent on damaged plots whereas saprophytic macrofungi increased their fruiting along the moth damage gradient. Population densities of voles increased with the increased moth damage after the outbreak. These differences were noticeable even 10 after the outbreak. Snow track counts revealed that winter densities of willow ptarmigan and mountain hare crashed in the damaged forests after the outbreak.

Coherence, stability and species turnover in boreal stream communities

Kaisa-Leena Huttunen

Department of Ecology and Genetics, University of Oulu

Describing how and why species composition of ecological communities varies across spatial and temporal scales is a primary objective for ecological research. A key challenge is to distinguish changes in community composition resulting from external factors from the natural background variability. Using long-term data sets from Finnish boreal streams I studied (natural) temporal variation of stream macroinvertebrate communities its level, causes and consequences. A majority of the studied communities showed lower

level of inter-annual variation than expected by chance. The observation of high stability was further supported by the low level of inter-annual variation in taxonomic completeness (quotient of observed and expected number of species, O/E). However, despite the low absolute variation in O/E, ecological status assessments varied annually. Thus the use of one year data may bias management decisions. Macroinvertebrate communities experienced similar dynamics across several spatial extents suggesting that large-scale extrinsic factors are the major driver of community dynamics. Especially climatically exceptional years may have a strong effect. However, at the within-stream scale, coherence was lower than expected, indicating that community dynamics may be driven by different processes at different spatial extents. Stream macroinvertebrate community dynamics were strongly related to in-stream vegetation, temporal variability decreasing with increasing macrophyte cover. Importantly, the effect of in-stream vegetation on temporal turnover of macroinvertebrate communities was masked by the stochastic effect of habitat connectivity, suggesting that unless stochastic effects are controlled for, the role of deterministic processes may be obscured, thus affecting our ability to understand and predict community changes through time.

Mycological long-term inventories at Kuusamo, Oulanka

Esteri Ohenoja

Botanical Museum, Department of Ecology and Genetics, University of Oulu

Kuusamo is situated on the northern boreal zone, but the mycoflora is characterized by both the southern, eastern and northern elements. Variable topography and basic bedrock have created rich and diverse habitats. Knowledge of the fungal flora of Kuusamo (Koillismaa biological province) is moderate and dealt by several Finnish and foreign mycologists. Tens of the species are listed in the Red Book of Finland.

Quantitative-qualitative mushroom yield measurements have been carried out in the years 1976-1978 (Ohenoja 1993) and 1989-1993 (Pynssi 2014) at Oulanka where in all 12 permanent experimental plots were monitored during mushroom seasons from July to September. Fungal species and their production were also measured on different elevations of the sloping terrains (Kela 1979) during three autumn seasons. Because the studies were performed in the Oulanka national park, the human influence has not been as effective as in the forests under economic utilization, but the continuous trampling by the reindeer herds has had a large-scale impact on the field layer specially in the driest pine stand. Also the severe winter conditions in 1986-1987 were reflected to the crop of that pine stand where some trees even died. Less dry ecosystems were more stable from year to year, though the natural dynamics of the fungal world are always driven by successional changes.

According to the studies in Great Britain (Gange et al.2007) the fungi have also given some indication of the possible effects of climate change, and there have been changes in the phenology of fungal fruit body production, too. The phenology of the yields and the seasonal occurrence of different species in our materials need more analytical work and may give some information also about the impact of climate change.

References:

Gange, A.C., Gange, E.G., Sparks, T.H. & Boddy, L. 2007: Rapid and recent changes in fungal fruiting patterns. – Science 316, 71.

Kela, P.1979: Sienten itiöemätuotosta Pohjois-Suomessa vv. 1976-77 sekä rinteiden sienisadosta ja –lajistosta Oulangalla vv. 1976-78. – Pro gradu-tutkielma, manuscript (unpubl)

Ohenoja, E. 1993: Effect of weather conditions on the larger fungi at different forest sites in northern Finland in 1976-1988. –Acta Univ. Oulu, Ser. A, 243.

Pynssi, K. 2014: Sienten itiöemätuotanto ja lajisto Kuusamossa Oulangan kansallispuistossa vuosina 1976-1978 ja 1989-1993. – Pro gradu-tutkielma, manuscript (unpubl.)