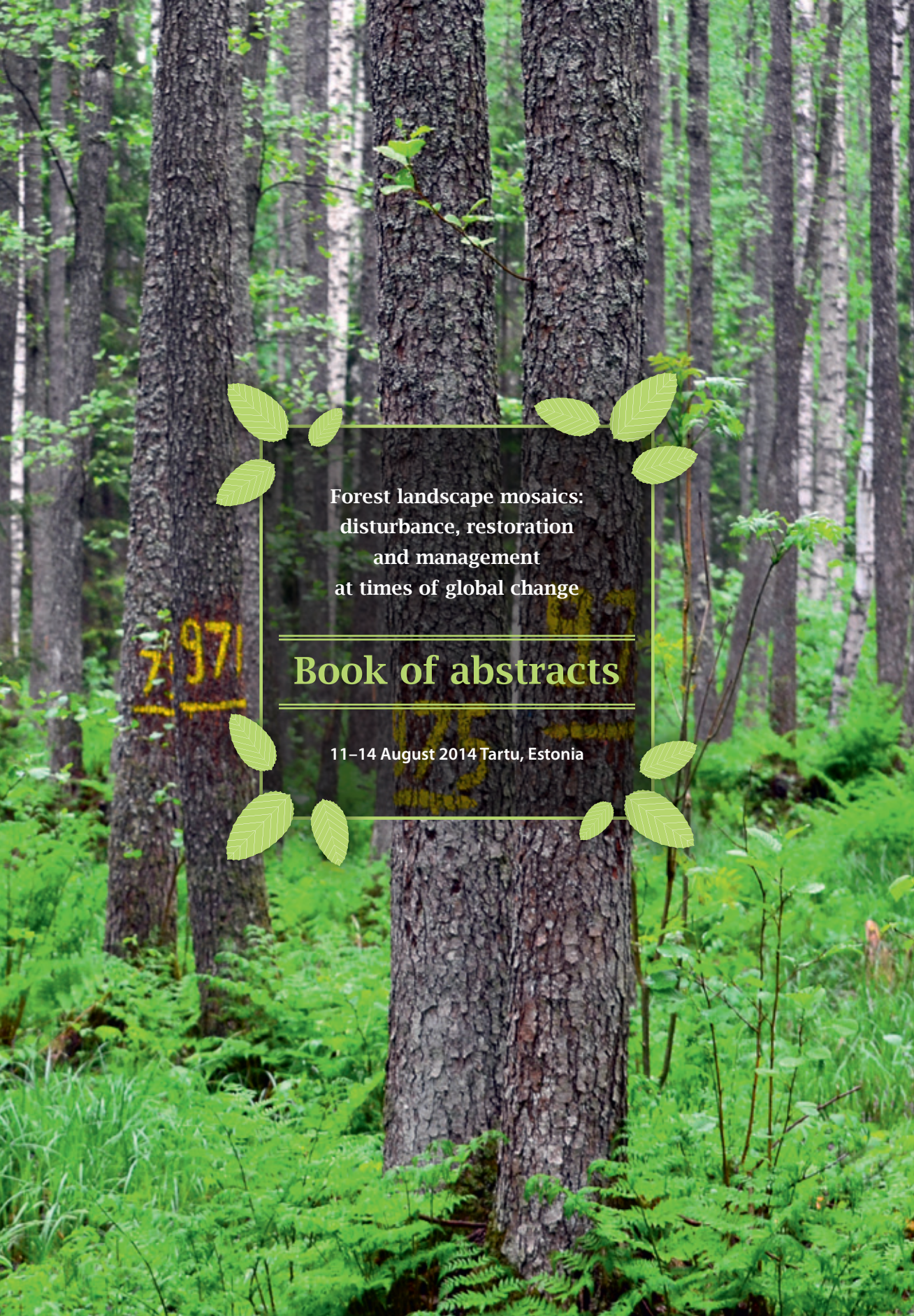

Forest landscape mosaics: disturbance, restoration and management at times of global change

Book of abstracts

11–14 August 2014 Tartu, Estonia

Transactions of the Institute of Forestry and Rural Engineering
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Book of abstracts

Edited by:
Ahto Kangur, Marek Metslaid, W. Keith Moser, Piret Trei

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Foreword

The nature which surrounds us plays a central role in our existence. This is difficult to comprehend, as usually we place ourselves at the center of human existence. If we think of humans as a part of nature, then the environment will be equally important and central (the Estonian word "keskkond" for environment refers to the "center of being").

Ecology has typically focused on pristine systems free from human interference. However, as human influence has become ever more pervasive, there is a growing need for theory to address less than pristine systems. A major question then for ecologists and land managers is the degree of naturalness of a system.

Although in the past forestry focused on production of a few commodities, the threat of global environmental change demands that we adopt a new paradigm of forest management that combines past knowledge with innovative management planning strategies that consider a full range of projected ecosystem responses, and resilience to unanticipated factors.

It is our great pleasure to host the conference **Forest landscape mosaics: disturbance, restoration and management at times of global change, August 11–14, 2014**. This meeting brings together scientists, practitioners, policymakers and other experts to share experiences with disturbance management, and evaluate past, present and future application and implementation of research findings from the scientific community.

The initiative comes from two working groups of EFINORD/SNS: the network of Natural Disturbance Dynamics Analysis for Forest Ecosystem Management (FORDISMAN) and the Nordic Working Group on the Ecology of Primeval Boreal Forests (PRIFOR). Two major organizations, IUFRO (International Union of Forest Research Organizations) and IAVS (International Association for Vegetation Science) create the main stage for the event. Sponsors supporting the meeting are gratefully acknowledged.

The meeting venue is Tartu, second largest city in Estonia and the center of university and science life in this country. The academic atmosphere of this town supports the constructive discussions and research environment needed for people to better understand the relations between humans and nature. The Estonian hemiboreal forest is a unique example of co-existence of people and trees: balanced management and conservation is our planned future.

We expect that good colleagues from all around the World will enjoy an interesting program, exciting excursions and social events.

Kalev Jõgiste
Chairman of the
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Invited speakers

Forest disturbances and ecosystem management strategies in a climate change context: examples from the Canadian boreal forest

Sylvie Gauthier

Natural Resources Canada, Canadian Forest Service, Canada

Natural disturbances are important drivers of the Canadian boreal forest dynamics. In Canada, sustainable forest management (SFM) is the framework upon which the boreal forest is managed. One approach to conducting SFM in management units is ecosystem management (EM) inspired by natural disturbances. While this approach is now being implemented in several Canadian jurisdictions, there is a realization that as climate is changing, so are natural disturbances. In this talk, I will give examples of regional natural disturbance regimes, notably fire and insects in the Canadian boreal forest. I will describe how this knowledge is used to define EM strategies and practices that aim at reducing the differences between natural and managed landscapes. I will then show how these disturbance regimes are projected to change in the future and discuss how this may impact our ability to conduct SFM. In light of these forecasted changes, I will also discuss the usefulness of the EM approach. Finally, I will provide adaptation avenues for maintaining our ability to conduct SFM in these conditions.

Gauthier, S. 2014. Forest disturbances and ecosystem management strategies in a climate change context: examples from the Canadian boreal forest. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 7.

Management of disturbance legacies in forest ecosystems of the hemiboreal zone

Kalev Jõgiste, Floor Vodde, Ahto Kangur, Marek Metslaid, Henn Korjus, Kristi Nigul

Estonian University of Life Sciences, Estonia

Quantitative models of forest ecosystem dynamics after disturbances are important tools to study the scenarios of management of natural resources. The template for management activities is sought in the process patterns of near-natural forest communities. Near-natural forest communities are rare in areas of intensive forest management. The condition of those forest ecosystems depends on the temporal and spatial pattern of management interventions and natural disturbances.

Natural and anthropogenic disturbances of forest ecosystems affect the carbon balance on a global scale. Times of global change require consideration of underlying causes and ecosystem response. Knowledge of ecosystem response and resilience provide basic descriptive components required to construct numeric models of the carbon balance.

We have defined a conceptual framework to compose an operational model of forest dynamics depending on the condition and type of legacies. Gap dynamics create steady state conditions at the stand and landscape scale. Stand replacing disturbance events result in forests in different stand development phases at the landscape scale. Biotic and abiotic legacies after stand replacing disturbances determine the dynamic properties of forest ecosystems and vary according to forest conditions and disturbance agent. The three main scenarios involving anthropogenic drivers from the East-Baltic Sea area that substantially change successional trajectories via legacies are these: disturbance manipulation, common forest management practice and temporal agricultural deforestation. The management of legacies in the course of forest dynamics determines the basic characteristics of a near-natural forest. Conversion (restoration) of semi-natural vegetation to desired state depends on the legacy manipulations.

Characteristic for the eastern Baltic Sea region are the historically relatively close-to-nature approach to forest management (to a large extent based on natural regeneration) and the nationally high level of forest cover throughout the centuries (promoting the continuity of habitat related to old-growth forest). Rational management of natural disturbance legacies (CWD, geomorphological heterogeneity, advance regeneration) can benefit commercial forestry, carbon sequestration and ecological integrity of a forest ecosystem.

Jõgiste, K., Vodde, F., Kangur, A., Metslaid, M., Korjus, H. Nigul, K. 2014. Management of disturbance legacies in forest ecosystems of the hemiboreal zone. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 8.

Restoration of forests from practitioner's perspective

Kaisa Junninen

Metsähallitus Natural Heritage Services, Finland

Over 16,000 ha of forests have been treated with restoration measures by Metsähallitus Natural Heritage Services in protected areas of Finland since 2003. Practical measures of restoration include controlled burning, artificial creation of deadwood, and opening small canopy gaps. In addition, ecological management, like removal of spruce from herb-rich forests or creating habitat for the white-backed woodpecker, has been commonly practiced in protected areas. Recently the first results on biodiversity impacts of some of these activities have been published. For example, burning has proved to be effective in creating habitat for species-rich assemblages of polypore fungi, and canopy gaps in facilitating the establishment of tree seedlings. On the other hand, some unexpected outcomes of restoration measures have been observed. The way of producing artificial deadwood may affect the quality of deadwood which, in turn, may greatly affect the deadwood-dependent species communities. Furthermore, climate change and bark beetles impose new challenges on restoration, and practical measures need to be adjusted accordingly. At the moment, the emphasis is shifting from traditional forest restoration to ecological habitat management, e.g. management of herb-rich forests and sun-exposed habitats.

Junninen, K. 2014. Restoration of forests from practitioner's perspective. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 9.

Projecting future forest composition and the importance of disturbance assumptions in temperate and boreal forests

W. Keith Moser[1], Stephen R. Shifley[2]

(1) Rocky Mountain Research Station, U.S. Forest Service, Southwest Forest Science Center, United States of America
(2) Northern Research Station, U.S. Forest Service, United States of America

Concerns about future climate have generated many projections of the composition of future natural ecosystems. The challenge in such modeling is the expected outcomes of novel situations, i.e., future conditions that do not exist today and hence are difficult to project. The Northern Forest Futures Project represents one approach of modelling temperate forests in a part of North America. It examines today's trends and choices and projects how these might change the future forest landscape under differing climate and disturbance scenarios. The study area covers a 20-state region over the U.S. Midwest and Northeast. This region is the most heavily forested and most densely populated region in the nation (Shifley et al., 2012). Analyses for northern forests explore projected conditions from 2010 to 2060 for seven scenarios with differing assumptions about changes in population, land use, harvest removals, and climate. The transition matrix used to drive these projections (Wear et al., 2013) was based upon historical data derived from national forest inventories of 1999 through 2008. Those projections suggest that differences in the trajectory of forest change attributable to alternative climate scenarios become apparent in approximately 2050. However, for the period in question, the principal influences remain other anthropogenic disturbance factors associated with shifts in land use, population change, management practices, and the inadvertent transport of invasive organisms. Although some climate models project increased disturbances (e.g., due to violent weather), these projections did not attempt to generate novel (i.e., non-historical) weather-related disturbances. Without widespread, severe disturbances or dramatically increased biomass harvesting for energy, we project forest changes in the study area over the next 50 years will be dominated by continuation of patterns of gradual forest aging and species succession that will be complicated, but not overwhelmed, by a changing climate and expansion of 5 million ha of new urban land into forested areas. Future global forces that may substantially alter these expected changes in U.S, forests include 1) introductions of new invasive species facilitated by increased global trade, 2) global energy prices that affect the economic feasibility of wood based-bioenergy in the U.S. 3) energy policy decisions in foreign countries that increase demand for wood pellets from U.S. forests, 4) international progress (or lack thereof) in reducing greenhouse gas emissions and the associated impact on relative forest value for energy or carbon sequestration, and 5) global technology breakthroughs that greatly reduce carbon dioxide emissions associated with energy production and/or greatly increase demand for wood fiber (e.g., efficient cellulosic fuel production or increased utilization of cellulosic nanomaterials).

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Shifley, S. R., Aguilar, F. X., Song, N., Stewart, S. I., Nowak, D. J., Gormanson, D. D., Moser, W. K., Wormstead, S., Greenfield, E. J. 2012. Forests of the northern United States. Gen. Tech. Rep. NRS-90. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 202 p.

Wear, D. N., Huggett, R., Li, R., Perryman, B., Liu, S. 2013. Forecasts of forest conditions in regions of the United States under future scenarios: a technical document supporting the Forest Service 2012 RPA Assessment. Gen. Tech. Rep. SRS-GTR-170. Asheville, NC: USDA-Forest Service, Southern Research Station. 101 p.

Moser, W. K., Shifley, S. R. 2014. Projecting future forest composition and the importance of disturbance assumptions in temperate and boreal forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 10.

A dynamic view on primeval forest landscapes

Ekaterina Shorohova[1, 2]

(1) Finnish Forest Research Institute (METLA), Finland
(2) Saint-Petersburg State Forest University, Russia

Temporal and spatial scales influence our perceptions of whether changes are gradual or abrupt; is an ecosystem resilient or not. The knowledge on the long-term dynamics of primeval forests especially at the landscape scale is rather limited. We examine the range of spatial and temporal variability in the structure of primeval European boreal forest landscapes based on changes in living biomass, coarse woody debris (CWD) mass and diversity, dominating tree species and their population attributes as well as the proportion of patches with different disturbance regime and stand dynamic types. Variation in above parameters characterize the resilience of forest landscape - its capacity to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks. We summarize the results from 6 case studies in the Norway spruce dominated landscapes of Vepssky Reserve, Central Biosphere Forest Reserve, Vodlozersky national park, Visimsky Reserve and Kenozersky national park as well as Scots pine dominated landscape of Aschozersky reserve. The landscape structure and dynamics were examined for the periods of 20–100 years using complex set of methods including analyses of forest inventory data, archive materials, periodic aerial photographs, satellite images, thematic mapping, results of measurements on regularly placed sample plots and transects and dendrochronological dating of fire scars. Wind was prevailing disturbance agent in spruce dominated landscapes. In some years, it led to substantial changes in the landscape structure. The living biomass decline up to 51% was followed by 'burst' of regeneration and consequent biomass growth. Young and small trees became dominating in the tree population structure for few decades. The share of large CWD of earlier decay classes increased significantly as compared to pre-disturbance stages. The proportion of the even-aged stands in the landscape increased as well. The dynamics of pine dominated landscape driven by surface fire caused wavy fluctuations in all parameters. The severity of disturbances and rates of recovery after them depended on the successional status of landscapes determined by proportions of forest stands with fine-scale gap dynamics vs. cohort or even-aged dynamics being at phases of living biomass increase, decrease or stable state.

Shorohova, E. 2014. A dynamic view on primeval forest landscapes. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 11.

Forest vegetation change during Holocene: climate and human

Shinya Sugita

Institute of Ecology, Tallinn University, Estonia

Sedimentary records of plant and animal remains and geochemical tracers from lakes and bogs provide useful, and sometimes surprising, information on the Holocene changes in climate and vegetation. Very rare events, such as pathogen outbreaks, regime shifts of cyclonic systems, and extreme climate events that have occurred once every few millennia, were once regarded as quaint but irrelevant for modern plant and forest ecology. In addition a major gap in thinking, or misunderstanding, between ecologists and palaeoecologists persisted because of the differences and mismatches in spatial and temporal scales of the research framework and in research approaches (e.g. experimental vs observational.) However, advances in theoretical and modeling approaches and technology, such as remote sensing and GIS, over the last few decades have helped bridge the gap greatly. In view of human-induced global environmental and climate change, palaeorecords and their implications become relevant for ecologists to consider future changes in forest dynamics across space and time. Taking examples from studies of my own and collaborators' in northern Europe and North America, this talk will demonstrate the extent to which anthropogenic impacts have affected the Holocene forested landscapes in northwestern Europe, how forest and land-cover mosaics in the local- and landscape scales have changes in Scandinavia and its vicinity and a part of the Midwest of the US, and what the major factors and possible mechanisms are for those changes. A combination of observational, experimental and modeling approaches is critical in both ecology and palaeoecology to better understand how natural and anthropogenic forcing factors interact and affect on forest dynamics in complex and unexpected ways – a unique event in the Earth System history.

Sugita, S. 2014. Forest vegetation change during Holocene: climate and human. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 12.

Oral presentations

Decadal-scale changes in naturally dynamic boreal forests

Tuomas Aakala[1], Louis Degrandpré[2], Yasuhiro Kubota[3], Timo Kuuluvainen[1], Sylvie Gauthier[2]

(1) University of Helsinki, Finland
(2) Natural Resources Canada, Canada
(3) University of the Ryukyus, Japan

Global environmental change is altering forest dynamics. Emphasis in many studies documenting this change has been on growth responses of individual trees to altered conditions, while the influence of other demographic processes (recruitment and mortality) in natural forests remains elusive. The sum of these processes is apparent at stand and landscape levels, but understanding the drivers behind this development requires linking the observed development to the individual tree-level.

To explore the developmental trends in stand structure in recent decades, and to clarify the influence of different demographic processes, we compare trends and variation in tree growth and stand structural development using dendroecological reconstructions spanning several decades. Our data comes from two areas with contrasting disturbance regimes, consisting of a total of 66 mapped 0.1 ha plots in northern Finland and northeastern Quebec, Canada. Here, we report variation and developmental trends in stand structure, and partition the observed changes to those due to growth of individual trees, recruitment of new trees, and tree mortality.

Aakala, T., Degrandpré, L., Kubota, Y., Kuuluvainen, T., Gauthier, S. 2014. Decadal-scale changes in naturally dynamic boreal forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 15.

Response of wood-inhabiting fungal species to species associations

Nerea Abrego[1], David Dunson[2], Panu Halme[1], Isabel Salcedo[3], Otso Ovaskainen[4]

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(2) Duke University, United States of America
(3) University of the Basque Country, Spain
(4) University of Helsinki, Finland

Many ecological works have measured the impact of forest management on species richness and community composition. Nevertheless, the effects that human induced changes cause on species interactions are in general poorly investigated. Wood-inhabiting fungi provide an interesting case study of a highly interactive community following resource-consumer dynamics. Moreover, wood-inhabiting fungi have been much influenced by forest management, which has increased fragmentation in forested landscapes and reduced the availability of dead wood. However, it remains unknown how the specialized associations between wood-inhabiting fungi influence their responses to forest management and conversely how the associations are affected by forest management. Here we address this topic using a dataset consisting of ca. 22,000 dead wood pieces located in both managed and natural beech forests. The aims of this work are to examine 1) if species which are specialists in the sense that they are associated with other species are especially sensitive to habitat loss and fragmentation, 2) how much of the responses of species to management can be assigned to direct effects (reduced availability of resources) and how much to indirect effects (effects mediated by interactions), and 3) if habitat loss and fragmentation have modified the outcomes of species interactions.

We found a large number of ecologically relevant negative and positive species-to-species associations within the wood-inhabiting fungal community. Apart from the loss of niche-specialist species, forest management has led to a loss of those species which have strong associations with other species. Further, our results suggest that the environmental changes caused by forest management can modify the interactions among species: the associations estimated from natural forests were much stronger than those present in managed forests.

These results enhance the importance of the conservation of wood-inhabiting fungal species interaction networks. Indeed, we show that in managed forests, the disappearance of such species which are specialised in growing associated to others can carry secondary species-loss, and that competitive hierarchies among species can be altered, increasing the risk of pathogen fungal infections or altering the decomposers food web.

Abrego, N., Dunson, D., Halme, P., Salcedo, I., Ovaskainen, O. 2014. Response of wood-inhabiting fungal species to species associations. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 16.

Dead wood in managed and abandoned *Quercus petraea* and *Q. cerris* dominated forests in north Hungary

Réka Ádám, János Bölöni

MTA Centre for Ecology Institute of Ecology and Botany, Hungary

Dead wood has great importance in forest ecosystems. Snags, logs and broken-down branches are essential habitats for several groups of organisms. *Quercus cerris* and *Q. petraea* dominated oak forests cover more than 120 000 ha in Hungary. The species composition of this forest type is well known, but we have less information about stand structure, especially about the quantity and quality of dead wood. The amount and quality of dead wood was assessed in managed and abandoned oak forests. 332 sampling plots were selected in North Hungary: 154 in managed and 178 in abandoned stands. In case of living and standing dead trees, we used a combined sampling method: we measured smaller trees (DBH 30 cm) was negligible (1/ha). In case of abandoned forests the average living stock was 310 m^3/ha and the basal area was 28.12 m^2/ha. In these stands there were more dead wood: total volume was 39.3 m^3/ha, dead wood ratio was 11%, average standing dead wood volume reached 13.8 m^3/ha, the log volume 25.5 m^3/ha, and the number of large dead trees was 16/ha. Compared with few available data, there are similar amount of dead wood in European managed (1–27 m^3/ha) and abandoned (1–209 m^3/ha) oak forests than in Hungarian ones. Regarding the remaining European primeval oak forests, we could find dead wood data only from Poland (Białowieża), where the total dead wood volume was 132 m^3/ha, and 90% of this amount was lying dead trees (average 119 m^3/ha). As the results show, there are fewer dead wood in managed stands than in abandoned forests. In some cases the amount of dead wood in abandoned forests approach the amount measured in primeval forests. It seems the more time elapsed since the last human disturbance the higher is the lying dead wood ratio.

Ádám, R., Bölöni, J. 2014. Dead wood in managed and abandoned *Quercus petraea* and *Q. cerris* dominated forests in North Hungary. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 17.

Ground vegetation diversity and carbon storage in abandoned and afforested arable land in South Lithuania

Jurate Aleinikoviene[1], Kestutis Armolaitis[1], Vilma Zekaite[2], Milda Viltrakyte[1]

(1) Lithuanian Research Centre for Agriculture and Forestry, Institute of Forestry, Lithuania
(2) Lithuanian Research Centre for Agriculture and Forestry, Perloja Experimental Station, Lithuania

Abandonment of infertile arable sandy soils is prevalent in the south of Lithuania. The abandoned arable land could be maintained as perennial grassland or afforested. We evaluated the changes in ground vegetation and carbon accumulation in Arenosols, when arable land was abandoned for an 11- to 13-year-period or afforested with Scots pine (*Pinus sylvestris* L.) plantations 45–47 years ago. It was determined that the coverage of ground vegetation in abandoned and in afforested landscapes was similar and exceeded 70 percent. Thus, compared with abandoned land, ground vegetation plant diversity was about fivefold lower in Scots pine plantations. However, in both landscapes the warmth-tolerant plants in ground vegetation were predominant. The indicated changes in ground vegetation could be similar to those that are predicted under climate warming. Meanwhile, the carbon storage in the biomass of Scots pine plantations (tree storey + ground vegetation + roots) was more than 40 times greater and the stocks of soil organic carbon (soil organic layer + 0–100 cm mineral horizons) - by 1.7 times higher than that in abandoned arable land.

In changing landscapes the estimation of ground vegetation diversity and carbon storage could assume the dimensions of expected trends under climate change. Our findings suggest that the afforestation of abandoned arable land is relevant with the focus on carbon storage. Thus, the abandonment may be an appropriate way to preserve ground vegetation diversity.

Aleinikoviene, J., Armolaitis, K., Zekaite, V., Viltrakyte, M. 2014. Ground vegetation diversity and carbon storage in abandoned and afforested arable land in South Lithuania. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 18.

Long-term impact of wind storm on stand composition in hemiboreal forests: case study in Slitere National Park, Latvia

Endijs Baders[1], Kalev Jõgiste[2], Karlis Taukacs[1], Janis Donis[1], Aris Jansons[1]

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(2) Estonian University of Life Sciences, Estonia

Natural disturbances are affecting composition of forest stands and landscapes. However, information on natural composition of forest stands forming as a result of large scale disturbances is mostly limited to studies covering sparsely inhabited areas in boreal forests. Therefore aim of our study was to quantify characteristics of forest stands forming after large-scale wind storm in absence of any management.

Study site was located in north-western region of Latvia (57°38'N, 22°17'E), part of Slitere National Park that has been excluded from management activities since year 1923 and has been severely affected by wind storm in November 1969. Areas for the study were randomly selected from list of compartments where less than 10% of trees have survived after the storm based on forest inventory data. Borders of stands were determined according to forest type (indicated by ground vegetation) and 4 circular sample plots (500 m^2) established systematically on longest diagonal of the stand. Tree height and diameter were measured, damages noted and, to determine age structure, increment cores taken form 15 trees per sample plot.

Naturally regenerated stands almost 45 year after the storm (October 2013) had remained Norway spruce dominated on dry mineral soils (Oxalidosa forest type) – spruce 51%, birch 30%, aspen 17% from total number of trees – but changed to broadleaved tree dominated with notable spruce admixture on wet mineral soils (Myrtilloso-polytrichosa and Myrtilloso-Sphagnosa forest type) – birch 43%, spruce 40%, black alder 15%. Analysis of age structure revealed, that most of the spruces were advance regeneration, released after the storm. Stands had density ranging from 1773 tree ha^{-1} to 1888 tree ha-1, corresponding to basal area 25 m^2ha-1 and 43 m^2ha^{-1} on wet and dry soils respectively. Basal area in un-managed stands was notably higher than in 45 years old managed Norway spruce stands: 19.2 m^2ha^{-1} and 24.4 m^2ha^{-1} (NFI) however, the diameter of trees was significantly smaller: 11.2±0.24 and 11.3±0.34 cm vs. 19.3±2.2 and 22±2.0 cm for Norway spruce on wet and dry soils respectively and 12.1±0.36 and 14.3±0.63 cm for un-managed birch on wet and dry soils respectively.

Indexes characterizing stand structure are calculated and implications for conservation measures discussed.

Study was permitted by Nature Conservation Agency and financed by European Social Fund project No. 2013/0022/1DP/1.1.1.2.0/13/APIA/VIAA/052.

Baders, E., Jõgiste, K., Taukacs, K., Donis, J., Jansons, A. 2014. Long-term impact of wind storm on stand composition in hemiboreal forests: case study in Slitere National Park, Latvia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 19.

Forest restoration after land use change: the formation of landscape mosaics in the center of European Russia

Maxim Bobrovsky[1], Svetlana Moskalenko[1], Larisa Khanina[2]

(1) Institute of Physicochemical and Biological Problems in Soil Science RAS, Russia
(2) Institute of Mathematical Problems in Biology RAS, Russia

About 400,000 km^2 of agricultural lands were abandoned in Russia in 1980–1990. Spontaneous reforestation has begun since then and has continued over the last 20–30 years. The aim of our study was to compare a restoration of the vegetation on abandoned lands with and without human impacts (mainly grass burning).

Abandoned arable lands and pastures surrounded by old-growth broad-leaved forest and located in the Reserve "Kaluzhskie Zaseki" (Kaluga region) were selected as our study area. The ancient forest contains all of the species of broad-leaved trees which can grow here, such as *Quercus robur, Fraxinus excelsior, Tilia cordata, Ulmus glabra, Acer platanoides,* and *A. campestre*. Trees in the stands were up to 300 years old. Vegetation was sampled at the plots (10 m × 10 m) along transects; adjacent plots (2 m × 2 m) have also been described along transects to explore the dispersal of forest herbs.

Our results show that rates of change and pathways of the forest restoration are determined by (i) the type of lands (arable land or pasture), (ii) the presence and frequency of exogenous disturbances (grass burning), and (iii) forest plants' seed flow from the neighbour forests.

Composition of the forest vegetation recovers rather quickly after the abandonment of tillage, provided that no fires occur. *Betula* spp. and *Salix caprea* dominate in the overstorey over the entire area of the arables. In the understorey all tree species from the adjacent high forest are found. Soil fertility and texture of deposits do not influence the composition of trees in the understorey. For 30 years forest herbs settled at a distance of 120 m from the ancient forest. Most herbs became established 50–70 m from the forest.

On pastures without grass burnings complex communities with forest species and rich meadow-edge flora have been formed. Light-demanding trees, such as *Quercus robur, Malus sylvestris, Pyrus communis,* are successfully renewed there. If the succession is interrupted by grass burning, the greatest number of vegetation communities with the highest plant diversity will ocur. However, dispersal of forest plants is considerably delayed.

The 20- to 30-year length of forest restoration on the abandoned lands is equal to the duration of the "rest phase" in traditional land uses, such as slash-and-burn and shifting cultivation. It allows us to estimate the input of traditional land-use systems into the formation of forest landscape mosaics.

Bobrovsky, M., Moskalenko, S., Khanina, L. 2014. Forest restoration after land use change: the formation of landscape mosaics in the center of European Russia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 20.

Impact of 80 years of forest management on landscape structure and pattern in the eastern Canadian boreal forest

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Natural disturbances create a mosaic of patches of different compositions and ages in the landscape, which are themselves heterogeneous in their fine-scale composition and patterns. Forest management can greatly alter these patterns, particularly in landscapes where the rate of forest harvesting is greater than of natural disturbances. The objectives of this study are 1) to assess the effect of 80 years of forest management at the landscape scale on forest age, composition, density and spatial configuration and 2) to compare the composition, density and heterogeneity of forest originating from harvestings of 1920–1950 *versus* fires of the same period. We used forest inventory maps and satellite images to compare two contiguous managed and an unmanaged territories of ≈18 000 km^2 of eastern boreal forest of Canada. In addition to reduce drastically the proportion of old-growth stands in the landscape, results indicated that forest management greatly changed the composition at both landscape and harvesting/fire scales, favouring the late-successional species balsam fir. The predominance of this species in old harvested forests could be explained by the great abundance of advanced regeneration kept intact by harvestings but destroyed by fire. Species that established naturally after fire as black spruce or hardwoods were greatly reduced in harvested forests. Stand density was higher in the managed territory but less associated to physical factors (elevation, slope, deposit thickness) than in unmanaged forests at both scales. Analyses of landscape metrics indicated that old-growth forests were more fragmented, presented less connectivity and were confined into smaller patches in managed territory than in unmanaged one. Young harvested stands in managed territory were also more fragmented than old-growth stands in unmanaged territory, suggesting that these patterns will persist for many decades.

Boucher, D. 2014. Impact of 80 years of forest management on landscape structure and pattern in the eastern Canadian boreal forest. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 21.

Cross-border comparison of forest cover changes in northeastern Europe caused by clear-cutting

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Boreal and northern temperate forests are subjected to several kinds of tree removal disturbances dominated by clear-cut logging. There is a need for quick and cost-efficient remote sensing methods to provide an independent means of detecting disturbances and recording the history of disturbances both at regional, national as well as at European level.

The forests at northern latitudes are characterized by winters in which snow cover remains for some months of the year. Winter images are particularly suitable for change detection in forests, while snow provides a uniformly bright background that accentuates tree crowns and their shadows and provides remarkable conditions for separating forested areas from non-forested areas.

We highlight a methodological approach of remote sensing based mapping of forest patches and forest disturbances in the Baltic region covering the areas of Estonia, Latvia and Lithuania. We have used multi-temporal winter imagery, obtained from archives of moderate resolution satellites Landsat and Spot and from scanner Aster. The winter images are supplemented with leaf-on summer Landsat imagery. The time period covered with satellite images is from 1985 to 2013. The disturbances are recorded with approximately five year time increment intervals. The moderate resolution satellite images were supported locally with high resolution satellite images, orthophotos and database data if available.

Results show that a very simple approach using winter images is useful in mapping forest patches, and canopy removal disturbances in forests. Our results show that forest harvesting rates were moderate in the early 1990s, however harvesting rates accelerated in all three countries several years after the system change in 1991 leading to higher levels of forest fragmentation. Forest disturbance rates differed among the countries and were markedly different locally.

Budenkova, J., Kardakov, A., Liira, J., Peterson, U. 2014. Cross-border comparison of forest cover changes in northeastern Europe caused by clear-cutting. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 22.

Using polar ordination to evaluate ecosystem recovery and restoration progress

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Monitoring of ecological restoration is an essential component of adaptive resource management, both to evaluate the project site's contribution to landscape values and to compare and improve various restoration techniques that may have been employed. All restoration work has at least two points of reference: the original damaged state and the target or reference state. Most restoration projects have multiple values and attributes that we hope to improve, so it is typical that multiple traits can and should be monitored. These features make polar ordination (also known as Bray-Curtis ordination) in one dimension a useful tool for evaluating overall restoration progress relative to both original and target conditions. In this application, the ordination anchors or reference cases are explicitly identified *a priori*, rather than allowed to emerge from the multivariate data structure. Compositional data at the species or growth form level can be employed, as can structural or demographic data, with weighting applied to reflect management priorities. Using cover data after alternative techniques were employed to restore damage caused by off-road vehicles in wet subalpine meadows in west-central British Columbia (Canada), this technique showed that "no treatment" sometimes proves more effective than active management. This suggests the use of control plots (sampled contemporarily with treatment plots, and an essential component of all restoration projects) to be the more appropriate alternative as one anchor of the ordination when determining improvements gained by restoration interventions. Polar ordination can also be applied to document the successional recovery of ecosystems after natural disturbances, as illustrated in another example comparing early pine forest dynamics after mountain pine beetle and after fire.

Burton, P. 2014. Using polar ordination to evaluate ecosystem recovery and restoration progress. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 23.

Holocene spatio-temporal variability in natural and anthropogenic disturbance dynamics in Fennoscandia

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Vegetation dynamics and biodiversity are driven by a complex interplay of natural and anthropogenic disturbance and the associated feedbacks between vegetation dynamics and forest disturbance. Identifying and disentangling the cause and effect of forest disturbance is challenging, especially detecting natural and anthropogenic disturbance.

Holocene vegetation dynamics and disturbance history can be observed using palynological proxies e.g. pollen and charcoal and through the analysis of these proxies at varying spatial scale, we can explore forest succession, development and more specifically identify periods of high and fluctuating floristic diversity in relation to past disturbance history.

At the local scale, two forest hollows (<20 km apart) in southern Finland were analysed for high resolution pollen and charcoal analysis. Their compositional turnover and palynological richness are compared to identify unique and mutual vegetation change and disturbance history. Pollen gives an intuitive analogue of past vegetation change but does not give a spatially explicit description of land cover estimates so data from nearby regional lakes are used to quantify the vegetation reconstruction using the LRA model. At the continental scale, fire history variability was reconstructed for Fennoscandia using existing charcoal and fire scar records and compared to the Holocene distribution of Norway spruce (*Picea abies*) in five time series maps. Further, the dynamics LPJ-GUESS model was used to explore climate and fire disturbance as individual drives of Holocene biodiversity.

Early-Holocene vegetation dynamics and fire frequency are primarily driven by climatic variation. The regional expansion of Norway spruce does not coincide with local disturbance but is most likely driven by climate, specifically, continentality. The mid-Holocene decline in deciduous species and loss of floristic diversity corresponds to an increase in fire frequency at both local stand-scale sites however, this occurs 1600 years apart suggesting disturbance, not climate as the primary driver of biodiversity in Fennoscandia. This is confirmed in the modelled data. The natural re-occurring fire frequency in the southern Finnish boreal forest is approximately 400 year intervals, occurring pre- and post-spruce establishment at the local scale. However, the step-wise expansion of Norway spruce in Fennoscandia reduces biomass burning prior to the mid-Holocene increase in anthropogenic disturbance.

Clear, J., Bradshaw, R. 2014. Holocene spatio-temporal variability in natural and anthropogenic disturbance dynamics in Fennoscandia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 24.

Forest regeneration in north-eastern Poland following a catastrophic blowdown

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The most frequent disturbances in European forests are windthrows. In July 2002 hurricane damaged 30,000 ha of forests in northeastern Poland. Most of the damaged trees where logged and the area was planted. However, 445 ha in the Pisz Forest District was left without any intervention to observe the natural processes.

A study was conducted in the Pisz Forest District to better understand 1) the role of large-scale disturbances in the forest regeneration process, 2) the relationship between regeneration and the level of forest damage, and 3) the role of dead wood in the process of regeneration. We tested following hypothesis: the process of forest regeneration after the wind blowdown is shorter than 100 years as Polish foresters assumed.

Data were collected on sixty-fire 100-m^2 circular plots established in four forest compartments with different levels of forest damage. The measurements were done in 2005, and repeated in 2011 and 2013. All live and dead trees and live saplings were measured in each plot. Seedlings were measured in circular 10 m^2 subplots.

The results showed that tree species were mainly wind-snapped. Structure of stands has changed; basal area of slightly damaged stands has increased. Changes in forest floor cover were observed. Herb cover increased whereas mosses cover decreased in 2011. Natural regeneration began immediately after the hurricane, and the process apparently will take much less time than the 100 years expected by many Polish foresters. In 2005 four tree species regenerated in the studied area: Scots pine, silver birch, pedunculate oak and Norway spruce. The main tree species regenerated in this area was pine. The level of stand damage influenced the density of pine regeneration. In 2011 and 2013 density of natural regeneration increased and new species established. Scots pine was still the dominant tree species in the regeneration except in the completely damaged stand with removed wood, where birch dominated. Number of pine saplings increased dramatically in 2013. The same results were obtained for oak regeneration. Disturbances increase species diversity and create new forests of varied age, height and species structure. The results of the study will be useful for foresters and policy makers to change the approach for large-scale disturbances in Poland's forests.

Dobrowolska, D. 2014. Forest regeneration in north-eastern Poland following a catastrophic blowdown. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 25.

Fire disturbance pattern in Latvia: spatial and temporal aspects

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Fire is one of the most important disturbance agents, which affects forest in boreal zone. In Latvia, which is located in the hemiboreal zone, impact of fires is assumed to be less important. In accordance with the projections of climate change in the future, it is expected that in Latvia there will be an increase in frequency and length of drought periods.

Goals of the research project financed by JSC "LVM" were 1) to assess the actual relationships between the number of wildfires and stand types (forest fuel type (FFT)) depending on weather conditions, 2) assess spatial and temporal distribution of fires, 3) prepare future prospects of fire disturbances according to climate change models.

We analysed relationship between number of fires and weather conditions characterised by Nesterov index (NI) for period 2007–2011. During analysed period 50 days were with very high fire danger index and 205 to 250 days with high fire danger index. During these days emerged 65–75% of registered fires. Relationship between emergence of fires and forest fuel type group was not as strong as expected. The highest probability of fire emergence was during average or high NI periods in stands of high fire danger class (FFT). We found out that emergence of forest fires was more related to the vicinity of settlements, recreation sites etc.

Based on results of climate change models (ENSEMBLES) for scenario A1B we prepared outlook maps of fire danger for periods 2021–2050 and 2071–2100 at regional scale assuming no change in forest types and human behaviour.

Donis, J., Zarins, J., Jansons, A. 2014. Fire disturbance pattern in Latvia: spatial and temporal aspects. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 26.

Long and short-term regeneration patterns after large-scale disturbances in primeval Norway spruce forests in Bulgaria

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Subalpine Norway spruce forests in Europe are among the most affected by the different types of natural disturbances in alpine ecosystems. Studying succession as part of the cyclic model of natural ecosystems (succession-disturbance) is of key importance for understanding the dynamics of Norway spruce forests. Toward this end we present an analysis of natural regeneration in two primeval Norway spruce forests in Bulgaria, SE Europe – Parangalitsa and Bistrishko braniste forest reserves.

The natural regeneration was studied after natural disturbances of various types - large-scale disturbances in a 130-year-old uniform forest, and large-scale and medium-scale disturbances in old-growth forests ≥ 150-years-old, as well as in unmanaged and "cleared" parts of the disturbed forests. We have analysed data from recent large-scale windthrow (2001) and bark-beetle outbreak (2003–2010), and from windthrow up to 50 yrs. ago (1962, 1983). Through these efforts, we obtained an overview of regeneration processes in a continuous period and after disturbance in different phases of forest development.

In general, advance regeneration was found in the studied areas. Post-disturbance Norway spruce regeneration in windthrow areas was concentrated predominantly on dead wood and root plates. Where advanced regeneration is sparse and available dead wood is limited, as in the mature Norway spruce forests in Bistrishko branishte reserve, regeneration has been slowed down considerably. In contrast, the presence of advanced regeneration and appropriate regeneration substrates such as highly decomposed dead wood and seeding trees may promote a very fast recovery, as was the case in Parangalitsa reserve. Contrary to our expectations, pioneer species did not play a major role in regeneration. Most regeneration was from *Picea abies* (L.) Karst and from the other species originally present in the stand – *Abies alba* Mill., *Sorbus aucuparia* L., *Salix caprea* L. and *Fagus silvatica* L.

Dountchev, A., Tsvetanov, N., Panayotov, M., Yurukov, S. 2014. Long and short-term regeneration patterns after large-scale disturbances in primeval Norway spruce forests in Bulgaria. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 27.

Environmental controls of the northern distribution limit of yellow birch in Eastern Canada

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(2) Ministry of Environment, Canada

To evaluate environmental controls of yellow birch (*Betula alleghaniensis* Britton) distribution at its northern distribution limit in eastern Canada, we analysed abundance, age structure, biomass accumulation rate, and growth sensitivity to climate of this species at 14 sites along a 200-km latitudinal gradient spanning three bioclimatic domains and reaching frontier populations of this species in western Quebec. We observed a large variability in seedling density across domains and presence of sites with abundant yellow birch regeneration within all three bioclimatic domains. Seedling density was positively correlated to the mean age and the abundance of yellow birch trees in the canopy, while sapling density was positively associated with dryer habitats. Growth patterns of canopy trees showed no effect of declining temperatures along the south-north gradient. Environmental controls of birch distribution at its northern limit were realized through factors affecting birch regeneration and not growth of canopy trees. At the stand scale, regeneration density was strongly controlled by local site conditions, and not by differences in climate among sites. At the regional scale, climate variability could be an indirect driver of yellow birch distribution, affecting disturbance rates and, subsequently, availability of suitable sites for regeneration.

Drobyshev, I., Guitard, M.-A., Asselin, H., Genries, A., Bergeron, Y. 2014. Environmental controls of the northern distribution limit of yellow birch in Eastern Canada. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 28.

Canopy gaps after target diameter cutting in a multi-layered forest in south Sweden

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Stand structure and canopy gaps after target diameter cutting in a multi-layered forest in southwest Sweden were analyzed. The stand was established by man, but comprises a very heterogeneous forest structure today, characterized by Scots pine in the overstory and naturally regenerated Norway spruce and Sessile oak trees in different height layers.

Four replicated management treatments were applied across the stand: Target diameter cutting (TDC), TDC with additional management measures as soil scarification in gaps, TDC with alternated target diameters to reduce the spruce proportion, and a control treatment with no management. After the removal of 15% largest trees (equal to 40% standing volume), the forest canopy covered more than 80% of the area. 174 canopy gaps were recorded with a total gap area of 28.600 m^2. The size of the largest gap was 1.720 m^2 with 25 recently harvested trees and 26 older tree remnants. 112 gaps were smaller than 100 m^2, covering 24% of the total gap area. In this size class, 3 remnants of trees were found on average per gap. Gaps larger than 1000 m^2 covered 18% of the total gap area, with ca. 40 tree remnants per gap on average. Crown coverage in the gap center ranged from 2% to 75%. Compared to open land, the diffuse site factor in gaps ranged from 30% to 70%, while it was ca. 10% under closed canopy. The density of advanced natural regeneration in gaps just after cutting was 1000 individuals per ha, dominated by Norway spruce. Browsing damages were much higher for broadleaf species compared to spruce. The annual height growth of spruce seedlings <1 m was about 5 cm before cutting. The height growth of small spruce trees with 3–5 m height was ca 20 cm per year.

In order to explore future stand dynamics, three future ingrowth scenarios were derived on the base of advanced regeneration in the forest. The scenarios ranged from low height growth and high mortality before cutting to height growth comparable to open-land conditions and zero mortality. In the maximum scenario, the regeneration pool would provide ingrowth of 10 new trees per year and hectare over the next 15 years, comparable to rates reported from single-tree selection forests in Sweden. The moderate scenario resulted in 4 new trees per year and ha, comparable to estimates for the study stand by a Swedish ingrowth model.

The study is complemented by a literature review on regeneration and ingrowth in multi-layered forest stands dominated by Scots pine and Norway spruce in northern Europe.

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Drössler, L., Ekö, P.-M. 2014. Canopy gaps after target diameter cutting in a multi-layered forest in south Sweden. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 29.

Do small mammal populations depend on landscape composition, and what influence does this have on tick-borne diseases? A meta-analysis and review

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Land-use and climate change alter the habitats of small mammals and could affect small mammal-tick interactions. A change in the abundance of ticks and infection rates has implications for tick-borne diseases and for human health.

In a meta-analysis we tested the hypothesis that forest fragmentation leads to habitat losses for forest inhabiting mice species (*Myodes glareolus, Apodemus flavicollis*) and to habitat gains for mice species (*Apodemus sylvaticus, Apodemus agrarius*) living in more rural and frequently disturbed habitats like arable fields. We further hypothesize that generalist species will suffer less from forest fragmentation than specialist species.

Ticks (*Ixodes ricinus*) depend largely on small mammals while the ticks are in their larval stage and to a lesser degree during their nymphal stage. A certain composition of a small mammal community thus determines a certain tick abundance. Due to different reactions of certain small mammal species to tick-borne diseases, the small mammal community also influences the incidence of tick-borne disease like Lyme disease and tick-borne encephalitis.

As a second hypothesis we tested the assumption that alterations to the landscape and forest composition will not only alter small mammal communities, but also tick densities and the incidence of tick-borne diseases.

We used a meta-regression approach to quantify the effects of landscape composition (forest cover and quality, edge density, land-use) on small mammal population densities. We derived explanatory variables from CORINE land-cover datasets and the literature if the datasets were available in the original articles. The articles from which the necessary statistics for a meta-analysis were not included, were then used to perform a qualitative comparison to look for trends or clusters in the overall data. Finally, we discussed the consequences our results might have on tick-borne diseases on a landscape level and whether certain management practices might be useful in controlling the impact of tick-borne diseases on human health.

Ehrmann, S., Glatthaar, E., Gärtner, S., Scherer-Lorenzen, M. 2014. Do small mammal populations depend on landscape composition, and what influence does this have on tick-borne diseases? A meta-analysis and review. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 30.

The condition of advance regeneration in the understory of close-to-natural hemiboreal stands

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Increased global demands for sustainability, i.e. productivity and biodiversity, have urged forest management to more actively incorporate natural disturbances and successional processes. Such natural processes are considered to maintain the heterogeneity of natural gap-mosaic forest landscapes such as in the hemiboreal zone of Europe. A major challenge will be to forecast changes in disturbance regimes and the capability of forest ecosystems to adapt as vegetation zones will shift northwards.

As part of a wider research focused on natural forest regeneration influenced by disturbance, this study investigates the characteristics and condition of advance regeneration in the understory of close-to-natural forest stands before disturbance. We hypothesise that in the understory of semi-natural forests in the hemiboreal zone, there is a continuous recruitment of new seedlings, but mainly advance regeneration of shade tolerant tree species is able to establish. Because of the limited growing conditions, advance regeneration is predominantly small in size and relatively old, but fully acclimated to limited light and resource availability. We expect advance regeneration is sufficiently abundant and evenly distributed, to replace the existing forest canopy layer. This study was conducted in the hemiboreal zone, in Estonia. We collected data in 7 semi-natural mixed forest stands, over 100 years old, with comparable meso-eutrophic forest site types. We assessed advance regeneration characteristics, i.e. tree species, age, height and diameter increment, vitality, as well as abundance, spatial distribution and competition.

Preliminary results show that advance regeneration consist primarily out of shade tolerant and late successional deciduous tree species, like Norway spruce (*Picea abies*) and small-leaved lime (*Tilia cordata*), mainly distributed over the lower height classes. Vitality of spruce compared to birch (*Betula spp.*) advance regeneration shows no clear difference, however, spruce is often located in more competitive canopy positions. Per height class, early-successional regeneration is significantly younger than spruce, with late-successional deciduous species of intermediate age, indicating shade intolerant species can not maintain themselves over longer periods of time. Although advance regeneration has spatially established itself in clumps and patches, it is still distributed and abundant enough to potentially replace the canopy.

Engelhart, J., Jõgiste, K. 2014. The condition of advance regeneration in the understory of close-to-natural hemiboreal stands. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 31.

Canopy disturbance caused by bark beetle *(Ips typographus)* outbreak has little influence on the species composition of *Picea abies* forests

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(2) Institute of Botany of the ASCR, Czech Republic

Boreal-type forests do not only occur in the boreal zone but also in high mountains of the temperate zone, for example in the mountain range called Bavarian/Bohemian Forest along the border between Germany and Czech Republic in elevations above 1050 m asl. In the mid-1990s a bark beetle outbreak started to happen there; meanwhile nearly all the spruce forest stands above 1050 m asl. are affected.

According to the assumption, strong impacts cause strong reactions we hypothesized that the influence of the disturbance on the total species composition should be fundamental. And we hypothesized that there are enough saplings to regenerate a new tree layer in a reasonable period of time. To test these hypotheses, in 1998 we established a set of permanent plots in the Bavarian Forest National Park for analyzing 1) the species composition in the course of time (phytosociological relevés) and 2) the regeneration of the tree layer (labeling the existing seedlings and saplings). The test plots were selected in a randomized manner. In 2010 we repeated the data collection on the permanent plots. For data analysis we used multivariate classification and principal component analysis.

In contrast to the expectation we found that, although the layer of living trees was totally gone, the species composition of the ground vegetation did only change a bit. Few light demanding species (*Epilobium angustifolium, Rubus idaeus, Galium saxatile*) increased, but starting from and ending up at a very low cover degree; the main grass *Calamagrostis villosa* doubled its cover degree. Neither did new species occur nor did former species disappear. The reason is that, in contrast to windfall or fire, the disappearing of the tree layer caused by by bark beetles is not accompanied by mechanical disturbances of the soil and the ground vegetation (no open space for establishing of new species available).

The spruce seedlings and saplings, already existing before the disturbance event took place, were mostly smaller than 10 cm. Their survival rate depends on the height: for sapling with a height of more than 10 cm the survival rate is above 95%. Based on this we calculated a mean population density of spruce trees taller than 10 cm of around 7,900 per hectare for 2004 as a population peak. A partial data collection in 2004 showed that the reality was close to the expectation; and in 2010 still around 4,000 saplings (meanwhile much higher that 10 cm) per hectare were present. This is much more than in other close-to-nature spruce-dominated forests in Central Europe usually can be found.

What may be learned from these results is that the processes initiated by bark beetle disturbance are totally different compared to other disturbance types. The tree layer may disappear for a while, therefore the ecosystem's structure may change fundamentally, but nevertheless the total species composition may nearly be unchanged.

Fischer, A., Fischer, H. S., Wild, J. 2014. Canopy disturbance caused by bark beetle (*Ips typographus*) outbreak has little influence on the species composition of *Picea abies* forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 32.

Climate and forest composition influence the dynamics of the dominant disturbance agent in Canada

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Insect outbreaks are dominant disturbance agents in the boreal forest, and outbreaks of the spruce budworm (SBW, *Choristoneura fumiferana*) are perhaps the most important of these disturbance agents in Canada. Population density of SBW exhibits a cyclic pattern, and periods of very high population density (outbreaks) occur approx. every 30–40 years causing significant mortality and growth loss over almost 100 mil. ha. Climate and forest composition are dominant factors in SBW outbreak dynamics through their direct influence on the pest, its natural enemies, and its hosts, and through their influence on the multitrophic interactions that are important in outbreak dynamics. But more than 43 primary parasitoids and 21 entomopathogens have been associated with SBW populations on just one of its three primary hosts, and climate (principally temperature and precipitation) have a demonstrated effect on SBW and its natural enemies – but the precise (quantified) effect is known for only a few of these. Given the complexity of the SBW system, and the shortage of precise knowledge regarding the effects of climate on many of the natural enemies, statistical techniques have been employed to attempt to determine how climate and forest composition influence SBW outbreak dynamics, and to predict how future outbreaks may differ from historical outbreaks because of climate change.

This presentation will describe two techniques, with particular focus on one (constrained ordination), and the effects of climate and forest composition on SBW outbreak dynamics that are suggested by the analysis. Outbreak duration and outbreak severity (defoliation level) were both most strongly influenced by spring temperatures, but not by the same characteristics of spring temperatures. A projected future climate scenario is predicted to cause spatially variable changes to the duration and severity of future outbreaks.

Gray, D. 2014. Climate and forest composition influence the dynamics of the dominant disturbance agent in Canada. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 33.

Tree retention on clearcuts and tree mortality

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Green tree retention is often applied in forests harvested by clearfelling. Tree retention contributes to a continuity of live trees in the new generation of a forest, and an increase of dead wood in the forest landscape. Few studies have made an assessment of what happens to retention trees over a longer time period. We assess the mid- to long-term survival of the trees that are left on a clearcut by comparing tree structure and survival rates after a time period of six, 12 and 18 years after clearcutting. Preliminary results showed that the annual tree mortality was 9.8% in six years old retention patches and 1.8% in those twelve years old, indicating stronger effects within an early period after the clear-cut. The number of persisting trees and the volume of dead wood depend on the location of trees in the clear-cut, whether trees are removed, and on the circumstances within the first six years after the tree harvest.

Hallinger, M., Ranius, T., Sjöberg, S., Schmalholz, M. 2014. Tree retention on clearcuts and tree mortality. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 34.

The effects of forest fuel harvesting on decomposer fungi during the first post-harvest decade

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The interest to use wood-based renewable energy has heavily increased because of the requirements of current climate and energy policies. Therefore, the removal of logging residues and stumps from clear-cuts has become a common forestry practice. Finland has been one of the most active countries in forest fuel harvesting. Currently both slash and stump removal have become common and increasing practices. Due to the short history (approximately ten years) of these treatments their ecological effects are poorly known. Naturally, forest fuel harvesting decreases the, already initially low, volume of dead wood in managed forests, but the biodiversity effects remain largely unknown. We have studied the effects of forest fuel harvesting on decomposer fungi on 20 clear-cut Norway spruce stands in central Finland. Our first surveys were conducted 4–5 years after the harvesting and stump removal, and the surveys were repeated five years later. Thus we are able to provide some insights into the biodiversity effects of stump removal and slash harvesting during the first post-harvest decade. In this talk we present results from both surveys. We discuss the results in the context of conservation biology, especially thinking about the potential local extinctions that forest fuel harvesting may induce. We also discuss these treatments in relation to forest restoration where these very same resources are increased in the very same forest landscapes.

Halme, P., Toivanen, T., Kotiaho, J. 2014. The effects of forest fuel harvesting on decomposer fungi during the first post-harvest decade. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 35.

The value of retained Scots pines and their dead wood legacies for lichen diversity in clear-cut forests: the effects of retention level and prescribed burning

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(2) University of Tartu, Estonia

Forest management has caused drastic changes in the northern boreal forests. Late-successional forest stands have been replaced by structurally simplified, even-aged managed stands, and efficient fire suppression has shifted the natural disturbance dynamics of forests. To mitigate the negative impact of these changes on biodiversity, several conservation techniques are used in production forests. We studied the effect of two such measures, green-tree retention and prescribed burning on epiphytic lichens 11 years after timber harvests in Scots pine-dominated forests of middle boreal Finland. Lichen assemblages were sampled from retained Scots pines and their dead wood legacies (snags and logs) on 18 experimentally treated study sites. Treatments were combinations of two factors: green-tree retention and burning. Two different green-tree retention levels (10 m^3/ha and 50 m^3/ha) were included in this study, each of these replicated on six study sites. Prescribed burning took place after harvest on half of the sites of each retention level. Six uncut old-growth forest sites, of which half were also burned, were used as controls. A total of 42 and 65 species were found from burned (B) and unburned (UB) sites with 10 m^3/ha retention, 41 and 74 from B and UB sites with 50 m^3/ha retention, and 63 and 80 from B and UB controls. Mean species richness per tree did not differ between control and harvested sites of either retention level on any of the substratum types. However, microlichens' species richness was significantly lower on harvested than control sites on both living trees and snags. At burned sites the species richness was lower than on unburned, and also the composition of lichen assemblages differed between burned and unburned sites. The negative effect of fire was significant on living trees and snags, but not on logs. We conclude that retention of Scots pines seems to be a promising method for maintaining epiphytic lichen richness in a timescale of 11 years after harvest, and that approximately equal numbers of living trees and their dead wood legacies are needed to support the lichen species richness on harvested site. Given the negative effect of prescribed burning on epiphytic lichens, it should not be applied on stands with particularly species rich lichen assemblages. However, the specific impact of prescribed burning on specialist lichen species should be evaluated on a longer timescale.

Hämäläinen, A., Kouki, J., Lõhmus, P. 2014. The value of retained Scots pines and their dead wood legacies for lichen diversity in clear-cut forests: the effects of retention level and prescribed burning. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 36.

Sprucification in protected forests: myth or veracity? – Evidence from 60 years survey data

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Forests excluded from forestry are key-elements in conservation strategies in production landscapes. Being more or less isolated patches in landscapes were the disturbance regimes are strongly altered by anthropogenic influence the trajectories of development may be significantly different than if located in areas with more natural dynamics. It has been suggested that the lack of fire may cause a shift in tree species composition towards a dominance of late successional species. In boreal Europe this would imply an increase in the shade-tolerant Norway spruce, which has a low resistance to fire. We used long-term (60 years) data from the National Forest Inventory, representing a majority of the protected forest area in Sweden, to analyze changes in forest structure and indicators of late successional stages (sprucification). During this period the density (m^3 wood ha^{-1}) of the forest had doubled. This increase concerned both early and late successional tree species and there was no clear evidence for differences in development between species. However, among the ecologically important large trees spruce had increased significantly more than the other species indicating a shift from co-dominance towards dominance, and in successional trajectory. The amount of dead wood in the protected forests was relatively low, even though it had doubled during the observation period. We conclude that 1) the density of these forests as well as the amount of dead wood was low in the 1950ies, probably as an effect of disturbances (selective cuttings, forest grazing and fires), 2) the forest density has increased considerably due to an increase among the largest trees, which may be both beneficial from a conservation perspective as it implies increasing amount of coarse woody substrate, and negative for light-demanding and/or thermophilic species, 3) there is evidence for an increase in spruce, which may indicate a shift towards a larger share of forests in late successional stages. The implications of these changes for the long-term functionality of the protected areas are dependent on the landscape context and whether disturbance dependent species can persist in the production landscape. Hence, if protected areas are to be exposed only to stochastic disturbance events (no active management), restoration measures in the remaining parts of the landscape will be urgent.

Hedwall, P.-O., Mikusinski, G. 2014. Sprucification in protected forests: myth or veracity? – Evidence from 60 years survey data. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 37.

Effects of retention level and fire on retention tree dynamics in boreal forests

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Green-tree retention aims to decrease unfavorable impacts of forest clear-cutting on biodiversity. For example, it is assumed that retention trees can provide coarse woody debris (CWD) for several saproxylic species. Despite being applied widely for about 20 years by now, long-term effects of retention harvests have remained elusive. In particular, it is not known how retention trees die and maintain CWD. In 2000, we established an experimental tree-level study, to investigate the effects of burning and retention level on the dynamics of retention trees. We asked how two retention levels (10 m3/ha and 50 m^3/ha) and prescribed burning influence the survival of the trees and the continuity of dead wood on post-harvest forest sites. We followed the dynamics of 2758 individually marked retention trees over 10 years on 12 sites in eastern Finland. The results show that the effect of fire was clear: at the lower retention level fire killed practically all trees, but at the higher retention level about 10 m^3/ha (20%) were still alive ten years after the burning. On the unburned sites mortality of the trees was much lower and quite constant throughout the years: at higher retention level the amount of living trees was still over 30 m3/ha ten years after the logging. Fire, especially combined with higher retention level, creates quickly diverse assemblages of dead wood, but weakens the supply of living trees and fresh dead wood in later years. At lower retention level, however, the effect of fire was too severe for maintaining living trees at all or continuity of diverse dead wood. Our study proved that green-tree retention is a good method to maintain the continuity of dead wood over early successional stages, but that burning of the harvested sites markedly change the dynamics of retention trees.

Heikkala, O., Suominen, M., Junninen, K., Hämäläinen, A., Kouki, J. 2014. Effects of retention level and fire on retention tree dynamics in boreal forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 38.

An analysis of past EU funding on ecological restoration of forests in Latvia – problems and recommendations

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The Conference of the Parties to the Convention on Biological Diversity in 2010 adopted a new Strategic Plan for Biodiversity for 2011–2020, which includes the Aichi Biodiversity Target of restoring 15% of degraded ecosystems and protection for 17% of the land territory. The EU Directive 92/43/EEK„Council Directive on the conservation of natural habitats and of wild fauna and flora" calls for significant proportion of EU protected habitat to be in a favourable status, i.e., when its natural range and areas it covers within that range are stable or increasing, and contains specific structure and functions necessary for its long-term maintenance. The new 2013 EU assessment of status of forests in Latvia lists unfavourable status for all EU forest habitats. Therefore, there is a need for an objective survey of the past efforts in Latvia to improve the biological quality of forests and their present level of protection, in view of the stated targets. This can enable the development of quantitative targets for conservation of biological diversity of forests in Latvia. The past projects in improving conservation of biological diversity were surveyed to determine the target EU protected habitats, surface area restored, proportion of habitat area in Latvia restored, type of restoration employed (including passive restoration – doing nothing), assessment of success. Also, the area of each EU habitat was determined. The main projects in Latvia involving restoration of forest habitats have been: Woofland Key Forest Habitat inventory and management, the LIFE Project Protection and Management of the Northern Gauja Valley (2003–2007), and habitat management by the Stock Company Latvijas Valsts Meži as outlined in management plans for protected areas. The main problems of the past efforts have been: extremely low proportion of habitat restored, lack of knowledge of restoration methods, reliance on passive management, and focus on Life projects, which generally cover very small areas, no landscape perspective to reduce fragmentation and no long-term monitoring. There are no quantitative targets for conservation priorities in legislation, and as a result even clear-cutting in Natura 2000 territories has occurred. Conservation of biological diversity in Latvia will need development of targets for habitats and species, with specific management options for each (under development), increase capacity of the respective governing administrations, and increase involvement of researchers in planning of conservation activities.

Ikauniece, S., Brūmelis, G., Liepiņš, K. 2014. An analysis of past EU funding on ecological restoration of forests in Latvia – problems and recommendations. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 39.

Ice damages of coniferous trees in hemiboreal forests: case study in Latvia

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Forests in eastern part of Latvia in December 2012 were affected by a rainfall in sub-zero temperatures that formed an ice layer on stems and branches, causing many trees to bend or break and creating notable financial losses. Therefore aim of the study was to assess the amount and character of ice damages in Scots pine and Norway spruce stands and factors influencing those damages.

Stands were selected randomly within the affected forest district in a way to represent different age classes (from 20 to 120 years), most common forest types on dry, drained and wet soils, and time after last thinning (up to 3 years and more than 3 years). Ten circular sample plots (200 m^2) were systematically placed within each stand and tree height, diameter, height of green crown were measured as well as damages assessed: for broken trees – height of standing trunk, for bent trees – height and angle of the curve or angle of slope. Data from 163 stands (98 pine, 51 spruce and 14 mixed) were used in analysis.

Ice damages were found for 27% of trees. Dominant tree species was not affecting the proportion of damaged trees or type of damage (mostly broken tops – 18% of trees). Stand age had no notable influence of proportion of damaged trees, but was affecting the type of damages: bent trees were found mostly in young (up to 40 years) stands. Forest type had a statistically significant influence on proportion of damaged trees: highest proportion was found on drained (for Norway spruce) or wet (for Scots pine) peat soils. Recent thinning had no influence on proportion of damaged dominant trees, but was negatively affecting proportion of damaged suppressed trees, especially Norway spruces. Mathematical models describing the rate of damages caused by ice were developed. Tree diameter was a significant variable, affecting the probability of damage, and only slight improvement in the precision of the model can be achieved when including also tree height and slenderness as variables.

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Jansons, A., Baders, E., Rieksts-Riekstins, J., Jansons, J. 2014. Ice damages of coniferous trees in hemiboreal forests: case study in Latvia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 40.

Importance of deadwood for vascular plants in oak-hornbeam forest in Bialowieza Primeval Forest (NE Poland)

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Deadwood may constitute a favorable substrate for forest plant regeneration. Its properties change with time, as decomposition progresses. We investigated the process of colonization of logs by herbaceous plants and trees in meso-eutrophic oak-hornbeam forest.

Field data was collected on 1 ha plot in the strict reserve of Bialowieza National Park. One hundred six dead trees were measured and assigned to Hunter's 5-class decay classification. Half of logs were Norway spruce, remaining were: hornbeam, small-leaved lime, Norway maple, pedunculate oak, hazel and silver birch. All ramets of herbaceous plants were counted, species listed and their coverage estimated: on the log, on the ground next to log and 1 m away.

The number of species colonizing deadwood was approximately two times higher than reported in literature. Some species were present on logs but not on the ground in their vicinity, which suggest that deadwood may increase local plant diversity. Contrary to literature, vascular plants colonized logs in early (1st–2nd) decomposition classes with both number of species and density of ramets were decreasing on moderately decomposed logs (3rd class).

Six plant species reached maximum of abundance on the logs, with the most abundant being *Oxalis acetosella*. Three groups of species may be distinguished in terms of coverage and frequency on logs: 1) species increasing coverage with progressing deadwood decomposition; 2) species with no clear tendency; 3) species which coverage and/or frequency was high in the 1st and 2nd decomposition classes, but then dropped down in 3rd or 4th class.

We found deadwood to be important substrate for the establishment of juvenile trees of nine species. The highest frequency (>30% of logs) and highest coverage coefficient was characteristic for Norway maple, hornbeam and small-leaved lime. All of them appeared on logs in all decomposition classes, however their density was higher on soil than on logs. Norway spruce was the only species present on logs (most frequent on weakly decayed substrate – 2nd class) and not present on the ground. This indicates that although deadwood may not be a key factor for the regeneration of oak-hornbeam forest, it may be essential for a long-term presence of some admixture species like Norway spruce.

Jaroszewicz, B., Chećko, E., Olejniczak, K. 2014. Importance of deadwood for vascular plants in oak-hornbeam forest in Bialowieza Primeval Forest (NE Poland). – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 41.

Active management in forest set-asides for biodiversity conservation – planning a systematic review

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The traditional approach to limiting impacts of forestry on biodiversity is to set aside forest areas of particular conservation interest, either as formally protected reserves or on a voluntary basis. Most set-asides have then been left more or less untouched. However, many of them may gradually lose the qualities that were to be safeguarded unless they are actively managed, e.g. by means of burning or thinning. In recent years, interest in such measures has increased, but opinions differ among conservationists on how active management should be balanced against non-intervention. A choice between these alternatives also has to be made when forest stands formerly subject to large-scale harvesting are to be restored.

The topic will now be subject to a systematic review titled *What is the impact of active management on biodiversity in forests set aside for conservation or restoration?* This initiative has met approval and even enthusiasm among key scientists, government agencies and non-governmental organizations in Sweden. The project will be financed and managed by the Mistra Council for Evidence-Based Environmental Management (EviEM) in Stockholm. An international team of ecologists has been appointed to conduct the review.

A systematic review entails a structured technique for collecting and synthesizing existing data in order to answer a specific question. It includes the development of a peer-reviewed *a priori* review protocol, compilation and analysis of available evidence and in the end a peer-reviewed report. The process aims to guarantee a comprehensive, well-documented and unbiased assessment of available knowledge. Being developed originally within medical science, the systematic review approach is now applied to a wider range of disciplines, including environmental management.

The only major obstacle for a systematic review on active management of protected forests is the scarcity of relevant scientific literature. Numerous combinations of management forms and biodiversity outcomes can be conceived, and it remains to be seen whether any such combination is covered by sufficiently many studies to allow a meaningful meta-analysis. Nonetheless, it is probably feasible to produce a useful qualitative synthesis of the available evidence on how different forms of management affect different aspects of biodiversity. The synthesis would also be able to identify knowledge gaps and research needs within this field.

Jonsson, B. G., Bernes, C. 2014. Active management in forest set-asides for biodiversity conservation – planning a systematic review. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 42.

The effects of forest management, grazing, and afforestation on wood-inhabiting fungi occupying dead wood of different diameter fractions

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Forest management has caused severe ecological degradation throughout the Globe. One of its most prominent consequences is the drastic change in dead wood profile and, consequently, in the dead wood dependent biota. Wood-inhabiting fungi are, considering ecosystem functions, the most important species group utilizing dead wood, because they take care of majority of the decaying process. The earlier research focusing on the effects of forest management on wood-inhabiting fungi has strongly focused on large dead wood pieces (i.e. coarse woody debris, CWD), even though it has been shown that a major part of fungal diversity utilizes (also) small dead wood pieces (i.e. [very] fine woody debris, [V]FWD). We studied the effects of 1) earlier forest management, 2) grazing history and afforestation on the wood-inhabiting fungi occupying all dead wood diameter fractions including the smallest pieces. The study was conducted in boreal forests in Central Finland. We first surveyed corticioid and polyporoid fungi from 113 269 dead wood pieces in 8 previously managed and 8 natural coniferous forests. In addition, we surveyed 66 929 dead wood pieces in 4 natural broadleaved herb rich forests, 4 afforested birch dominated fields and 4 birch dominated wood pastures. In both studies, we found differences among fungal communities occupying FWD in different forest types. Moreover, many rare species were detected only in one or two forest types. Spruce dominated natural forests and, surprisingly, afforested fields were especially rich in rare species. The main focus in forest conservation and restoration efforts may still be targeted on increasing CWD volume in managed landscapes, but simultaneously reasonable volume of FWD must be retained to ensure that specialist species utilizing it will not be driven to local extinctions. Combining this recommendation with increasing pressure for energy wood harvesting will remain as a challenge.

Juutilainen, K., Mönkkönen, M., Kotiranta, H., Halme, P. 2014. The effects of forest management, grazing, and afforestation on wood-inhabiting fungi occupying dead wood of different diameter fractions. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 43.

The effect of forest management and landscape planning on bats

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Forests and cultural woodlands, i.e. parks, are multifunctional habitat for bats, providing opportunities for foraging, roosting and commuting. Bats cover long distances on nightly bases between habitats and therefore they are likely to be affected by both – disturbance and management in a particular stand and the structure of surrounding landscape.

We address multi-scale complex of factors (local habitat, landscape and region) driving foraging bat diversity in the forest landscape, shaped by agriculture, landscaping and forest clear-cuts. Survey took place in 28 landscape windows in southern- and central-Estonia consisting of 63 woodland survey points in mature forests and parks. We used GLM modelling to assess relative importance of woodland structure and surrounding landscape on species richness of bats.

We recorded the whole national bat fauna. Species richness was largely explained by landscape composition and woodland properties across all spatial scales. Large proportion of variability in richness was also determined by regional species pool.

We show that parks and forest can be seen as equally important habitat for bat species as long both woodland edge and interior are considered together. In small-scale, species richness on edge habitat was significantly higher and had a strong impact on species richness in woodland interiors. Therefore we conclude that sharp edges of woodland patches can be suitable habitats for bats, but only if the landscape complexity supports richness in landscape scale.

Kalda, R., Liira, J., Kalda, O., Lõhmus, K. 2014. The effect of forest management and landscape planning on bats. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 44.

Farmland abandonment and forest area increase in northeastern Europe

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Fine-scale and spatially explicit data on changes of the expansion of forested patches on the formerly agricultural land are sparse. Remotely sensed data are suitable for accomplishment of monitoring land cover changes on abandoned agricultural land over extensive areas. However non-managed grasslands with early-successional shrubs and forest regrowth, are not easily distinguishable from managed grasslands due to subtle changes in reflectances.

We used both moderate and high resolution satellite images from a less conventional methodology for land cover mapping to monitor and map shrub encroachment on former agricultural lands, as we used images from winter season when both forests and open areas are covered with snow cover. The innovation was used, because radiance contrast between forested patches and the surrounding non-forested areas is high in these conditions and therefore classification errors are minimized.

We studied the area of the three Baltic countries Estonia, Latvia and Lithuania in North Eastern Europe. Our goal was to map post-socialist farmland abandonment using Landsat images from 1985 to 2014 and to identify spatial determinants of abandonment.

For the classification of „forested former agricultural land", we used at least one image for pre-abandonment period (mid to late 1980s) and at least one image for post-abandonment (early 2010s).

At this stage of afforestation of former agricultural land the added new forest patches share common boundaries with permanent forest patches. In these conditions special attention should be pointed on boundary detection of forest patches to separate real boundary changes from classification errors.

We found locally extensive afforestation of abandoned farmland in the studied region. However, we also found strong differences in the rates and spatial patterns of afforestation of abandoned agricultural land among the three countries in our study area.

Kardakov, A., Budenkova, J., Liira, J., Peterson, U. 2014. Farmland abandonment and forest area increase in northeastern Europe. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 45.

Historical forest resource maps help to explain regional differences in species loss and response to forest restoration

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Large-scale historical forest resource maps provide a valuable source of information on the loss and fragmentation of primeval forests in Finland. Analysis of the 150 year period (1850–2000) of development reveals patterns that are useful in explaining the observed regional patterns in species loss as well as species recovery after restoration actions. Regional extinctions of threatened beetle species have been found to differ between regions in Finland. There is a strong gradient in the likelihood of dead tree trunks to be colonized by threatened polypore species between eastern and western Finland. Similar clear east-west gradient has been observed also in the recovery of beetle and polypore species after forest restoration activities.

These observed regional patterns have been explained by forest management history. Regions with shorter history of intensive forestry, like eastern and northern Finland, have suffered less regional extinctions than regions with longer history of forestry. However, the regional differences in forest utilization history have not been systematically verified by historical data. The earliest large scale forest resource map of Finland was published in 1850 by the Land Survey of Finland and the next one in 1895 in the Atlas of Finland. In 1950 Viljo Lihtonen produced a map of forest areas where logging of timber was economically unprofitable. In 1999 Taiga Rescue Network compiled a map of the remaining old-growth forests in Finland. Although these four maps are not similar in their purpose and criteria, they all provide information on the extent and location of the least impacted forests at the time. Based on the information from these four maps, a set of maps was compiled to visualize the 150 year-long (1850–2000) advancement of the "timber frontier" and the decline of the near-natural forests in Finland. The temporal decline of near-natural forests within each region was compared to the observed patterns of regional extinctions of threatened beetle species. The observed regional differencies can be significant in explaining the patterns in species loss and species recovery after restoration between western and eastern Finland.

More detailed data of the fragmentation history of near-natural forests can be obtained from the national forest inventories, forest surveys, management plans and aerial photographs. These historical data-sets can be used for localizing forest landscapes which are of high value for forest restoration.

Keto-Tokoi, P. 2014. Historical forest resource maps help to explain regional differences in species loss and response to forest restoration. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 46.

80-year changes in forest vegetation diversity within the landscape units in the Voronezh Nature Reserve

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Voronezh Nature Reserve (an area of 310 km^2) is situated in the south of Central European Russia, in the forest-steppe region. We have distinguished 13 landscape units within the Reserve area according to the river basin approach. An aim of the study was to evaluate vegetation diversity at the community, landscape and total area levels over 80 years on the basis of analysis of 1100 phytosociological relevès which have been collected since 1930 at temporal plots located over the area. There was no clear overall design of the data collection, so we used Monte-Carlo procedures and an analytical method of the species cumulative curves building for the assessment of dynamics of vegetation diversity in the Reserve.

According to the forest inventory data, in 1923 (before the Reserve proclamation) there were mainly young and middle aged forests dominated by *Quercus robur, Pinus sylvestris, Populus tremula, Alnus glutinosa* and *Betula* spp. Abandoned agricultural lands, swamps and sands occupied 10% of the area. We concluded that in the 1930s vegetation in all landscape units was quite similar to each other: the meadow - pine forest vegetation referred to the associated groups *Pineta prato-pineticoliherbosa, Querceta prato-pineticoliherbosa, Betuleta prato-pineticoliherbosa* (Starodubtseva & Khanina. Vegetation of Russia 2009 14: 63–141) occurred in all landscape units; only floodplain vegetation was significantly different from the vegetation within the other landscape units. The main trend in the vegetation dynamics is the increase of species of broad-leaved forests in all layers of the vegetation, in the overstorey and understorey as well. There is a significant decrease of alpha diversity in the vegetation 80 years after the reserve was created. This process is observed for the Reserve as a whole, for each community type and for each landscape unit with two exceptions: floodplains and the western site of the second Voronezh River terrace located on deep sands where ground fires often occur. Statistical modeling showed the total number of plants was the same in all landscape units and in the entire Reserve area over the all observation period. A high level of the vegetation diversity is maintained today by fires, mass tree-falls and mowing.

Khanina, L., Smirnov, V., Starodubtseva, E. 2014. 80-year changes in forest vegetation diversity within the landscape units in the Voronezh Nature Reserve. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 47.

Natural disturbance regime and disturbance interactions in mountain forests of the Julian Alps

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Natural disturbances are an integral component of forest ecosystems and have a strong impact on forest stand dynamics. Mountain forests of central Europe are particularly prone to natural disturbances, especially to wind, snow and bark beetles. The severity and frequency of natural disturbances vary substantially due to interactions between different disturbance agents, site characteristics, stand properties, and forest management treatment. Disturbance regime in the period 1979–2010 was studied in the secondary Norway spruce forests of the Eastern Julian Alps (study area of 4,792 ha). Analysed forest stands were characterised by a high growing stock (≈400 m^3 ha^{-1} in the average) and a large proportion of Norway spruce (>85%). The amount of salvage cutting due to three disturbance types – windthrow, snow break and insect attack – was used as an indicator of the natural disturbance regime in the study area. Various statistical modelling techniques were used 1) to examine the natural disturbance regimes, 2) to determine main influential factors of occurrence and intensity of natural disturbances, and 3) to identify disturbance interactions in different time lags. In the analysed period, annual salvage cutting averaged to 32.1% of total harvest. Insect attacks were the main reason for salvage cuttings (8.2% of total cuttings), followed by snow damages (6.8%) and windthrows (5.8%). All together, 0.62% of stand volume and 33.2% of annual stand volume increment were harvested each year due to the analysed disturbance types. Salvage cutting was strongly influenced by several site factors, stand attributes, forest management characteristics, and previous occurrences of natural disturbances. The likelihood of disturbance occurrence in the site increased if natural disturbance(s) occurred in previous years. Preliminary studies showed that disturbances in the previous 5 years strongly increased the susceptibility of forest stands to subsequent disturbances. Recommendations for forest management were suggested to reduce the risk of natural disturbance occurrence, but even more so to reduce the intensity of disturbances, reducing also a potential economic damage.

Klopcic, M., Boncina, A. 2014. Natural disturbance regime and disturbance interactions in mountain forests of the Julian Alps. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 48.

Vegetation changes in permanent plots during an 80-year period of no human impact in forest stands in the Moricsala Island Nature Reserve, Latvia

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In 1912 a strict nature protection reserve was established on Latvia's Moricsala Island, located in the boreo-nemoral forest zone. Previously, at least 30% of the island area was used for hay collection and as pasture. Dead and fallen trees were also removed regularly. The island is now covered almost entirely by forest, and stands are mostly dominated by *Quercus robur* and *Tilia cordata*. In 1932, a dissertation on forest types on Moricsala Island was defended by J. Grožinskis. The work contained detailed descriptions of vegetation and tree structure in plots that were precisely mapped, and thus could now be placed on digital maps enabling restablishment of the plots in the field. The aim of the study was to determine changes in tree species composition and vegetation in these permanent plots, and to analyze plant communities by plant attributes to determine the most important processes governing the change. As conducted previously, in 50×50 m plots, diameter at breast height was measured for all trees (>10 cm), saplings were counted in 2×2 m subplots, and cover of species was estimated in 1×1 m subplots. Dead wood biomass was also estimated. As expected, considerable turnover of species occurred, as the proportion of species typical of open habitats decreased, with replacement by species typical of nemoral forest plant communities. However, the total cover of species grouped by attributes (e.g., life form, CSR category, dispersal type, Ellenberg scale classes) showed remarkably little change, indicating considerable resistance of the plant communities to respond to the land-use change. Thus, while many species with a particular plant attribute were lost, other species present with that attribute took their place. However, there were slight significant shifts in community composition to greater cover of stress-tolerant species, species requiring a lower pH, and species with a spring flowering aspect. The amounts of dead wood increased considerably over the 80-year period, but in most plots were far lower than described in the literature for natural nemoral woodland.

Kokarēviča, I., Brūmelis, G., Grods, J. 2014. Vegetation changes in permanent plots during an 80-year period of no human impact in forest stands in the Moricsala Island Nature Reserve, Latvia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 49.

Disturbance management: the practice perspective

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Insects and diseases, storms, wildfires, drought, or damages caused by wildlife affect to various extents different European forest areas. From an ecological perspective these influences are part of natural development cycles of forests thus playing key roles in forest ecosystem dynamics. Whereas in the human value system such impacts usually have economically negative consequences, especially when being of more 'catastrophic' nature affecting whole landscapes and habitats, the disturbance agents can strongly disrupt targeted forest management goals and has severe consequences to wood production and environmental services. They may even jeopardize the economic base of forest owners. This raises the concern how better disturbance management can help to .adapt (productive) forest ecosystems to future developments.

Disturbance management plays a role mainly in the following fields that we see here as the main pillars of our approach: Restoration ecology, silvicultural strategies and disturbance emulation, prevention and response, and landscape level planning. We give examples for each field of where disturbance management based on scientific findings has improved overall management goals in forest ecosystems. Special emphasis is given to practical approaches that could and should be transferred to forest management.

Kraus, D., Krumm, F., Jain, T., Junninen, K., Kulakowski, D., Kuuluvainen, T., Bollmann, K., Mirailles, M., Rydkvist, T. 2014. Disturbance management: the practice perspective. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 50.

The effect of altered distribution of precipitation on height growth and biomass of saplings of main forestry species (Scots pine, Norway spruce, silver birch, common aspen) in Latvia

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Changes of distribution of summer precipitation are forecasted for Northern Europe, thus drought might become as additional disturbance affecting forest regeneration, causing stresses and hindering development of saplings. However, the effect of such hazard might be mitigated by the use of appropriate planting material.

In this study we compared height growth and biomass of different planting material of Scots pine, Norway spruce, silver birch and common aspen subjected to altered distribution of precipitation in different soil fertility (three types). Automated shelter was used to intercept natural precipitation and irrigation was done once a week during vegetation period; the amount of supplied water was maintained as sum of natural precipitation. Open air grown saplings were used as control. Saplings were grown one season. ANOVA was used to assess the effect of treatments and the development of saplings.

Height and biomass of sapling differed significantly between species, planting material and soil types. However; the effect of altered distribution of precipitation was unexpressed, significant differences were observed only for root biomass of spruce irrespectively of planting material and soil fertility. Spruce growing in conditions of altered precipitation increased the biomass of roots. Apparently, weekly periods of no precipitation (drought) are too short to significantly affect growth of sapling of studied species at present conditions in central part of Latvia. In further studies, longer periods of precipitation interception should be tested.

Study was carried out in Latvian Council of Sciences project "Adaptive capacity of forest trees and possibilities to improve it" (No 454/2012).

Krisans, O., Jansons, A., Purina, L., Purins, M. 2014. The effect of altered distribution of precipitation on height growth and biomass of saplings of main forestry species (Scots pine, Norway spruce, silver birch, common aspen) in Latvia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 51.

To integrate or to segregate? – How to balance commodity production and biodiversity conservation in European forests

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Recently the research project Integrate carried out by EFICENT (Reginal office of the European Forest Institute in Freiburg) was finalized. The main goals of the project were to assess the current state of knowledge of biodiversity in managed and unmanaged forests and to investigate how indicators can sufficiently describe biodiversity in multi-functional forests.

Based on the contributions from more than seventy renowned scientists in this field, Integrate has attempted to make available the most recent knowledge and the best international scientific expertise on the complex relationships, trade-offs and emerging challenges regarding the integration of forest biodiversity conservation into forest management.

Management goals and ecosystem functions such as biodiversity conservation can be met in both set-aside forest reserves and off-reserve forests. The major argument for well developed and protected forest reserves is the increase of alpha-diversity with extended succession periods and turn-over cycles. However, the establishment of new protected areas is limited due to space and competing management goals. Trade-offs have to be made where such conflicts of interest occur. Accordingly, emphasis is shifted towards integrating rare forest biotopes and structural attributes into production forests.

In segregative forest management systems, strictly protected areas are embedded in a matrix of intensively managed forests or plantations. The matrix in integrative systems in Central Europe is often managed on the basis of silvicultural principles with high forest management standards. Integrative forest management aims to maximize the cross-section between the different main functions of modern forestry: production, protection and conservation. The area of synergy, however, is limited and a certain amount of exclusive area is needed to guarantee different ecosystem functions. Consequently, a dual strategy where segregative instruments for biodiversity hotspots are embedded in a high standard forest management landscape presents a viable alternative. This concept enables connectivity and habitat resistance within managed forests.

Krumm, F., Kraus, D., Schuck, A., Bollmann, K. 2014. To integrate or to segregate? – How to balance commodity production and biodiversity conservation in European forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 52.

Composition of forest communities in an anthropogenically-fragmented landscape at the interface of southern and middle taiga

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Species composition of adjacent communities of forest, felled site, meadow, and roadside was described in a landscape with uniform ecological characteristics but fragmented vegetation. The area is situated in southern Karelia near the Russian-Finnish border, where there had been Finnish farms in the first half of the past century, and spruce, larch, and Siberian pine crops had been planted. The farms turned to ruin, and the meadows used for hay mowing and cattle grazing until the early 21st century have been abandoned. Forest logging is now very active there.

Analysis of the species composition of vascular plants in the habitats surveyed has demonstrated that the species richness of anthropogenic communities such as felled site (110 vascular plants species), roadside (105), and meadow (102) was three to five time higher than that of zonal middle-aged and mature spruce stands (23 and 39 species, respectively). The highest diversity among forest communities was found in 80-year-old larch plantations (45 species). Larch ameliorates soil conditions and creates more favorable light conditions than in pure spruce stands. The composition of forest habitats was highly specialized. Ground cover composition was not enriched despite proximity to meadows, roadside, or felled sites. Only two non-native vascular plant species (including larch) were found in forest communities in contrast with 22 on the felled site and 37 on the meadow site.

The felled site proved to be the richest and least specialized in terms of vascular plants composition. Removal of the tree layer and disturbance of the ground cover cleared the area for colonization by species from adjacent communities, while leaving the chance for forest species to survive the unfavorable conditions in refugia provided by branch debris and stumps. As a result, this site contained the lowest absolute and relative abundance of species compared to other surveyed communities.

Anthropogenic fragmentation of the landscape has generally enlarged its flora diversity and promoted its synanthropy. Forest communities have demonstrated the capacity to resist the invasion of alien elements, revealing the importance of the phytosocial factor in the dynamics and stability of the communities.

Kryshen, A., Gnatiuk, E., Genikova, N., Ryzhkova, N. 2014. Composition of forest communities in an anthropogenically-fragmented landscape at the interface of southern and middle taiga. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 53.

Predictors of long-term boreal forest dynamics at the modern western range limit of Siberian larch in NW Russia

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To investigate the long-term drivers of stand-scale dynamics of taiga vegetation at the modern western range margin of Siberian larch (*Larix sibirica*) in northwestern Russia, fossil pollen, conifer stomata and charcoal records from three small forest hollow sites, covering last 10 000 years, were studied. Together with pollen data stomata records provide reliable evidence of the in situ presence of conifer tree species. Particularly larch stomata are more abundant and identifiable than larch pollen, and when analysed from small hollows within the modern larch stands, can produce more reliable evidence for past occurrence of Siberian larch. To our knowledge, these are the first records revealing the Holocene history of the Siberian larch and the long-term stand-scale forest dynamics in this area. Pollen and stomata records show little compositional variability in vegetation during the Holocene, and that all common tree taxa, including Siberian larch, have been present at the study region since early Holocene.

To detect the predictors of long-term boreal forest dynamics we applied local climate data generated from a climate model, microscopic charcoal data as proxy for forest fires and peat humification data as proxy for growing site wetness. To determine the importance of these three environmental factors on boreal forest composition we employed variation partitioning and wavelet coherence methods for statistical analyses. The charcoal records from three small hollow sites show markedly different Holocene fire histories indicating the importance of local site specific factors on local fire frequencies. The preliminary results from variation partitioning suggest that, of the three environmental variables used in the analyses, climate is the most important predictor of the variation in forest composition and that most of the variation is undeterminable by climate, forest fires and growing site wetness. However, the wavelet coherence results indicate that forest fires have significant effect on the forest composition, especially on spruce (*Picea abies*) population.

Kuosmanen, N., Clear, J., Fang, K., Reitalu, T., Bradshaw, R., Seppä, H. 2014. Predictors of long-term boreal forest dynamics at the modern western range limit of Siberian larch in NW Russia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 54.

Episodic, patchy disturbances characterize an old-growth *Picea abies* dominated forest landscape in northeastern Europe

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The conventional theory of boreal forest dynamics recognizes two distinct disturbance regime types, small-scale gap dynamics and dynamics driven large stand-replacing disturbances. We used satellite imagery and extensive field measurements to examine the landscape-level pattern and impact of an extensive disturbance episode that occurred in the early 2000s in primeval forest dominated by *Picea abies* in the Arkhangelsk region, Russia, due to drought and subsequent bark beetle (Coleoptera, Scolytidae) outbreak. We also quantified forest age structures and deadwood characteristics at the landscape-level to study how such disturbances shape forest structures over larger scales. Satellite image analysis revealed that disturbance patches covered about 16% of the land area in the 12 km × 12 km landscape studied. The size of the disturbance patches was strongly skewed toward small ones (median size 0.12 ha) and they were distributed across the landscape with some tendency of aggregation. The landscape forest matrix was dominated by old-growth forest. The dominant trees in the forest were established prior to 1850, and approximately half of the forest had established prior to 1800. However, the patchy occurrence of younger forest suggests that the landscape previously was subject to patchy disturbance similar to the recent one. This conclusion also gained support from historical records. We conclude that the structure and dynamics of the studied primeval forest landscape was driven by the combined impact of small-scale "background" mortality (classical gap dynamics) and infrequent episodes of patchy intermediate severity and scale disturbances.

Kuuluvainen, T., Wallenius, T., Kauhanen, H., Aakala, T., Mikkola, K., Demidova, N., Ogibin, B. 2014. Episodic, patchy disturbances characterize an old-growth *Picea abies* dominated forest landscape in northeastern Europe. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 55.

The resilience of the forest field layer to anthropogenic disturbances

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The resilience of the boreal forest field layer to anthropogenic disturbances is insufficiently understood because of the multitude of direct or indirect driver pathways and environmental conditions involved. We hypothesized that the impact of the forest-management-induced disturbances on field layer varies along the gradient of site productivity. To explore that we proposed a method for estimating the proportional effect of each driver on the field-layer composition, in a survey data of 273 mature or overgrown boreal forests, by combining variogram analysis with multifactorial general linear modelling. In forest types of very low and high productivity, field-layer composition was sensitive to the management disturbances in general and, particularly, to the management-controlled variations in the structure of the stand and its understory, i.e., in environmentally stressful conditions the main limiting factors were light availability and its spatiotemporal variability. At intermediate productivity, instead, the natural heterogeneity of ground layer conditions was the dominant driver, pointing to the limitation of regeneration microsites. Accordingly, on soils with low and high productivity, biodiversity-oriented sustainable forestry should diversify silvicultural approaches among stands and (or) enhance the within-stand mosaic, small-scale natural disturbances of the ground-level "organic blanket" should be promoted in forests of intermediate productivity.

Liira, J., Kohv, K., Zobel, M. 2014. The resilience of the forest field layer to anthropogenic disturbances. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 56.

From borealization to de-borealization in southern Sweden – Could production forestry help rectify the past?

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The transition from broadleaf to conifer dominated forests in many regions of Europe is thought to be a key driver behind population declines for many taxa. We investigated the spatial and temporal patterns and processes which underlie this development in southern Sweden. A novel combination of paleoecology and national forest inventory databases revealed that after spruce arrived in the region 1000–2500 years ago, it became the most common species in terms of volume approximately 60–90 years ago, and our results indicate the more recent years as a key period for this development. The data from this and other studies help to explain how the agricultural revolution (abandonment of forest grazing and slash-and-burn cultivation) and early selection cutting benefited the establishment and growth of spruce. Hence, prior to the impacts of industrialized forestry that began in the 1950s, other processes were already favouring large increases in spruce abundance.

Despite production forestry being a key driver of past borealization, it can also be employed to act against the further borealization of the region. We have reviewed and surveyed the potential biodiversity benefits of two of the more economically viable production forest alternatives to spruce monocultures; mixed forests and plantations of fast growing deciduous trees.

We projected likely changes to the diversity with the replacement of spruce monocultures with mixed forests of spruce and birch for five different taxonomic groups. It can be expected to result in an increase in biological diversity for many but not all taxa, but it is unlikely to benefit many red-listed forest species. There are strong production incentives for planting hybrid aspen, due to rotation periods of just 20–30 years, and its potential to produce up to twice as much biomass as spruce. We compared the avian biodiversity of 13 fenced hybrid recently regenerated aspen stands on forest lands in Sweden with similarly aged stands of unfenced spruce monocultures, the latter being the most common forestry alternative the region. The study shows the hybrid aspen stands had higher bird species richness and abundance as well as a distinct community composition compared to the spruce stands. We conclude that an increased use of these alternatives to spruce monocultures would be beneficial for diversity both at stand and landscape scale in the region.

Lindbladh, M., Felton, A. 2014. From borealization to de-borealization in southern Sweden – Could production forestry help rectify the past? – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 57.

Disturbance type could explain, which organisms, and how, are adapted to disturbance regimes

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Adaptation to natural disturbance regimes is one of the main assumptions of natural disturbance-based management. However, this assumption has been seldom tested and, in fact, both the existing as well as theoretical approaches have provided highly variable results on the evolutionary processes under the conditions of disturbance. The theoretical approaches have usually included considerations such as disturbance severity, frequency, and regularity. In this presentation, I argue that the evolutionary consequences depend fundamentally on two ecological characteristics of rapid environmental change: the appearance of novel key factors and a return to relative 'baseline' functioning. Based on this, I define eight main types of rapid environmental change, including four distinct types of disturbances and two borderline situations, which can be considered disturbances in specific contexts. I then outline the most likely evolutionary processes for those disturbance types, and review the current support from case studies.

Lõhmus, A. 2014. Disturbance type could explain, which organisms, and how, are adapted to disturbance regimes. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 58.

Change of ground vegetation after shelterwood cutting in Scots pine forests in hemiboreal zone, Lithuania

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Aleksandras Stulginskis University, Lithuania

Currently, sustainable forestry becomes one of the uppermost trends in forestry policy. One measure is replacing clear cutting by shelterwood cuttings. The aim of this study was to evaluate the succession of ground vegetation, undergrowth, herbs and moss after shelterwood cuttings in hemiboreal pine forests. Investigations were conducted in mature Scots pine stands after shelter wood cuttings of different time in hemiboreal zone, Lithuania. Plots in pine forest stands were selected after the first step of shelterwood cuttings of different age and in stands of nearby uncut pine forest in the same site conditions. 780 plots were described in total. We recorded projection cover of herbs and mosses in percent in 100 m^2 (10×10 m) plots and amount of saplings in transect of 20 m length and 1 m width. It was determined that average number of species did not change in the shelterwood cutting of different age. The highest number of pine seedlings was recorded in shelterwood cuttings in second year after cutting and number of seedling decreased in older shelterwood cuttings. The overall average projection cover of herb layer increased after shelterwood cuttings. Average projection cover of *Vaccinium myrtillus* and *V. vitis-idaea* decreased, while average projection cover of *Calamagrostis arundinacea* increased. Average projection cover of mosses decreased after shelterwood cuttings. According to Ellenberg's indicator values after the shelterwood cuttings more light-demanding, temperature-demanding and nitrogen-demanding species and less xerophilic species were found.

Marozas, V., Sasnauskienė, J. 2014. Change of ground vegetation after shelter-wood cutting in Scots pine forests in hemiboreal zone, Lithuania. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 59.

Applying a framework for landscape planning under climate change for the conservation of biodiversity in the boreal forest

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Conservation measures are often established without consideration of the impacts of climate change. However, these impacts are expected to threaten species and ecosystem persistence and have more dramatic effects at the end of the 21st century. Landscape suitability for species under climate change is determined by several interacting factors including dispersal and human land use. Designing effective conservation strategies at regional scales to improve landscape suitability requires identifying the vulnerability of regions to climate change but also measuring their current conservation capacity. The framework for defining vulnerability categories is already established but the way to implement this prioritization in a systematic cost-effective way is still unclear. We use an ecosystem model to define the potential resilience of the Finnish forest landscape by relating its current conservation capacity with its vulnerability to climatic change. In applying this framework we take into account at the same time very different types of response to climate change from red-listed species with different niche requirements. Using this systematic approach we identified four categories which proportion in the landscape varies among the SRES scenarios (B1: low, A1B: intermediate, A2: high emissions): a) susceptible (B1=4.7%, A1B=16.0%, A2=9.4%): the most intact forest landscapes highly vulnerable to climate change, requiring management for enhancing heterogeneity and resilience; b) resilient (B1=21.9%, A1B=10.1%, A2=16.4%): mainly intact areas with low climatic vulnerability that could represent important climate refugia, where maintaining high landscape quality and monitoring; c) resistant (B1=63.8%, A1B=40.9%, A2=35.8%): landscapes with low habitat quality but with low climatic vulnerability recommended for restoration projects; d) sensitive (B1=5.1%, A1B=33.1%, A2=38.5%): low quality landscapes and vulnerable to climate change where alternative measures are required: in low sensitivity landscapes amelioration through restoration/conservation measures, in highly sensitive landscapes abandonment to effectively allocate scarce conservation resources. Our results indicate that higher emission levels will increase the proportion of sensitive landscapes while reducing resistant landscapes. This increased fragility of the landscape with higher emission levels translates into a higher uncertainty for landscape managers in the choice of conservation measures.

Mazziotta, A., Triviño, M., Tikkanen, O.-P., Kouki, J., Strandman, H., Mönkkönen, M. 2014. Applying a framework for landscape planning under climate change for the conservation of biodiversity in the boreal forest. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 60.

Potential of advance regeneration of Norway spruce in forest regeneration in Estonia

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Forest management puts increasing effort in imitating natural processes and dynamics. One way to emulate natural forest dynamics is the use of advance regeneration as a basis for forest regeneration. It provides options to a faster and more vigorous restock of the stand after logging and sustains biodiversity. Forestry practices in Estonia recommend saving viable advance regeneration during forestry operations. This regeneration varies in size and age distribution. However, little is known about how such released trees acclimate to the new environmental conditions and their following growth performance.

The present study examines the growth of advance regeneration of Norway spruce in four permanent sample plots in the Järvselja Training and Experimental Forest District of the Estonian University of Life Sciences. Clear-cut of selected forest stands occurred during winter. One of the sample plots was left untouched and used as a control. In another sample plot, trees were harvested five years after release: basal discs were removed and tree rings were measured and counted.

Advance regeneration varied in height throughout all plots. Accelerated growth was observed for released advance regeneration. Initial tree diameter growth response was faster compared to tree height growth. There was an increase in shoot length and needles mass in subsequent years, stabilisation at 4–5 years after release and tendency to decrease slightly after. Larger sized advance regeneration showed stronger response to release as concerns growth. On the sample plot where advance regeneration was harvested trees had various ages and mean height of trees increased with tree age.

In forestry practice the challenge is to develop new regeneration methods, which enable a combination of natural and artificial regeneration. In order to generate a pure Norway spruce stand, a practical implication is that dense groups of advance regeneration need to be tended by selection of future trees and removal of, especially fast-growing, competitive trees. Alternatively, mixed species stands where birch, spruce and other deciduous species are establishing at different times, follow more natural successional dynamics. One major advantage for use of advance regeneration is that forest management has multiple possibilities to regulate tree species composition by saving and promoting the growth of the desired tree species during forest management operations.

Metslaid, M., Engelhart, J., Jõgiste, K., Metslaid, S., Vodde, F. 2014. Potential of advance regeneration of Norway spruce in forest regeneration in Estonia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 61.

Optimizing management for ecosystem services and biodiversity in production landscapes

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(1) University of Jyväskylä, Finland
(2) Finnish Forest Research Institute, Finland
(3) University of Eastern Finland, Finland

Reconciling biodiversity conservation with increasing demands of natural resources in production landscapes requires that the ecological, economic and functional values of the landscape are taken into account in planning and decision-making. Here we present a methodological approach on how to deal with these conflicts. We applied seven alternative management regimes on 30,000 forest stands for 50 years into the future. We first assessed the capacity of a boreal forest landscape to simultaneously produce different landscape values: suitable habitats for a set of species (representing several social and conservation values), economic returns (from timber extraction) and ecosystem services (climate regulation through carbon storage/sequestration). Then, we analyzed the trade-offs among the landscape values using multi-objective optimization and revealed combinations of alternative forestry management regimes to achieve the desired levels of landscape values. Refraining from silvicultural thinnings on a proportion of stands should be considered as a cost-effective management in commercial forests to reconcile the conflict between economic returns and habitat required of species associated with dead-wood as well as to increase the amount of carbon sequestered. For reconciling the conflict between timber revenues and climate regulation (through carbon storage), extended rotation periods should also be considered. Our results showed that with carefully and informed forest management planning at landscape level it is possible to achieve win-win situations among the landscape values. This requires adequately targeted and diversified management regimes.

Mönkkönen, M., Juutinen, A., Mazziotta, A., Podkopaev, D., Miettinen, K., Reunanen, P., Tikkanen, O.-P., Triviño, M. 2014. Optimizing management for ecosystem services and biodiversity in production landscapes. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 62.

Long-term impacts of disturbance patterns in relict and managed temperate deciduous stands

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Disturbance regimes of temperate deciduous forests are characterized by small-scale canopy gaps. The patch-mosaic structure of these forests is related to the distribution of gap-sizes and frequency of gap creation; the process of gap formation can have long-term effects on the variability of forest composition and structure. Long-term studies to understand the lasting impacts of management on interactions between disturbance and structure are essential to maintain forest resilience and function, and may help maintain biodiversity and functional diversity in managed forests.

We used dendroecology to explore the disturbance regime of two *Quercus–Carya* stands in Indiana, U.S.A. We evaluated disturbance frequency and gap size by combining ring series and spatial information for fine-scale temporal and spatial resolution. One stand was an unmanaged relict forest, and the second stand had a selection harvest in 1951; Dutch elm disease also impacted both stands around the 1950s. We predicted that disturbance frequency and severity would differ between the two stands after the different disturbance intensities.

There was no difference in the distribution of gaps sizes or mean gap size between the relict and managed stands between 1920–1999. The annual relict stand mean of 1.3 gaps per ha and the total annual gap area of 164 sqm per ha were significantly higher than the managed stand for the period. Gaps <200 sqm in the relict and managed stands accounted for 88.3% and 89.2% of the total number of gaps, respectively, and gaps <200 sqm accounted for 69.2% and 67.2%, respectively, of all disturbed area. After the introduction of Dutch elm disease and harvest, the relict stand had a higher mean annual number of gaps per ha (1.5 vs. 0.7), and larger mean total gap area per ha (150 vs. 54 sqm). The relict stand also had a greater number of larger (>200 sqm) gaps. Between 1953 and 1999, the relict stand only had a single year with no gaps formed, but the managed stand had a total of nine, or about 19% of the years had no disturbance. Differences in species compositions were also evident in response to the patterns, timing, and intensity of disturbances in each stand.

After five decades, changes to managed stand structure related to previous disease and harvest disturbances has resulted in fewer disturbances, less disturbed area, and fewer large disturbances; this may limit opportunities to preserve or enhance functional resilience and biodiversity.

Morrissey, R., Saunders, M., Jenkins, M. 2014. Long-term impacts of disturbance patterns in relict and managed temperate deciduous stands. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 63.

Quantifying biomass allocation patterns of Scots pine (*Pinus sylvestris* L.) along north-south gradient in Europe

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Scots pine is one of the most widely distributed species throughout Europe. Despite the fact that the species often occurs in the boreal forest, it occupies large areas on relatively dry sites of the Mediterranean regions. In this context, it is of interest to study the influence of climatic factors, of forest management and of tree interactions on the allocation patterns of this species. The objective of this ongoing work is to develop a methodology of quantifying the allocation principles in terms of height and diameter growth of Scots pine based on the allometric coefficient. We have used the observed allocation patterns to establish a typology for identifying exposure to different environmental factors and development stages. Cluster analyses were applied for developing this typology. We have studied annual height and diameter increment data from stem analyses of 114 Scots pine trees from Estonia, Poland and the Czech Republic with an age span between 40 to 115 years (age when sampled). Ten dominant patterns of allometric relationship were found in three countries. Our results indicate no significant growth and allocation patterns in response to environmental factors and development stages.

Key words: height and diameter growth, allometric coefficient, cluster analysis, forest development stages.

Motallebi, A., Pommerening, A., Kangur, A., Kiviste, A. 2014. Quantifying biomass allocation patterns of Scots pine (*Pinus sylvestris* L.) along north-south gradient in Europe. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 64.

Forest structure assessment for describing structural legacies in semi-natural hemiboreal forest

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Maintaining the processes that lead to the development of diverse forest ecosystems, it is needed to understand the biological, ecophysiological and physical conditions that direct forest ecosystem development (ensuring development of various habitats to different species). The evolving of the current structural and functional elements of the stand is directed by the site, species specific and disturbance regime dependent variables. The current state of stand structure, tree species composition and susceptibility to future disturbance in naturally developing forest is depending also on spatial arrangement of biological remnants and physical structures, as the heritage of natural disturbance(s).

In the current study we describe the remnant elements/legacies impact to forest structure based on the Järvselja primeval forest (19.7 ha). These forests have been out of conventional management about 90 years. We aim with this work to describe the prevailing disturbance regime directing natural forest dynamics in the studied stands through the description of the current structural legacies.

We focus on the standing live and dead trees (>7 cm DBH), laying trees (>6 cm diameter) and high snags in the analysis. The measurement in the stands include next to the tree locations description of the live and dead trees decay stages (5 decay stages), vitality (vital, poor, normal), dominance (co-dominant., sub-dominant etc), tree layers, height (tree height, live crown base height and dead crown height) and diameter. Based on the currently occurring structural legacy elements, we reconstruct the patterns of possible historical disturbance pathways.

Nigul, K., Kangur, A., Metslaid, M., Korjus, H., Laarmann, D., Sims, A., Jõgiste, K., Frelich, L. E. 2014. Forest structure assessment for describing structural legacies in semi-natural hemiboreal forest. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 65.

Assessing process dynamics in the forest ecosystem – atmosphere continuum using the SMEAR Estonia station

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(2) University of Tartu, Estonia

The dynamic processes within the forest ecosystem – atmosphere continuum are driven by fluxes of energy and matter between the biosphere and atmosphere. To assess and understand the process dynamics in such a complex adaptive system required comprehensive data. Since the first integrated forest ecosystems – atmosphere measurements conducted in 2008 at the Järvselja Experimental Forest Station a large-scale infrastructure called the Station for Measuring Ecosystem – Atmosphere Relations (SMEAR) Estonia has been established. Combining research in biology, chemistry, ecology, forestry, mathematics and physics the station provides a multidisciplinary tool to meet future challenges on forest ecosystems related to changing climate and socio-economic developments.

Here, we present some recent results. Fluxes of carbon and water as well as atmospheric concentrations of greenhouse gases, reactive trace gases and air ions and atmospheric particles have been characterised. The theoretical description of forest ecosystem functional processes has been started within the last few years, but there is a clear gap within the reality of scaling between different temporal and spatial scales of forest ecosystems. By applying models at different scales, feedbacks between atmospheric and biospheric processes can be described to reflect the scale and scope of the research question.

Noe, S. M., Kangur, A., Lukjanova, A., Niinemets, Ü., Portillo-Estrada, M., Püttsepp, Ü., Kimmel, V., Hõrrak, U., Krasnova, A., Krasnov, D., Liiva, H., Mirme, S., Komsaare, K., Eller, M. 2014. Assessing process dynamics in the forest ecosystem – atmosphere continuum using the SMEAR Estonia station. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 66.

Bryophyte species richness on retention aspens recovers in time but community structure does not

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Green-tree retention is a forest management method in which some living trees are left on a logged area. The aim is to offer 'lifeboats' to support species immediately after logging and to provide microhabitats during and after forest re-establishment. Several studies have shown immediate decline in bryophyte diversity after retention logging and thus questioned the effectiveness of this method, but longer term studies are lacking. Here we studied the epiphytic bryophytes on European aspen (*Populus tremula* L.) retention trees along a 30-year chronosequence. We compared the bryophyte flora of 102 'retention aspens' on 14 differently aged retention sites with 102 'conservation aspens' on 14 differently aged conservation sites. We used a Bayesian community-level modelling approach to estimate the changes in bryophyte species richness, abundance (area covered) and community structure during 30 years after logging. Using the fitted model, we estimated that two years after logging both species richness and abundance of bryophytes declined, but during the following 20–30 years both recovered to the level of conservation aspens. However, logging-induced changes in bryophyte community structure did not fully recover over the same time period. Liverwort species showed some or low potential to benefit from lifeboating and high potential to re-colonise as time since logging increases. Most moss species responded similarly, but two cushion-forming mosses benefited from the logging disturbance while several weft- or mat-forming mosses declined and did not re-colonise in 20–30 years. We conclude that retention trees do not function as equally effective lifeboats for all bryophyte species but are successful in providing suitable habitats for many species in the long-term. To be most effective, retention cuts should be located adjacent to conservation sites, which may function as sources of re-colonisation and support the populations of species that require old-growth forests.

Oldén, A., Ovaskainen, O., Kotiaho, J. S., Laaka-Lindberg, S., Halme, P. 2014. Bryophyte species richness on retention aspens recovers in time but community structure does not. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 67.

Different disturbance regimes in Norway spruce forests in Bulgaria dependent on forest histories and site conditions

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Natural disturbances are among the most important factors shaping forest dynamics and forest landscapes. At the same time the natural disturbance regimes of many Norway spruce forests in Europe are not well understood mostly because there are few unmanaged forests to be studied. We present analysis of the disturbance regimes in three forest reserves in Bulgaria, SE Europe – Parangalitsa, Bistrishko braniste and Beglika.

Parangalitsa forest, a high-productivity unmanaged spruce ecosystem, was characterized by numerous medium scale disturbances during the last 200 years. They were mostly windthrows but also a few fires. The largest windthrow patch was 10 ha. Most affected were uniform Norway spruce forests with age of more than 130–150 years. The frequent disturbances created a complex landscape mosaic, in which all stages of forest development were present. Thus far there has been no large bark beetle outbreak, which we attributed in part to the very diverse forest structures which hinder outbreaks. Bistrishko braniste forest was characterized by large-scale disturbances. A 60-ha windthrow in 2001 was followed by an *Ips typhographus* outbreak on more than 200 ha. We believe that the outbreak was facilitated by the history of the forest, which was highly affected by intensive human use up to about 150 years ago. As a consequence the forest was composed of similar-sized trees with age of 80–130 yrs, characteristics that would support rapid bark beetle infestation. Since the outbreak, only a few small patches of old trees are intact. Beglika forest, a subalpine spruce ecosystem, is characterized by small-scale disturbances. Dendroecological analysis showed that gaps started to form and increase in number after the majority of trees reached an age of about 60 years. Most gaps were up to 100 sq. m in size. Most of them did not expand over time.

Our data show that Norway spruce forests in the European mountains can be characterized by different disturbance regimes. Forest history and site conditions may strongly affect natural dynamics and especially susceptibility to large-scale disturbances.

Panayotov, M., Tsvetanov, N., Alexandrov, N., Bebi, P. 2014. Different disturbance regimes in Norway spruce forests in Bulgaria dependent on forest histories and site conditions. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 68.

Mortality processes in self-thinning stands of spruce-dominated mountain forests

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Dense, uniform stands have increased in spruce-dominated mountain forests during the last century and present a management challenge for silviculturists. Dense, uniform spruce forests become widespread after natural disturbances or fragmentation of land-use and forest management. It remains unclear how forests develop without human interventions in mountainous areas and how susceptible they are to disturbances of different scales. During recent years, different research activities in Bulgaria and Switzerland have addressed the natural dynamics in such dense spruce-dominated mountain forests with or without active management. Standard dendroecological methods were used to investigate competition and self-thinning processes and spatial influences on mortality and developmental processes. Competition significantly influenced tree mortality in the investigated plots. Mortality was not random, showing higher values in high competition areas. In the Swiss plots we observed differences in basal area and stand density between north- and south-facing slopes. While basal area increment was significantly higher on south-facing slopes, stand density was generally higher on north-facing slopes. The comparative study in Bulgaria showed that mortality was associated with high competition and compounded by climate extremes, of which the most important were droughts.

This comparison shows the importance of local environmental factors on the development of self-thinning stands with low management intensity. The results point out that influences of competition are crucial for the development of forests and may strongly vary according to environmental factors in space and time. These studies confirm that within a few decades of stand initiation, the trees in approximately 80–150-year-old stands were already strongly affected by competition-induced self-thinning processes, which subsequently triggered small-scale mortality processes. At the same time our data show that climate extremes play an additional role in the mortality process.

Panayotov, M., Krumm, F., Bebi, P. 2014. Mortality processes in self-thinning stands of spruce-dominated mountain forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 69.

Impact of post-fire management treatments on regeneration

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Fire is a significant disturbance in boreal and hemiboreal forests creating a large amount of dead wood, causing alterations in vegetation species composition and soil seedbank. Forest management activity is often applied to fire disturbed areas to reduce the risk of secondary disturbance (e.g. insects), to remove timber suitable for industry and to prepare the area for regeneration. In northwestern Estonia forest fires are frequent in pine-dominated dry sites, but clear guidelines how to manage these stands to accelerate forest regeneration, prevent future fires and avoid erosion, are absent.

Post-fire management impact on natural regeneration (abundance, tree species composition and tree growth) was studied in Scots pine (*Pinus sylvestris* L.) forests on *Calluna* and *Vaccinium uliginosum* site types in northwestern Estonia. Forest fires in this area occured in 1992 and 2008. Permanent sample plots were established with a size of 20×40 m (N=30), each sample plot had 2 subplots with a size of 2.5×40 m (N=60). Study included 5 types of management treatments: (1) burned and cleaned – trees removed after fire (BC); (2) burned and uncleared– no management applied after fire (BU); (3) control– no fire and management (CO); (4) burned and uncleared– areas with dead standing trees (BUD); and (5) burned and uncleared– areas with alive trees (BUA).

Natural regeneration was low on BC areas compared to BU, BUD and BUA areas, especially during the first years after fire. In the uncleared areas regeneration was lowest on BUA areas. Regeneration was minimal in CO areas, which shows that forest succession in the studied area without fire disturbance is very slow and fire is normal and integral part of this forest ecosystem. Birch (*Betula* spp.) regenerated abundantly in all permanent sample plots, Scots pine and European aspen (*Populus tremula* L.) regenerated generally later and less abundantly. Later pine started to dominate and outcompete deciduous trees.

Effective use of wood as a renewable natural resource has become actual and even non-merchantable wood is used as a biomass for energy. At the same time conservation of biodiversity is in focus. In northwestern Estonia, it is advised to provide mosaic and diverse forests by using BU and BC management treatments. In that way financial benefit is sustained and biodiversity characteristic to fire disturbed areas is preserved. Further research is needed to provide guidelines for sustainable cuttings and regeneration.

Parro, K., Metslaid, M., Renel, G., Sims, A., Köster, K., 2014. Impact of post-fire management treatments on regeneration. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 70.

Controlled burning of artificial canopy gaps facilitates seedling establishment and multi-cohort age classes in restored Scots pine dominated forests

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(2) Finland
(3) Metsähallitus, Finland

Conversion of natural forests into single-cohort stands and the decline in forest fires have altered the landscape of boreal forests in northern Europe, most notably in Fennoscandian countries. Because many currently protected forests are former timber production areas, restoration activities are often needed to re-establish their natural structures. In this experimental study, we monitored the establishment of seedlings in previously managed but currently protected Scots pine (*Pinus sylvestris* L.) stands in southern Finland. The forests had been restored by creating within-stand canopy gaps and/or by using controlled fire, to facilitate establishment of multi-cohort age classes and to diversify the tree species composition. We compared the seedling abundance between five experimental groups, one of which was an untreated control forest, five years after restoration. Density of seedlings was highest in canopy gaps that had been also burned (mean 25.4±3.4 seedlings/100 m^2). Especially silver birch (*Betula pendula* Roth) and Scots pine clearly benefited from the use of fire in canopy gaps, also when compared with unburned gaps. We conclude that within-stand artificial canopy gaps can be useful in forest restoration and controlled use of fire is beneficial when the aim is to diversify tree species composition and age-class structure.

Pasanen, H., Rehu, V., Junninen, K., Kouki, J. 2014. Controlled burning of artificial canopy gaps facilitates seedling establishment and multi-cohort age classes in restored Scots pine dominated forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 71.

Challenges for the conservation of native forest biodiversity in Scotland

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Scotland, along with other part of the British Isles, was dominated by forest in postglacial period but was largely deforested through a combination of human land use and climatic change. Woodland cover was as low as 4% by the 17th century. A large re-afforestation programme occurred in the 20th century, mainly using introduced conifer species. However over the last 25 years greater emphasis has been placed on restoring and expanding the area of remnant native woodland.

The Native Woodland Survey of Scotland was completed in 2014; a major project which mapped and described the condition of every area of native woodland over 0.5 ha in size.

This paper describes the outcomes of this work and outlines how they can be used to spatially target action to restore native woodlands and make them more resilient to climate change and other pressures. Measures proposed for resilience include developing forest habitat networks to promote species movement and gene flows at landscape scale, an enhanced role for natural regeneration to promote genetic adaptation, and promoting greater diversity of native tree and shrub species. Controlling herbivore impacts and invasive non-native species are key challenges.

Patterson, G., Tullis, J. 2014. Challenges for the conservation of native forest biodiversity in Scotland. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 72.

The effect of small forest roads on understory vegetation of Scots pine forests

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A forest edge is an ecotone habitat where conditions of open environment and closed forest interior meet and create a new community consisting of species from both sides. In the forest, road is a linear edge with a specific disturbance regime. It passes through the core area of the forest and changes environmental conditions of understory which has never confronted the boundary conditions. Although, road verges are widespread, quite little is known about their specific effect to the forest understory. Therefore, purpose of our study was to evaluate the effect of small forest roads on the herb layer of mature Scots pine forests and to find out the most profound factors. For that we set 56 transects in forest core areas, from road verge toward forest intact interior, and used five 1×10 meter plots parallel with the road. We described herb community, stand characteristics and also light and soil conditions.

Generally, the road verge community was statistically different from the community found in the forest: there were more graminoid and forb species. Nevertheless, typical forest species were found on road verges too. Statistical test emphasized that the overall species richness was positively correlated with the soil pH, the width of the road corridor and tree species composition. Additionally, the richness of forest interior species was affected positively by moss layer thickness. Common road edge species preferred more lit conditions, greater soil pH values and thinner moss layer. Therefore, in road-forest boundaries species had greater Ellenberg values of light, temperature, fertility and acidity, the bigger average height and a wider dispersal range.

We conclude that the herb layer of Scots pine forest is quite unaffected from the road induced effect. The most evident changes in vegetation take place on the road verge, and the effect is quite marginal from the first meters into the forest. The strongest indicator of road impact was the width of the road corridor, because it determines changes in multiple environmental conditions simultaneously.

Rammi, I.-J., Liira, J. 2014. The effect of small forest roads on understory vegetation of Scots pine forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 73.

Metapopulation dynamics of a beetle species confined to burned forest sites in a managed forest region

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Despite an increasing awareness of the theoretical importance of habitat dynamics on metapopulations, only a few empirical studies have been conducted. The aim of the present study is to increase our understanding of how patch size, dynamics and connectivity affect colonization-extinction dynamics and the occurrence patterns of a beetle (Stephanopachys linearis), which breeds only in burned trees, which exist as dynamic habitat patches that have become rare in managed forest landscapes. We assessed species' presence/absence twice in all known habitat patches (i.e. >1 ha sites where forest fires had occurred during the previous 2–15 years) in a 200 km × 150 km region of central Sweden, dominated by managed boreal forest.

Over six years, the colonization rate was 47% and the local extinction risk was 65%. The probability of colonization increased with patch size (number of suitable trees in a site) and connectivity to occupied patches within 30 km, and decreased with increasing time since fire. The local extinction risk decreased with habitat patch size but increased, unexpectedly, with connectivity. Occurrence increased with patch size and decreased with increasing time since fire. At a regional scale, S. linearis tracks the fire dynamics by colonising sites with burned trees and by going extinct at rates which make the species rare at sites where burnt trees are more than eight years old. In managed boreal forest landscapes, a large proportion of sites may be created by prescribed burning (in our study area: 82%), and consequently human decisions strongly affect the future amount of habitat for fire-dependent species and its spatial distribution. Stephanopachys linearis uses burned sites more in sites where more trees are retained and, to some extent, if sites are concentrated in those parts of a region that already support high population densities of the species.

Ranius, T., Bohman, P., Hedgren, O., Wikars, L.-O., Caruso, A. 2014. Metapopulation dynamics of a beetle species confined to burned forest sites in a managed forest region. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 74.

Prescribed fire and green tree retention restoration practices enhance biodiversity and pollination services for *Vaccinium* shrubs in Finnish boreal forests

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The lack of natural disturbances in boreal forests (e.G. Fire, windstorms) and the subsequent homogenization and simplification of forest ecosystems because of intensive forest management poses a threat to biodiversity and it can endanger the provision of forest ecosystem services. In this study, we assessed how two restoration methods based on natural disturbances and aimed at increasing structural and functional heterogeneity of forest stands, i.E. Prescribed fires and green tree retention (gtr), affect provisioning and pollination services related with *Vaccinium* shrub species in boreal pine-dominated forests. 13 Years after their establishment. *Vaccinium myrtillus* (bilberry) and *Vaccinium vitis-idaea* (lingonberry) characteristics and pollinator samples were taken from 24 study sites within the framework of a large-scale ecological experiment, where retention tree level (clearcut, 10, 50 m^3/ha and uncut old-growth controls) and prescribed fire (yes, no) has been manipulated following a factorial design. We sampled pollinators using colored pan traps, while shrub characteristics were sampled on 1 m^2 quadrats. For bilberry, higher cover, number of flowers and berries, and berry survival were found in control sites; with number of berries increasing with bumble bee abundance on control forests. Lingonberry cover and number of flowers were higher on burned controls and lower on burned clearcuts. Fruit survival and number were higher on burned high-retention sites (50 m^3/ha). Total pollinators were more abundant on burned harvested sites over control forests. These large numbers were mainly due to the higher availability of bare soil, which is a fundamental nesting habitat from the two most abundant bee genera, *andrena* and *lasioglossum*. Pollinator species richness was also significantly higher in burned harvested sites, probably due to the higher structural complexity provided by bare soil patches and dead wood diversity, which increases nesting habitat. We hypothesized that the uncoupling of flower resources with their pollinators in Finnish boreal forests is a consequence of the historical absence of natural disturbances, which makes naturally disturbed stands isolated pollinator source habitats, putting ecosystem services stability at risk in facing global changes.

Rodríguez, A., Kouki, j. 2014. Prescribed fire and green tree retention restoration practices enhance biodiversity and pollination services for *Vaccinium* shrubs in Finnish boreal forests. – Transactions of the institute of forestry and rural engineering, estonian university of life sciences, 40, 75.

Stress mediates the dieback caused by *Hymenoscyphus pseudoalbidus* in the European ash (*Fraxinus excelsior*)

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The ash dieback is a widespread and invasive disease on ash trees in Europe. After initial weakening, caused by the ascomycete *Hymenoscyphus pseudoalbidus*, the trees usually die due to other causes (especially *Armillaria* spp. rot). So far, only genetic factors have been clearly shown to affect the resistance of individual trees, but we hypothesize that local stress can play a significant role. We studied 576 ash trees retained on 40 clearcuts in 2001–2002 in Estonia and likely to represent a random mix of genotypes. By the year 2013, 70% of studied ash trees remained alive. Canopy vitality (assessed in 4 classes) and diameter increment of all live trees was measured, and the presence of *Armillaria* spp. and *H. pseudoalbidus* was examined in 102 trees. We found that all investigated ash trees were infected with *H. pseudoalbidus* but some trees had no visible symptoms of the disease. In most viable trees (class 1), the average 12-year diameter increment was significantly larger than with the weakest trees (class 4), 9 cm and 3.5 cm, respectively. Diameter itself, as well as forest type, did not vary with vitality. However, there was a strong impact of the position of the tree in the clearcut: trees in the center had the worst vitality, trees at the forest edge showed better performance, and the (obviously acclimatized) trees retained close to pre-cut openings (e.g. nearby roads, ditches, open areas) performed best. The effects on diameter increment followed the same pattern. *Armillaria* spp. was present on 28% of ashes, and the occurrence probability was significantly higher on ashes with lower vitality and on trees close to edges of clearcuts (near forest, roads or open areas). The diameter increment of retention trees after cutting was significantly better on trees without *Armillaria* spp.

As the result of the study the conclusion is that although all studied retention trees are infected by *H. pseudoalbidus*, visible symptoms of the disease (canopy damage; decreased diameter increment) were more revealed in centre of clearcuts (even when the risk of *Armillaria* spp. infection is less there). The low stress and disease level of retention trees located closer to the edge is probably due to less changed growth conditions in the cut edge. Light intensity increases suddenly after cutting in the centre of a cut, but in the forest edge, the forest shade alleviates those changes and in open edge, retention trees are already acclimatized with intensive light conditions.

Rosenvald, R., Lõhmus, A., Drenkhan, R. 2014. Stress mediates the dieback caused by *Hymenoscyphus pseudoalbidus* in the European ash (*Fraxinus excelsior*). – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 76.

Diversity patterns of wild bees and wasps in managed boreal forest: effects of local resources and surrounding landscape

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Understanding which factors shape patterns of species diversity on different spatial scales is important for adapting management and optimizing conservation efforts. We aimed to determine which factors structure bee and wasp diversity in forest landscapes, and importance of management and conservation on local and landscape level. We surveyed bees and wasps (Hymenoptera: Aculeata) in eight landscapes in a managed boreal forest region, in 32 clearcut sites. We studied the total diversity of bees and wasps, as well as ecological groups with different nesting or foraging preferences. Species diversity and composition was related to local site properties like flower richness, use of prescribed fire, dead wood amount and habitat patch area, as well as to properties of the surrounding landscape, such as proportions of early-successional habitats, conservation habitats and deciduous forest. Species richness of all groups increased with high flower richness, indicating that flowering plants are an important resource to all bees and wasps, not just pollinators, in boreal forest-dominated landscapes. Large habitat patches (i.e. large clearcuts) also increased species richness of all groups. Prescribed fire had surprisingly little effect on bee and wasp diversity, but had a negative effect on predator species richness. Large proportion of early-successional habitats in the landscape was positively associated with ground and pollinator richness. Landscapes within the study region differed from each other in species composition, and beta diversity between landscapes made up the largest proportion of the total gamma diversity in the region. Our results indicate that, even though managed boreal forest landscapes are apparently homogeneous, species composition and richness is spatially structured in sub-regions of a few hundred square kilometers. It is on this scale biodiversity oriented management and conservation efforts should be applied.

Rubene, D., Schroeder, M., Ranius, T. 2014. Diversity patterns of wild bees and wasps in managed boreal forest: effects of local resources and surrounding landscape. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 77.

Can the restoration of long-ago drained mires damage forest biodiversity?

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Tartu University, Estonia

Active mire restoration is increasingly used to address the detrimental impacts of artificial drainage on ecosystem services of wetlands. We hypothezise, however, that the novel forest ecosystems on long-ago drained peatlands may have developed habitat value for forest dwelling organisms, thus raising a conservation dilemma. We explored the assemblages of polypore fungi in two mire landscapes in Western Estonia drained either 30 or 60 years ago. We conducted standard 4-hour inventories in 29 two-ha plots, now covered by Scots pine dominated forests of at least partial post drainage origin. The forests were relatively species poor, hosting 16–28 polypore species per plot and ca 75 species in total. However, these species richness estimates are not smaller than known from drier pine-dominant stands in natural forest areas in the region. Our 3299 records included repeated findings of putative 'old-forest indicators' *Diplomitoporus flavescens, Junghuhnia luteoalba, Meruliopsis taxicola, Perenniporia subacida* and *Phellinus pini*. The occurrence of species of conservation concern increased with forest age (age of the dominant tree cohort and the proportion of old trees in the stand).

We conclude that new forests on drained mires can indeed provide alternative habitats for some polypore fungi, and the decisions of restoring wetland conditions should consider forest habitat qualities at the landscape scale. Because the habitat quality of long-ago drained mires for forest species increased with forest age, the conservation management of such sites might be best accomplished by passive set-aside approaches rather than active restoration.

Runnel, K., Lõhmus, A. 2014. Can the restoration of long-ago drained mires damage forest biodiversity? – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 78.

Disturbances can control fine-scale pedodiversity in old-growth forest: Is the soil evolution theory disturbed as well?

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Biota–soil interaction in natural ecosystems is an area of considerable research. Our hypothesis is that individual trees play a significant role through biomechanical and biochemical disturbances in soil formation in temperate forest resulting in complex spatial pattern of disturbance regimes and a close relationship between disturbance histories and soil units.

In Žofínský Prales (Czech Republic) – the fourth oldest, continuously protected reserve in Europe and the only SIGEO site in continental Europe – we compared extensive dendrochronological, soil and pit-mound microtopography data on an area of 42.01 ha collected in 2008–2012. The datasets differ in terms of information complexity and length of memory. Tree cores contain complex information about disturbance history of the past 350 years, footprints of the specific tree uprooting disturbance can persist 1,700 years, and soils representing extensive composite phenotype have been developing for at least the entire postglacial period (10,500 years).

On average, 6.18–13.41% of the canopy was disturbed on individual soil units per decade. Even though the 'backbone' of key events in the development of the forest ecosystem remained the same (e.g. the 1870s, 1880s and 1980s), the internal structure of disturbance history often differed among soil units; the most exceptional were Gleysols and Histosols, where important feedback from soil to trees was expected. Characteristics of treethrow dynamics as well as frequencies of stronger releases in core series significantly differed along a gradient of soil weathering and leaching (Haplic Cambisols – Dystric Cambisols – Entic Podzols – Albic Podzols). Results suggest the existence of several disturbance regimes within the forest controlling fine-scale pedodiversity.

Samonil, P., Vasickova, I., Danek, P., Janik, D., Adam, D. 2014. Disturbances can control fine-scale pedodiversity in old-growth forest: Is the soil evolution theory disturbed as well? – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 79.

Earth observation based services to improve forest related data like forest area, landscape pattern or forest damages to fulfil reporting obligations in Austria

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As forests play a key role in the European economy and environment. International reporting obligations related to UNECE/FAO and to the Ministerial Conference in the Protection of Forests in Europe and local, regional and national authorities require forest area related data. The projects GSE Forest Monitoring and EUFODOS focused on these needs and provided timely and highly accurate data. The GSE Forest Monitoring covers whole Austria at a wall-to-wall basis. Products, based on high resolution optical satellite data and ancillary data have been provided: Austrian Forest Map, land cover statistics and derived forest environmental indicators. With regard to the MCPFE Pan-European Indicators for Sustainable Forest Management in Europe the landscape-level spatial pattern of forest cover gives information on size, shape and spatial distribution of forest areas in a landscape and reflects the potential to provide forest habitats.

Quantitative measures were derived from the forest map with a resolution of 1km by 1km and at community level: Forest Area Percentage, Number of Forest Patches, Number of Forest and Non-Forest Patches, Lengths of Forest Borderlines, Forest Border Index, Forest Fragmentation. The GSE FM results were novel with a very high thematic and geometric accuracy. The subsequent Forest Downstream Services (FDS) developed in EUFODOS included in particular the assessment of forest damage and the measurement of functional parameters for protective forests, defined by users organised in a User Executive Body. One application was the realization of an operational "IMPACT Change Detection Toolbox" for forest damage assessment. Especially due to devastating damaging events, such as storm events, one of key point is the fast delivery of Earth Observation data. For this purpose systems with a high temporal resolution, such as RapidEye or Sentinel-2, are well adapted to fulfil these requirements. Another downstream service was focusing on the derivation of forest parameters for the sustainable management of protective forests using LiDAR. A special software toolbox "IMPACT LiDAR Toolbox" was developed and implemented. Important parameters are computed from the LiDAR nDSM, such as crown coverage, tree height or vertical structure. The GSE and EUFODOS projects have proven that the use of innovative satellite and LiDAR technology can provide forest authorities with cost-effective, timely and comprehensive information on landscape, forest structure and damage.

Schardt, M., Gallaun, H., Granica, K., Hirschmugl, M., Mollatz, M., Wimmer, A., Linser, S. 2014. Earth observation based services to improve forest related data like forest area, landscape pattern or forest damages to fulfil reporting obligations in Austria. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 80.

Recovery of ecosystem carbon stocks in young boreal forests: a comparison of harvesting and wildfire disturbance

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Corresponding with increasing global resource demand, harvesting now affects millions of hectares of boreal forest each year, yet our understanding of harvesting impacts on boreal carbon (C) dynamics relative to wildfire remains unclear. We provide a direct comparison of C stocks following clearcut harvesting and fire over a 27-year chronosequence in the boreal forest of central Canada. While many past studies have lacked measurement of all major C pools, we attempt to provide complete C pool coverage, including live biomass, deadwood, forest floor, and mineral soil C pools.

The relative contribution of each C pool to total ecosystem C varied considerably between disturbance types. Live biomass C was significantly higher following harvesting compared with fire because of residual live trees and advanced regeneration. Conversely, most live biomass was killed following fire, thus post-fire stands contained higher stocks of deadwood C. Snag and stump C mass peaked immediately following fire, but dramatically decreased 8 years after fire as dead trees began to fall over, contributing to the downed woody debris C pool. Forest floor C mass was substantially lower shortly after fire than harvesting, but this pool converged 8 years after fire and harvesting. When total ecosystem C stocks were examined, we found no significant difference during early stand development between harvesting and fire. Maximum total ecosystem C occurred at age of 27 years, 185.1±18.2 Mg C ha^{-1} and 163.6±8.0 Mg C ha^{-1} for harvesting and fire, respectively. Our results indicate to a strong differences in individual C pools, but to a similar total ecosystem C after fire and clearcutting in boreal forests, and shall help improve modeling terrestrial C flux after stand-replacing disturbances.

Seedre, M., Taylor, A., Brassard, B., Chen, H., Jõgiste, K. 2014. Recovery of ecosystem carbon stocks in young boreal forests: a comparison of harvesting and wildfire disturbance. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 81.

Extinction risk of saproxylic beetles reflects the ecological degradation of forests in Europe

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To reduce future loss of biodiversity and to allocate conservation funds more effectively, major drivers behind large-scale extinction processes must be identified. A promising approach is linking Red Lists of functionally important taxa to specific habitat-related traits. In contrast to frequently used intrinsic and extrinsic traits, habitat-related traits reflect the influence of anthropogenic habitat changes and provide practical implications for conservation. We modelled the Red List categories of 1,025 saproxylic beetles of Central and Western Europe using an innovative linear mixed-effect model for ordered categorical responses, with distribution and habitat-related traits as fixed effects and phylogeny as random effect. The model also allowed predictions for un-assessed species. Our model revealed considerable potential extinction risks for lowland species and large species of saproxylic beetles. Furthermore, species that rely on dead wood of large diameter, broad-leaved host trees and open canopy suffer a higher risk of extinction. These results mirror the ecological degradation of European forests over the last centuries caused by modern forestry. Our results indicate that conservation activities of all forest types in Central and Western Europe should particularly focus on lowlands and increase the supply of dead wood of broad-leaved trees, dead wood of large diameter and dead wood in sunny areas.

Seibold, S., Brandl, R., Buse, J., Hothorn, T., Schmidl, J., Thorn, S., Müller, J. 2014. Extinction risk of saproxylic beetles reflects the ecological degradation of forests in Europe. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 82.

Relief entails mosaic natural plant restoration on inland dunes in subboreal zone (studies from northern Poland)

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The research was conducted in the military area located south of Toruń (52°55'N, 18°36'E). The area is situated in one of the biggest inland dune fields of Central Europe. The dominant soil type for the investigated dunes are sandy Podzols with Scots pine (*Pinus sylvestris*) forest as the climax vegetation. Since the 19th century the area was gradually deforested for military purposes and since then natural succession and fires were main factors determining vegetation development there. In this study we found that the vegetation that has naturally restoredvthe area forms regular mosaics reflecting position in dune mesorelief. Northern dune slopes are overgrown by loose pine and/or birch forests with heather (*Calluna vulgaris*) prevailing in forest floor vegetation. Xerothermic grasses cover southern slopes, tree density is on average 6 times lower than in northern slopes. The highest species richness occurs on intra-dune depressions that can be defined as "hot spots" of plant biodiversity in the studied area.

To determine related to relief site factors causing described vegetation pattern, we investigated microclimatic (air temperature and air relative humidity 30 cm above ground) and soil characteristics (morphology, moisture during growing season, texture, reaction, colour, hydrolytic acidity, content of TOC and of nutrients). This part of the study was conducted in a representative for the investigated area catena consisted of two northern and two southern slopes together with two intra-dune depressions. The results showed distinct and regular differences in microclimatic and soil characteristics depending on relief position. Southern soils were proved to be deep eroded after deforestation. As a result, at present they are deprived of primary organic and humus horizons and thus they form dry and poor in nutrients sites that are suitable for xerothermic plants mainly. Northern slopes, as more moist, are not eroded, they form much more favourable conditions for tree succession that can explain more density of trees on northern slopes in comparison with southern. While the contours of rich in species plant associations located in intra-dune depressions close overlap with ranges of the distinct richest both, in nutrients and moisture, soils in the study area. The soils are characterized by deep, formed as a result of a colluvial process, humus horizon that is crucial for forming favourable conditions for occurrence of high plant biodiversity.

Sewerniak, P., Jankowski, M. 2014. Relief entails mosaic natural plant restoration on inland dunes in subboreal zone (studies from northern Poland). – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 83.

The large poplar longhorn beetle, *Saperda carcharias* L. (Coleoptera: Cerambycidae) damages in the hybrid aspen (*Populus tremula* L. × *P. tremuloides* Michx.) stands

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Hybrid aspen (*Populus tremula* L. × *P. tremuloides* Michx.) is becoming one of the feature species in wood-based biomass production oriented short-rotation forest stands in Northern Europe. In Estonia the first hybrid aspen plantations were established in 1999. Hybrid aspen stands now cover approximate area of 700 hectares, all stands have been established on abandoned agricultural lands. Unfortunately, there is a lack of knowledge about the entomological fauna associated with hybrid aspen and also about the impact of insect herbivory on trees growth. In Estonian conditions, all insect pests found in endemic European aspen (*P. tremula* L.) are possible damaging agents of hybrid aspen, especially longhorn beetles (*Saperda* spp.). The large poplar longhorn beetle (*S. carcharias* L.) is very common and dangerous in Estonian aspen groves and mixed aspen stands. This less studied pest of young aspen stands causes significant damage usually until the age of 30 years. Larvae of *S. carcharias* are feeding in trunks of aspen causing failures of trees metabolism and infection with the fungus *Phellinus tremulae* (Bond.) Bond. & Borisov which induces central stem rot. The results of pilot testing conducted in 2013 showed that the damage rate of *S. carcharias* in young 5- to 14-years-old hybrid aspen stands in Estonia was significantly high (33–50% of trees were damaged). At the same time, some hybrid aspen clones proved quite resistant to the damage by *S. carcharias*. From Järvselja (Agali) comparative experimental area of hybrid aspen clones, established in 2009, samples were taken for testing. The results indicated significant relationship ($p<0.001$) between trees damaging rate (%) and geographical origin (i.e. genotype). It became evident that *S. carcharias* caused considerable damage to the Finnish clone no. C05-99-10. More resistant genotypes to the pest were hybrid aspen full-sib family W1 × Ihl 1 from Germany and Finnish clone no. C05-99-17, but also triploid aspen (*P. tremula f. gigas* Nilsson-Ehle) clone 'Haavametsa' of local origin.

Sibul, I., Sisask, S., Kivimägi, I., Ploomi, A., Lutter, R., Tullus, A. 2014. The large poplar longhorn beetle, *Saperda carcharias* L. (Coleoptera: Cerambycidae) damages in the hybrid aspen (*Populus tremula* L. × *P. tremuloides* Michx.) stands. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 84.

An old growth forest in the Pyrenees-implications of forest dynamics for management

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The designated Natura 2000 forest is in an isolated situation at the head of a branch of the Roncal Valley north of Pamplona, in the Spanish Pyrenees. The site is between 1500 and 1700 m above sea-level and is on calcareous substrates. The climate is Lusitanian but has above average snow cover because of the altitude. There is no evidence that trees have been felled for almost four hundred years and or that there has been significant human interference except some former grazing by domestic stock. The site covers about 70 hectares and the main tree cover is beech (*Fagus sylvatica*) with isolated Silver Fir (*Abies alba*). While the ground vegetation is sparse there is a rich fungal and lichen flora as well as many species of saproxylic insects feeding on the abundant fallen and standing dead trees. It is therefore comparable with high altitude forests in the Carpathian Mountains.

Two visits to the forest were made in 1985 and 2003 and records made of tree density, girths and seedlings. Whilst the overall structure of the forest is relatively stable there have been changes within the patterns of the size classes which will be presented in the paper. There had been a major wind blow event between the two visits but none since. Blown down trees were rapidly replaced from existing saplings.

As storm events may not be as rare as is often thought, the susceptibility of such relatively small sites to catastrophic change needs to be considered, especially as many reserves in across Europe are of a comparable size. The minimal size of reserves will be discussed in regard to this site which has existed for over four hundred years and accumulated a unique assemblage of taxa for an old growth forest in Atlantic Europe.

Smith, M., Bunce, R., Tomson, P., Elena-Rosello, R. 2014. An old growth forest in the Pyrenees-implications of forest dynamics for management. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 85.

A model of the post-fire recruitment of *Picea mariana* and *Pinus banksiana* as a function of salvage timing and intensity

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In this paper, we model the post-fire recruitment dynamics of two aerial seedbank species, *Picea mariana* and *Pinus banksiana*, in response to salvage logging. The model incorporates: 1) initial seed availability as a function of source tree basal area and proportion of stand salvaged; 2) seed abscission as a function of time; 3) seedling survivorship as a function of seed mass, seedbed proportion, and granivory; and 4) seedling and seed mortality as a function of salvage operations. We also elaborate a simulation of the effect of direct seeding via cone-bearing branches fed into a moving chipper. The model performed adequately when tested against data sets from two fires in Quebec and one in Saskatchewan. In particular, it showed that *P. mariana* was more adversely affected by early salvage than *P. banksiana* because of its far slower seed abscission rate. The model predicted that a delay in salvage or a decrease in salvage proportion would enhance tree regeneration densities, especially for *P. mariana*. Finally, model projections indicate that the use of a chipper to disseminate seeds during the harvesting would permit either species to be adequately regenerated cheaply even with low pre-fire basal area per area or very early salvage.

Splawinski, T., Greene, D., Gauthier, S. 2014. A model of the post-fire recruitment of *Picea mariana* and *Pinus banksiana* as a function of salvage timing and intensity. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 86.

Effects of retention trees and fire on polypore fungi on clear-cuts

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Green-tree retention is a worldwide practised method aiming at alleviating the negative effects of clear-cut forestry on biodiversity. However, little is known about the long-term impacts of this method for different species groups. Wood-decaying fungi are the main functional species group in dead wood. We established a large-scale, long-term experiment to study the effects of two different green-retention levels (10 m^3ha^{-1} and 50 m^3ha^{-1}) and pre-scribed burning on wood-decaying fungi, polypores, during a 10-year monitoring period. We monitored retention trees and polypores on 2,768 individually marked trees four times: in the first autumn after the treatments, and again two, four and ten years after the treatments. Our results show that 1) the number of polypore species and records increases during 10 years after the treatments, 2) red-listed species do not appear on the trunks during the first four years, 3) to maintain rich polypore assemblages at stand level, more retention trees are needed compared to what is typically left, and 4) the effect of fire is ambiguous: it can be useful in quickly increasing the amount of dead wood, but harmful by killing most of the trees at the same time so that there will be no continuity. However, when burning is done with higher retention levels, this leads to variable mortality patterns of trees and diverse substrate base for an extended period. We conclude that several polypore species can live on retention trees and that burning of retention trees is likely to be beneficial also for polypores but only if retention levels are comparatively high.

Suominen, M., Junninen, K., Heikkala, O., Kouki, J. 2014. Effects of retention trees and fire on polypore fungi on clear-cuts. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 87.

A novel evaluation method of voxelized LIDAR data: testing the feasibility of lacunarity approach for forest structure studies

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The geometrical structure of a forest is a very important property that determines its ecological context to a large extent. Many various approaches have been used to assess and evaluate it quantitatively, among others advanced mathematical models have also been applied to that. One possible approach is to consider the forest as a porous material that consists of the trees and other vegetation (representing material) and the empty space between the plants (as the porous space in the analogy). This model opens alternative approaches to study vegetation structure. Lacunarity, defined by Mandelbrot (1982), is a straightforward measure of structured empty space. The possible use of lacunarity theory in ecological applications was tested some 20 years ago. However, the technical difficulties of its implementation (the measurement technology was not yet suitable) have long hampered its practical application.

Today laser scanning (LiDAR) offers the opportunity for the appropriate data acquisition. Freshly available high-resolution, high-accuracy LiDAR datasets may allow the application of various concepts developed for porous media like tortuosity, percolation, directed percolation, anisotropic behaviour etc. In order to facilitate data processing, the original LiDAR point cloud is voxelized first using a voxel size determined by the point density. The horizontal voxel layers or the vertical voxel profiles form 2D images; the classic 2D lacunarities can be calculated based on them.

For analysing specific forest structural features, areas of interest (AOIs) can be defined, within which the pattern is assumed to be constant. AOIs will then be processed: the lacunarity curves are calculated for each voxel layer, i.e. the various levels of the forest structure can be evaluated. The lacunarity curves are suitable to evaluate and partly to quantify the structural diversity of the analysed AOIs. It is also feasible, though very computation-intensive to cover complete areas, but there is still a lot of research to be done to reveal the spatial behaviour of the lacunarity variation. In general, comparison and categorization of lacunarity curve sections may reveal hidden spatial structural context. Application of the technology on multitemporal LiDAR surveys allows to detect the structural development after natural and human disturbances.

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Székely, B., Standovár, T., Kania, A., Heilmeier, H. 2014. A novel evaluation method of voxelized LIDAR data: testing the feasibility of lacunarity approach for forest structure studies. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 88.

Disturbance effects on forest ecosystem service provisioning: a global meta-analysis

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In many parts of the world disturbance regimes have intensified recently, and climatic changes are expected to further amplify this development in the future. Yet, how such changes in the disturbance regime will impact the provisioning of important ecosystem services to society is still unclear. We here conducted a literature review on disturbance impacts by fire, wind and bark beetles on 20 different ecosystem services in the boreal, cool and warm temperate biomes of the world. Our objectives were to (i) synthesize the current knowledge about how disturbances impact ecosystem service provisioning, and to (ii) search for patterns between services, agents, and regions, in order to (iii) promote a more holistic understanding of disturbance effects in the context of sustainable forest management.

We screened a total of 1958 disturbance studies published between 1981 and 2013, and investigated one quarter of them in more detail. Using statistical meta-analysis (regression analysis and Fischer's Exact Test for Count Data) we further analyzed effects of disturbances on supporting and regulating services (biodiversity and climate regulation).

We found an overall positive effect of disturbances on supporting services, mainly driven by biodiversity. In contrast, provisioning and regulating services were generally negatively affected, even though there was a considerable number of studies also reporting positive (19.2% and 13.8%) and neutral effects (13.5% and 9.1%). Cultural services were predominantly negatively influenced, but remain understudied to date. With view on carbon storage, an example for a particularly important and well-researched regulating service, our results show a strong negative relationship between total ecosystem carbon storage and disturbance severity, when time since disturbance is considered ($p<0.001$). No significant trend was detected for biodiversity-related services in this regard. In order to investigate disturbance management impacts, we evaluated the role of salvage cutting and prescribed burning in a subset of our data. Salvage cutting was reported to reduce the positive effect of disturbances on biodiversity. Prescribed burning generally had a lower impact on ecosystem carbon storage than wildfire. Our results demonstrate the complexity of disturbance effects on ecosystem services and highlight the need for a more nuanced and context-specific evaluation of disturbances in relation to locally important ecosystem services.

Thom, D., Seidl, R. 2014. Disturbance effects on forest ecosystem service provisioning: a global meta-analysis. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 89.

Winners and losers of salvage logging – a meta-analysis of cross taxonomic species richness response

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Due to the high intensity of current production forestry, natural disturbances cause high economic losses, which forest managers try to limit by salvage logging. In contrast, benign neglect towards natural disturbances has been identified by ecologists as an important tool for forest restoration and nature conservation. Thus the disruption of the natural succession by salvage logging has increasingly led to controversial debates, particularly with regard to fast growing stocks over several decades. To estimate the impact of salvage logging, we compiled published and unpublished data of species richness across 20 taxonomical groups, concerning the most important large-scale causes of forest disturbance: fire, windthrow and bark beetle outbreaks. Our mixed (random effects) model revealed no overall loss of species due to salvage logging, independent of disturbance type. However the species richness of Mollusca, Araneae, Carabidae, Heteroptera and Coleoptera (exl. Carabidae & saproxylics) was promoted by salvage logging. In contrast, the species richness of wood inhabiting fungi, saproxylic beetles and epixylic mosses and lichens was significantly decreased by salvage logging. Furthermore, the species richness of birds, bats and moths did not reveal significant changes in species richness. We found no significant effects of time following the disturbance on overall species richness, independent of disturbance type. Even if some taxonomic groups were not affected, their assemblages might be altered by salvage logging beyond species richness like corroborated for the guild composition of birds for example. Thus, the impact of salvage logging is complex and should be carefully evaluated, particularly against the backdrop of deriving forest conservation strategies.

Thorn, S., Müller, J. 2014. Winners and losers of salvage logging – a meta-analysis of cross taxonomic species richness response. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 90.

Effects of anthropogenic disturbances on diatoms and Oribatid mites in riparian forest soils

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Soil biota is very important to the functioning of forest ecosystems. However, only some groups of soil organisms are well understood and a vast number of habitats are still unresearched. In this study the well-known environmental indicator properties of Oribatid mites are used together with diatoms to investigate the effects of multiple anthropogenic disturbances (e.g., alkaline air pollution, lake water contamination). Additionally the communities are compared to an area with similar soil conditions, but without significant human influence.

The main study site was Kurtna Kame field, which is one of the most human-disturbed natural areas in Estonia. The soil biota was studied in the riparian zone of seven lakes (a total of eight sampling sites). Mustoja Kame field was used as a reference site with low human influence and the sample sites were located in the vicinity of Mustoja stream. Previous studies have confirmed that the soil characteristics of the two areas are similar, excluding the effects of anthropogenic disturbances.

Diatom species richness and diversity were not significantly influenced by human influence level. However, some differences were noted in community structure. For example the dominance of certain taxa indicated the effects of multiple disturbances. The preliminary results indicate that the abundance of Oribatid mites is noticeably higher in the Mustoja study area. The species richness decreases with increasing human influence. In the study sites influenced by multiple anthropogenic factors the abundance of generalist species such as *Oppiella nova* and *Techtocepheus velatus* was high. Analysis of subsequent samples will provide supplementary information on Oribatid species, or group of species, providing the best classification to help identify the types and levels of human influences.

Vacht, P., Puusepp, L., Koff, T., Reitalu, T. 2014. Effects of anthropogenic disturbances on diatoms and Oribatid mites in riparian forest soils. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 91.

Can scar-based fire history reconstructions be biased? An experimental study in boreal Scots pine

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Determining forest fire history is commonly based on fire scar dating with dendrochronological methods. We used an experimental setup to investigate the impacts of low-intensity prescribed fire on fire scar formation 8 years after fire in 12 young managed Scots pine (*Pinus sylvestris* L.) stands. Five stands were between 30 and 35 years old and seven were 45 years old at the time of burning. A total of 217 fire scars were recorded in 142 trees. The number of separate scars per tree originating from a single fire ranged from 1 to 6, with 67% of the trees having just one scar. The proportion of fire-scarred trees out of all trees per plot ranged from 0% to 30%, averaging 16.5% in young stands and 2.8% in older stands. Four of the 12 burned plots did not have any trees with fire scars, and these were all in the older age group. This means that in the older stands, in only three of seven plots (43%) did the fire leave scars from which fire can potentially be detected and dated afterwards. Our results suggest that fire scar dating in Scots pine dominated forests may underestimate fire frequency, area, and the importance of historically common low-intensity surface fires in dendrochronological reconstructions of past fire histories. This applies especially to regions where low- intensity surface fires are known to have been historically common. Thus, caution must be used when constructing past fire histories and fire regimes derived from fire scar information.

Vanha-Majamaa, I., Piha, A., Kuuluvainen, T., Lindberg, H. 2014. Can scar-based fire history reconstructions be biased? An experimental study in boreal Scots pine. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 92.

Storm-affected community dynamics in unmanaged hemiboreal mixed forest

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Ecological forest management is often regarded as a tool for balancing the needs of people and nature and is ideally based on a thorough comprehension of natural forest dynamics, including natural disturbance regimes, for a given ecosystem. In the hemiboreal forest wind storms are an increasingly common disturbance event, but in many cases little is known about their effects on forest succession. Knowledge of changes in the pre- and post-storm tree community can help planning forestry related measures and support a nature-directed conversion of species composition.

We studied mortality in regeneration during the first post-storm decade in moderately- and heavily damaged stands in mixed forests in eastern and north-eastern Estonia and compared pre- and post-storm species composition. We expected that regeneration mortality would be initially directed by endogenous factors, generating a degree of spatial partitioning, whereas gradually species' life-history traits and competition would take over. Furthermore, we expected a more significant shift in species composition with increasing disturbance severity.

Comparison of logistic mixed effects models identified the most important factors for mortality probability of the species *Alnus glutinosa, Betula* spp., *Picea abies* and *Sorbus aucuparia* at different stages since disturbance. Regeneration was significantly taller in heavily-damaged areas and species traits only became significant at later stages since disturbance. Mortality probability is indifferent to microsite type and increases with storm severity for *A. glutinosa* and *Betula*, whereas *P. abies* initially benefits from increased levels of coarse woody debris. Subsequently, height and height increment in previous years are more clearly negatively related to mortality probability and competition levels in previous years increase chance of death. Shifts in successional pathway depend on a combination of disturbance severity and pre-storm stand composition: moderate disturbance tends to accelerate succession, whereas heavy disturbance sets development back to the early-successional stages.

This study indicates that interaction of storm severity, microsite heterogeneity and life-history traits of species present at a site lead to differences in regeneration mortality and species composition that may take several years post-disturbance to become apparent.

Vodde, F., Anoszko, E., Engelhart, J., Metslaid, M., Frelich, L. E., Jõgiste, K. 2014. Storm-affected community dynamics in unmanaged hemiboreal mixed forest. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 93

Influence of different patches of ground cover heterogeneity on species composition in three types of virgin spruce forests

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In the face of the sharp decrease in virgin forest areas, forest researchers and managers must understand the functional processes of native forests is order to restore lost forests. We studied three kinds of indigenous spruce forests of the Central Forest Reserve in Russia. Each of the three forests represented different zonal environmental groups. Patches of ground cover heterogeneity were described on each sample plot. Plot structure and composition was influenced by patterns of individual trees, vegetative growth of herbaceous plants and elements of microtopography, arising as a result of windfall or under the influence of small animals. Vascular plants and bryophytes were listed in each patch. We found that the contribution of different patches in species composition was determined by the quantity of species that are specific for this type of patches. Patches in the same position of microtopography have different quantity of characteristic species in different kinds of spruce forests. The patches of fallen logs have a lot of quantity of characteristic species in streamside forest. Boreal species such as *Vaccinium myrtillus* and *Dicranum polysetum* are distinctive for this kind of patches. Also *Serpoleskea subtilis, Ptilidium pulcherrimum* and epiphytic bryophytes such as *Orthotrichum speciosum, Neckera pennata* and *Radula complanata* have been found there. The patches, situated under the closed tree canopy are richer by characteristic species than other patches in nemoral spruce forest. For instance, boreal species such as *Vaccinium myrtillus, Rubus saxatilis,* and *Polytrichastrum longisetum* have been found under spruce trees. The patches of fallen logs and windfall mounds have a lot of quantity of characteristic species in boreal spruce forest. *Ptilium crista-castrensis, Plagiomnium cuspidatum* and *Nowellia curvifolia* have been found only on the patches of fallen logs. Species of soil outcrop such as *Dicranella heteromalla, Schistostega pennata, Atrichum flavisetum,* and *Herzogiella turfacea* are present at only on windfall mounds in this kind of spruce forests. Differences in patches composition may be a consequence of stochastic processes or differences in life conditions.

Voronina, V., Mirin, D. 2014. Influence of different patches of ground cover heterogeneity on species composition in three types of virgin spruce forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 94.

Guild specific response of bird assemblages to post-windthrow salvage logging

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Natural disturbances, like fire or windstorms are important drivers of biodiversity in forest ecosystems but simultaneously causing large economical losses. Therefore the subsequent management of windthrow is often debated, due to different interests of ecologists and economists.

As follows, salvage logging is commonly applied and accompanied by many negative effects to the environment, e.g. alterations of nutrient and species community compositions. This immediate anthropogenic disturbance after the natural one can cause serious additional damage to various taxonomical groups. As investigated so far, the loss in species richness of birds by salvage logging is slight, but it can seriously alter the species composition. However, an investigation of the effects of salvage logging beyond species richness of birds is still missing for wind-disturbed forests.

We followed up windthrow succession for 6 years with field campaigns every second season. Study transects consisted of logged and unlogged plots. We used a generalized linear mixed model (GLMM) with plot and year as random factors to account for repeated measurements to compare guild specific abundances of birds. As predictor for functional similarities we compared the phylogenetic diversity of bird assemblages using null-models, based on a distance matrix derived from a phylogenetic tree of studied species.

The abundance was significantly higher on unlogged plots in comparison to logged plots without significant differences in species richness. The abundance of cavity nesting birds decreased on both treatments from 2 years to 4 years after windthrow, whereas ground nesters increased on logged plots. Regarding foraging guilds, a higher abundance of ground- foragers were observed on unlogged plots 2 years after windthrow.

Investigations of fire disturbed forests postulate higher species occupancy of cavity-nesters and ground foragers on burned stands and more ground-nesters on salvaged areas. This contrasting pattern is caused by remaining vertical tree structures after fire, which still provide breeding possibilities for cavity nesters.

Overall, salvage logging caused a loss in phylogenetic diversity of bird assemblages, which implies in turn a loss of functional diversity.

Our results clearly demonstrate the importance of functional and phylogenetic approaches for understanding the impact of anthropogenic intervention in disturbed ecosystems, particularly if end consumer groups like birds are used.

Werner, S., Müller, J., Thorn, S. 2014. Guild specific response of bird assemblages to post-windthrow salvage logging. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 95.

Assessing ten-year blowdown and growth response after a spruce budworm inspired adaptive partial harvest in New Brunswick, Canada

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(2) University of New Brunswick, Canada

Models of adaptive forest management place an emphasis on the emulation of partial disturbances, e.g. fire or insect outbreaks, as a means of maintaining long-term ecological functioning after harvesting. However, little research is currently available that assesses stand dynamics in the aftermath of such practices. The aim of this study was to assess residual stand response to a spruce budworm (*Choristoneura fumiferana* Clem.) inspired adaptive partial harvest in the 10 years following the treatment (2002–2012). Stand and tree-level plot data were collected from balsam fir (*Abies balsamea* L. (Mill.)) dominated forest in New Brunswick, Canada, to assess blowdown, residual growth and woody regeneration response. The harvest treatment was based on expected mortality rates for balsam fir (remove 9 out of 10 trees) and spruce (*Picea* spp.; remove 6 out of 10 trees), with no non-host hardwood species removed except in harvest trails. This roughly recreated residual structures similar to those left following a typical spruce budworm outbreak in the region. Measurements taken before the harvest (2002), after (2004–2005), and in 2012, showed that blowdown increased with percent basal area harvested; and that this effect was most pronounced (52%) in plots subjected to treatments of between 75–100% (i.e. those with high pre-harvest fir-spruce content). Residual balsam fir (53%) and spruce (41%) displayed the greatest blowdown rates among individual species. Taller softwoods (when grouped), and those with considerable height-diameter ratios, were also more apt to blowdown, whilst no direct effect was observed for hardwoods. Post-harvest diameter growth (mm yr^{-1}) was significantly greater in four 25% harvest categories than in unharvested control plots. It is recommended that implementation of such natural disturbance-inspired harvest treatments should consider multiple entry harvests in plots with higher fir-spruce content, in order to reduce rates of blowdown.

Wilson, E., MacLean, D. 2014. Assessing ten-year blowdown and growth response after a spruce budworm inspired adaptive partial harvest in New Brunswick, Canada. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 96.

Poster presentations

Poster F1

Are post-disturbance canopy positions for *Picea mariana* and *Abies balsamea* determined by pre-disturbance relative dominance or specific differences?

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(2) Laurentian Forestry Centre, Natural Resources Canada, Canada

The Eastern Canadian boreal forest of Quebec's North Shore region is dominated by black spruce (*Picea mariana*) and balsam fir (*Abies balsamea*). Due to humid climatic conditions, fire return intervals in the region are long, and the primary disturbance agents are spruce budworm (*Choristoneura fumiferana* Clem.) and wind. Post-disturbance canopy development has been previously studied: Pham et al. (2004) found that stands dominated by either of the species are likely to self-replace themselves, while in mixed stand replacement is mainly reciprocal. However, Gauthier et al. (2010) found that stands dominated by either of the species show self-replacement, and that there is fluctuation of species composition in both stands dominated by either of the species and mixed stands.

Here, we study the response of saplings of the two conifers to overstory disturbances. Death in the overstory increases available resources, causing a growth release in the saplings. We test two hypotheses: 1) relative dominance, i.e. the size differences at the time of disturbance determine the post-disturbance canopy positions, or 2) species-specific differences in the response determine post-disturbance canopy positions.

To test these contrasting hypotheses, we collected samples from unmanaged old-growth forests in two study areas in the North Shore region. One of the areas was dominated by *P. mariana* and the other by *A. balsamea*. Four sample plots were selected from both areas. Depending on the presence of saplings, up to eight focal trees, four from each species, were selected from a disturbed area in each plot, as well as their strongest competitors from both species. Two samples (stem disks) were taken from each of the 140 saplings, one from root collar and one from 1.3 m height, resulting in 280 stem disks.

We measured ring-widths on each disk along four radii, and computed annual basal area increments. We then compared patterns of basal area increment to reconstruct tree size hierarchies at the time of disturbance, and compared focal tree characteristics to each neighbouring sapling. Here, we report first results of those analyses.

References

Gauthier, et al. 2010. Fifty-seven years of composition change in the eastern boreal forest of Canada. Journal of Vegetation Science 21(4): 772–785.

Pham, et al. 2004. Gap dynamics and replacement patterns in gaps of the northeastern boreal forest of Quebec. Canadian Journal of Forest Research 34(2): 353–364.

Ahokas, A., Aakala, T., Gauthier, S. 2014. Are post-disturbance canopy positions for *Picea mariana* and *Abies balsamea* determined by pre-disturbance relative dominance or specific differences? – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 99.

Poster F2

The effect of wind and bark beetle disturbance on *Picea abies* and *Sorbus aucuparia* coexistence in the subalpine primary forests of Central Europe

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To study the effect of disturbance on the forest communities has not yet been possible in Central Europe. This is because forest managers perceived severe disturbance as artificial and up until recently disturbance legacies have been removed from the forest. Consequently, there is a lack of knowledge about disturbance effects on *Picea abies* (spruce) and *Sorbus aucuparia* (rowan) species coexistence. Our research area is an old-growth subalpine spruce forest (1200–1300 m asl, Sumava National Park, Czech Republic) where severe wind disturbance and consequently spruce bark beetle outbreak occurred in 2007. Our aim is to determine how this disturbance affects survival rate, height increment, spatial pattern, and ungulate browsing of spruce and rowan species. The height, browsing presence and spatial pattern of individuals above 0.5 m were ascertained on two square plots with an area of 1 ha before (2006) and after (2010) the wind and bark beetle large-scale disturbance. Individual trees were re-identified to ascertain height increment, mortality with reason and change of ungulate browsing presence. The establishment of new individual trees was recorded. The survival rate of rowan was greater than that of spruce, primarily because rowan was not killed by mature tree uprooting or bark beetle attack. The height threshold between the survived and killed spruce individuals was 2.4 m. The response of height increment to light exposure was greater for rowan, despite its smaller average, pre-disturbance height. Post-disturbance, new individuals of both species show stronger spatial affinity to saplings of the same species that were established pre-disturbance. The individuals of rowan were less affected by ungulate browsing in patches, while spruce individuals were damaged by live mature tree uprooting. Overall, advanced regeneration of both species responds positively to the disturbance event. The rowan regeneration especially profits from wind disturbance. The rowan individuals are more adapted to tree-fall disturbance and to creation of pit-mound topography compared to spruce individuals and respond with a more intensive height increment post-disturbance. Further, rowan trees appear to be better protected against ungulate browsing in wind throw patches. The post-disturbance development and spatial structure of subalpine forest is determined by legacy of light and microsite limitation, formed in the previous stand.

Bace, R., Janda, P., Svoboda, M., Cada, V. 2014. The effect of wind and bark beetle disturbance on *Picea abies* and *Sorbus aucuparia* coexistence in the subalpine primary forests of Central Europe. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 100.

Poster C1

Mountain forest disturbances analysed using historical aerial imagery

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Wind-throw and bark beetle outbreaks have become very frequent in the last 50 years in Europe. It is usually ascribed to ever raising human impact on forests like recent extensive clear cutting and reforestation practices, or to global change by means of more wind-throws, higher drought stress or lower resistance to pathogens. To some extent, large-scale disturbances are a natural part of the forest dynamics, but certain management practices can increase the scale and severity of the disturbance. We have conducted a detailed analysis of a mountain ridge in National Park Šumava based on historical and recent black and white aerial imagery starting at 1949 up to recent large scale disturbances in 2003–2007.

The Region Polom-Plesná-Ždánidla ridge is a spruce (*Picea abies*) dominated forest around 1150 m a.s.l. with relatively low human impact in history. There have been a lot of changes in the area during the last century. Šumava became a military controlled border after the WW II, which helped to preserve the Czech side from urbanization and in 1991, National Park was established. Most of the area of NP Šumava is still covered by managed forest.

Our analysis shows that change of management practices in last 50 years triggered large-scale forest fragmentation or even deforestation, finally leading to a large disturbance in form of wind-throw and subsequent bark beetle outbreak. It began with small scale, patchy, managed wind disturbances captured on 1949 photos. Between 1949 and 1976 compactness of the forests had changed rapidly due to planned cutting in form of stripes.

Almost all (88%) of the fragmentation in 2003 is around these older cuttings. In 2007, the forest disintegrated on a large scale, mainly above 1150 m a.s.l., due to wind-throw and following bark beetle outbreak, again, it was mostly (94%)around former edges.

It is possible that such large-scale event would have occurred even without logging captured in 1976 imagery, but the effect could have been much smaller, maybe in form of isolated patches as captured in the 1949 imagery.

Brůna, J., Wild, J., Svoboda, M. 2014. Mountain forest disturbances analysed using historical aerial imagery. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 101.

Poster C2

Recovery of *Oplopanax horridus* (devil's club) after clearcut logging

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(2) University of Northern British Columbia, Canada

The persistence and recovery of devil's club (*Oplopanax horridus* (Sm.) Miq., Araliaceae) after clearcut logging in northwestern British Columbia, Canada, was investigated through a series of retrospective surveys. This species remains important to the traditional culture of many First Peoples of western North America, and like other members of the Araliaceae, is being investigated for its curative abilities by medical researchers. A shade-tolerant species with large leaves, many specimens were observed to have suffered from mechanical damage and high irradiance immediately after industrial logging operations. However, based on observations in 16 clearcuts that had been logged 3 to 37 years earlier it is clear that devil's club can survive and grow in these disturbed habitats. Stems can resprout from damaged stem bases, and appear to take at least 10 years to recover to sizes equivalent to those found in old-growth forests. The most successful populations of post-logging devil's club probably escaped damage during logging operations, showed no recent signs of fire, and were associated with loose piles of dead branches, tree tops and rotten logs which provide some shade and competition suppression. Considerations of these factors, in combination with the time since logging, provide guidance for the protection and sustainable management of this surprisingly resilient species.

Burton, C., Burton, P. 2014. Recovery of *Oplopanax horridus* (devil's club) after clearcut logging. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 102.

Poster F3

Changes in the ground cover structure in bilberry pine stands of different age and stocking density

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To investigate patterns in the change of the ground cover with the forest community age surveys were carried out in the Kivach Strict Nature Reserve in 2008–2010. The study objects were 2 sites in a bilberry pine stand: aged 185 years (BPS №1) and 70 years (BPS №2). Both sites belong to the same primary forest type. The ground cover was described by surveying transects. The transects were split into 20×50 cm sample plots in which the percent cover of each plant species was recorded. Data on the percent cover of individual species, and on layers of the plant cover were clustered into four groups corresponding to the four zones of the "phytogenic (ecological) field" (basal elevation, crown projection, crown spread bounds, inter-crown space) (Kryshen, 2000). Using the data analysis of variance of the percent cover of the ground cover species was carried out. Data on the percent cover of species were subjected to correlation analysis of contingency.

Comparison of the ground cover structure in the communities revealed both similarities and differences.

The differences consisted in 1) the number of plant species – the species diversity in the middle-aged community was higher owing to vascular plants; 2) moss species distribution – it was relatively even in the middle-aged community, whereas the ground cover structure in the old-growth site was patchy, with visually distinct moss synusium; 3) response of plants to the tree layer influence – more vascular plants in the 70-year-old pine stand demonstrated a significant response to the influence of trees, and the 185-year-old stand had more moss species with reliable distinctions.

The similarities were: 1) the number of species in the ground cover was the greatest between crowns and in the crown projection area in both the old-growth and the middle-aged stands; 2) variation of the average percent cover of mosses across zones of the phytogenic field was similar in both communities. *Pleurozium schreberi* abundance was equally high in the basal elevation area, decreasing outward from the trunk. *Hylocomium splendens* and *Dicranum* spp., in contrast to *P. schreberi*, grew more abundant from the trunk outward to the crown edge, their average percent cover being the highest between crowns; 3) the highest variation in the average ground cover percentages in both plots was observed for the dominant mosses *P. schreberi* and *H. splendens*.

Genikova, N., Kryshen, A. 2014. Changes in the ground cover structure in bilberry pine stands of different age and stocking density. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 103.

Poster B1

Are bats affected by wind farms in boreal forests?

Christer Gunnarsson

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Bats play an important role in many habitats around the world as they help control pests, are vital pollinators, seed-disperses for plants, and predators of night–flying insects. There are few studies about the ecological role of bats in boreal forests and how they are affected by clear cuts and other human land use.

Establishing wind power parks may affect bats by changed ecological conditions, as expansion of forest roads and removal of leaf vaults that may be important foraging habitats. Mortality of bats is not often observed or reported in the literature. However, wind parks may have an impact on population size and structure. Bats are one group of species that rely on tree cavities in forests, particularly for communal maternity roosting. Suitable sites are crucial for viability of the population. Bat activity is greater along forest – clear cut edges than in the center of clear cuts or in the forest interior and they increase in abundance with stand age, and are most abundant in old-growth stands.

Bats may be indirectly affected by wind power projects through habitat loss or fragmentation during construction, operation of a project and human activity. Deforestation associated with a project may remove woodland habitats important to breeding or roosting bats. Wind farms may also cause direct mortality for bats when colliding with the turbine blades.

Bat activity was measured in boreal forest in 2013 at two pre-construction sites in the county of Västernorrland. Automatic ultrasonic bat detectors were installed at two masts at 100 and at 10 meters height. The detectors were run continuously throughout the summer. We found no activity at 100 meter but some low activity at 10 meters height. Transect inventories in the areas also indicated low bat activity and abundance of few species.

It's an urgent need to get clear guidelines and field investigations at suggested wind parks, especially in boreal forests where the expansion will be significant in the near future. The most immediate examples include the boreal and hemi boreal forests, habitats where the effect of wind power establishment on bats not have been investigated in any country and were most wind facilities in Sweden are likely to be built in the near future. In 2014 three additional wind power parks in the county of Jämtland and Västernorrland will be investigated to study if there are any bat activity and risks of bat fatality.

Gunnarsson, C. 2014. Are bats affected by wind farms in boreal forests? – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 104.

Poster F4

A 3000 ha spatial explicit fire history illustrating the mosaic structure of boreal landscapes in Northern Europe

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(2) University of Wisconsin, United States of America
(3) National Property Board Sweden, Sweden

Although with some regional variation and differences among forest types, fires have been the major natural disturbance throughout the boreal forests of Northern Europe. As a consequence, several forest types and a large range of forest species are dependent on the natural fire regime. Since the late 19th century efficient fire suppression and changes in land use have basically excluded fires from a large part of the region. For that reason efforts are now taken to re-introduce fire as a management tool in protected areas as a mean to secure fire dependent forest types and species. However, there is limited knowledge of the natural fire regime calling for detailed studies on the spatial and temporal pattern of historical fires.

This was done in a 3000 hectare large nature reserve in central Sweden, and by using fire scarred trees we were able to reconstruct the fire patterns for more than 600 years. The results show that fires has been very common in the area and on average, seen over the entire area, one fire occurred every 8 years. We identified in total about 100 individual fires out which 12 fires are considered as large. The fire pattern over time showed three distinct periods. Prior to the 18th century the area was dominated by a few relatively rare but large fires. Between 1700 and late 19th century many small fires dominated the pattern, while from late 19th century to modern times, fires have basically been excluded. This pattern is likely linked to changes in human land use and potentially to climate variation.

Hjalmarsson, J., Jonsson, B. G., Larson, E., Yang, Y., Linder, P. 2014. A 3000 ha spatial explicit fire history illustrating the mosaic structure of boreal landscapes in Northern Europe. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 105.

Poster B2

Patterns of plant diversity in old-growth and managed silver fir-beech forests in their western distribution limit (Western Pyrenees, Spain)

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Old-growth forests are very rare in Spain, concentrated in national parks and other protected areas, and they have scarcely been studied. Concerning the Pyrenees, despite the great forest exploitation and tradition of livestock breeding in this mountain range, there are still some well conserved forests, such as Aztaparreta and Lizardoia, in the western Pyrenees. We have considered these well conserved forests that have been declared strict reserve, as old-growth forests in the Spanish context.

The goal of the study is to propose some guidelines for sustainable forest management based on investigation of old growth forest taken as a reference. This project may provide valuable information on plant diversity in silver fir-beech forests in their western distribution limit in Europe, subject to Oceanic and Mediterranean influence, and contribute to a better knowledge of old-growth silver fir-beech forests in Europe.

A pilot study has been carried out in order to compare plant diversity (mosses and vascular plants) in managed and unmanaged forests. Four forest types have been distinguished according to their protection status. A nested sampling design was used, with 2 forests in Strict Reserves, 2 forests in SCI, 2 forests within Natural Park, and 2 abandoned forests. All of them belong to the same association, *Scillo lilio-hyacinthi-Fagetum sylvaticae*, and grow on the same type of substrate and soil and with similar climatic conditions. Five 20×20 m plots were randomly sampled within each forest for species presence, and four 4×4 m subplots in each plot for species cover. Average size of each forest is 96 ha. Canopy cover and light quantity have been obtained using hemispherical photography. Data on forest management observed in the field was also registered.

Sampling was carried out in summer 2013. Subsequently several richness estimators were applied in order to determine sufficiency of samples. Total number of identified vascular plant species is around 100, and according to the results of statistical test variability is bigger than that obtained by pilot sampling. More sampling is required which will be performed in summer 2014.

Horvat, V., Biurrun, I., García-Mijangos, I. 2014. Patterns of plant diversity in old-growth and managed silver fir-beech forests in their western distribution limit (Western Pyrenees, Spain). – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 106.

Poster B3

Fraxinus angustifolia in central European alluvial hardwood forests over 40 years. Can it survive in the absence of flood disturbances?

David Janík, Tomáš Vrška, Dušan Adam, Libor Hort, Kamil Král, Pavel Šamonil, Pavel Unar

Silva Tarouca Research Institute, Czech Republic

Less frequent flood disturbances have changed the character of natural alluvial forests along most large European rivers, which affect the presence of *Fraxinus angustifolia* as well. Our research questions were: 1) How did *F. angustifolia* populations develop in the past 40 years in relation to other tree species? 2) How did *F. angustifolia* and other tree species react to the increase in available space after the decay of *Quercus robur* and *Ulmus laevis* layers? 3) How did the less frequent occurrence of floods and the decrease in the ground water table level affect the vertical distribution of *F. angustifolia* populations? 4) What are the characteristics of tree spatial pattern of *F. angustifolia* in comparison to other tree species?

The study was conducted in alluvial forests at the confluence of the Morava and Dyje rivers in the Czech Republic. The detailed surveys were performed in the Ranšpurk and Cahnov national nature reserves, which contain the best preserved old-growth forests of this complex. The pair correlation function was used to describe tree density variability. The analyses were carried out for datasets from the 1970s, 1990s and 2000s. Our results showed strong connection of *F. angustifolia* recruits to newly available space after the decay of old trees. The analysis of the vertical distribution of populations revealed an increase in the stand intersection of the *F. angustifolia* population with *Carpinus betulus* and *Acer campestre*. The *F. angustifolia* population demonstrated generally higher clustering than *C. betulus* and *A. campestre*. *F. angustifolia* recruits were positively connected to other conspecific trees to the distance of 7 m, *C. betulus* recruits showed the opposite and *A. campestre* recruits didn't reveal spatial dependency to other conspecific trees.

In conclusion our study suggests that in the absence of regular floods the proportion of *F. angustifolia* in alluvial forests will decrease. *F. angustifolia* gets into direct competition with *C. betulus* and maple, which have better abilities to mature under a closed canopy. By contrast, *F. angustifolia* is more successful under an open canopy, which, however, is limited after the decay of old *Q. robur* trees. It appears that alluvial forests are likely to turn into mixed broadleaved forests with dominant *C. betulus* and *A. campestre* in the future.

Janík, D., Vrška, T., Adam, D., Hort, L., Král, K., Šamonil, P., Unar, P. 2014. *Fraxinus angustifolia* in central European alluvial hardwood forests over 40 years. Can it survive in the absence of flood disturbances? – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 107.

Poster D1

Planning of ecological restoration in urban woodland in Riga, Latvia

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(2) Latvia University of Agriculture, Latvia

Urban forests form an important part of the complex urban ecosystem network. In urban forests the landscape usually lacks the structural and compositional diversity of natural woodland. The long-term goal of forest landscape restoration is to create a self-maintaining ecosystem that is resilient to perturbation. Vegetation in city forests is affected by recreational load and forest tract size. Forests with typical boreal vegetation in Riga, Latvia, has been replaced by broadleaved species such as *Quercus robur*, which might be promoted to provide an increase in the structural diversity. As in natural woodland, in managed forest gaps of various sizes also occur. The size of gaps, distance from surrounding trees and location within gaps are important factors that determine establishment and growth of tree species in the gaps. The aim of the study was to model the succession occurring in canopy gaps in the Vecdaugava forest tract (570 ha), located in the north-eastern part of Riga city. The dominant tree species is *Pinus sylvestris* and stand age is about 80–100 years. The dominant soil type is arenosols soils on sandy eolian deposits. Soils have weakly defined horizons, and the O horizon depth ranges from 0 cm up to 20 cm, depending on relief. Unsupervised classification of orthophoto images was conducted to delineate treetops, and the remaining area was defined as gaps. Fishnet generation (square or hexagon) was conducted and the gap share distribution by gap size was calculated. In fieldwork, *Q. robur*, *P. sylvestris* and *Betula pendula* seedlings and saplings in 30 randomly selected gaps were counted by height class to determine the proportion of gaps with seedlings and saplings of these species. In gaps the vegetation was described in subplots and tree discs were removed from a selected number of saplings to determine age-height relationships. This information was used to determine rates of height growth in relation to gap size and model succeesion in the canopy patches, depending on soil characteristics. Successful *Q. robur* recruitment to higher sapling height classes was found to occur in larger gaps, while *P. sylvestris* growth was not related to gap size. Management options were suggested regarding cutting of saplings to obtain specific targets: 1) regeneration of *P. sylvestris*; 2) regeneration of *Q. robur*; 3) maintaining open gaps with typical boreal vegetation.

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Jankovska, I., Brumelis, G., Straupmanis, G. 2014. Planning of ecological restoration in urban woodland in Riga, Latvia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 108.

Poster D2

Forest ecosystem responses to ecological restoration treatments in Estonia

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The legacy of structural homogenization due to forest management for commercial products is a loss of biodiversity. A common policy in many European countries is to increase forest diversity by converting managed forests to more natural conditions. The aim of this study was to provide an early evaluation of the effectiveness of different restoration treatments to rehabilitate managed stands in order to increase their naturalness. Restoration treatments were imposed on 30–60 years old conifer plantations including gap creation with and without added deadwood, added deadwood without gaps, gaps plus overburning, and controls. We sampled stand structure, understory vegetation and beetles before and after treatments on 50 circular permanent plots. Diversity of different groups responded differently to treatments with understory vegetation diversity increasing the most in gaps with burning, lichens in gaps without burning and bryophytes with the addition of dead wood. Increased beetle abundance and greater species diversity was a direct effect of changed light conditions inside the canopy. Gaps with overburning had the greatest recruitment of tree seedlings. Stands that were homogeneous pre-treatment increased in heterogeneity in structural conditions and microclimatic conditions after treatments and therefore richness and abundance of different species groups increased.

Korjus, H., Laarmann, D. 2014. Forest ecosystem responses to ecological restoration treatments in Estonia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 109.

Poster B4

The effect of forest stand on microclimate in mature temperate mixed forests

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The complex interplay of several stand characteristics and forest site conditions results in a specific understory microclimate that is essential for many forest-dwelling organism groups. Most forest microclimate researches focus on the effects of intense changes in canopy cover on microclimatic parameters induced by the impacts of natural disturbances, management practices or edge effect. Conversely, the aim of our study was to evaluate the relative importance of stand structure variables and landscape factors in explaining the microclimate in closed managed mature forest stands.

The effects of stand structure elements and management-related landscape factors on forest microclimate were studied in 70–100-year-old deciduous-coniferous mixed forest stands in Western Hungary. In thirty-five stands air temperature and relative humidity were measured at eight sampling period, between 2009 and 2011. Means, minima, maxima and ranges were calculated and analysed.

The variance of the microclimate variables varied through the sampled seasons. Generally, the highest variances occurred in spring. Mean daily air temperature and relative humidity were consistently highly correlated variables. Data structure of the microclimatic variables was explored by principal component analysis. The first axis (23.1%) represents a gradient of averages from higher temperature conjoined lower relative humidity to colder but more humid values. The second axis (17.1%) displays a gradient of the range of measured variables. Linear models were used for the exploration of the relationships between PCA axes and explanatory variables. It was found that higher hornbeam proportion and shrub density increased air humidity, while the ratio of old deciduous stands in the landscape and the relative volume of oaks decreased humidity.

This study demonstrates that tree species composition and stand structure substantially influence microclimate in closed mature forests. Subcanopy and shrub-layer play a key role in maintaining the special microclimate in forests with continuous canopy-cover. Our results provide adoptable aspects for forest management or nature conservation, thus maintaining the required specific conditions for sensitive forest specialist taxa (e.g. forest herbs, forest-dwelling ground beetles, epiphytic bryophytes and lichens).

Kovács, B., Ódor, P. 2014. The effect of forest stand on microclimate in mature temperate mixed forests. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 110.

Poster A1

Heterogeneity of hemiboreal forests and it relation to ecosystem functioning

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Heterogeneity is a key component of resilient ecosystems. Hemiboreal terrestrial systems have less biodiversity compared to tropical (or more southern) systems. Heterogeneity applies to species nutrient distribution, and habits. Main components of forest horizontal heterogeneity are related to: the horizontal distribution of dominant species, soil properties, topography and natural as well as human-caused disturbances. As the main source of nutrients, soil plays a very important role in the functioning of terrestrial ecosystems. Understanding the principles that regulate the spatial distributions of soil properties as soil acidity, nutrients available to living organisms, soil moisture and temperature, soil density and the role of dominant and co-dominant tree species can expand our knowledge of ecosystem functioning. Deeper knowledge of these relationships can improve models and help us to anticipate ecosystem responses to global changing climate. The aim of the project is to assess how the spatial distribution of soil properties, microtopography, and landscape position affect the spatial distribution of vegetation at sites within the Station for Measuring Ecosystem-Atmosphere Relations (SMEAR) Estonia.

Krasnov, D., Noe, S. M., Krasnova, A., Hallik, L., Niinemets, Ü. 2014. Heterogeneity of hemiboreal forests and it relation to ecosystems functioning. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 111.

Poster G1

Seasonal and diurnal variations of CO_2 fluxes over a hemiboreal forest

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Forest ecosystems are a major part of the biosphere and control a large portion of land surface-atmosphere interactions. As sources and sinks of trace gases and energy, they significantly influence atmospheric composition and climate.

We measured continuous eddy covariance CO_2 fluxes over a mixed hemiboreal forest at the Station for Measuring Ecosystem-Atmosphere Relations (SMEAR) Estonia. Hemiboreal forests are located in the transitional zone between boreal and temperate forest biomes. Mixed stands of both coniferous and deciduous tree species are characterized by a greater seasonal variability of forest microclimate, canopy shape and density compared to boreal forests.

A 20-m-tall scaffolding tower, located in Järvselja (58°16′N 27°16′E) in a forest stand dominated by Norway spruce (*Picea abies* (L.) Karst.) with codominant silver birch (*Betula pendula* Roth.) and black alder (*Alnus glutinosa* L.), was used for the CO_2 flux measurements.

We present CO_2 flux data for two years (2011–2012) and show seasonal and daily variations.

Krasnova, A., Noe, S. M., Krasnov, D., Niinemets, Ü. 2014. Seasonal and diurnal variations of CO_2 fluxes over a hemiboreal forest. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 112.

Poster B5

Biodiversity of alvar forests in Estonia

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Alvar forests are a research subject of special interest in Estonia and worldwide because they are unique and rare communities. In Europe, alvar forests are considered "responsibility communities" – communities which are abundant in some places but lacking in others and thus need protection. The purpose of this research was to study whether management of alvar forests has an effect on biological diversity. A structure and ground vegetation analysis was carried out in this research based on sample plots collected from alvar forests. The sample plots were located in both naturally regenerated and planted stands, and in managed and unmanaged stands in three age classes (I: ≤100 years, II: 100–140 years, III: ≥140 years). Data on species and communities were analyzed using canonical correspondence analysis (CCA) with the PC ORD. The results of the analysis showed that stand structure in moderately managed stands is more diverse than in unmanaged stands, as small gaps with natural regeneration appear after thinning, thereby diversifying stand structure. The analysis also revealed that the species composition of ground vegetation varies depending on stand origin, management and age.

Krumm, L. 2014. Biodiversity of alvar forests in Estonia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 113.

Poster H1

Assessment of value of indicator species by survey of biologically valuable forests

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The use of indicator species for survey of biologically valuable forests for forest certification in Russia is quite rare. The only manual is "Survey of biologically valuable forests in North-Western European Russia", by Andersson et al. It refers to the large area including middle boreal to hemiboreal zones. For 7 years, we have been working using these methods in the east of Leningrad region, which made it possible to analyze indicator valuability for many species of bryophytes. All of the sites included in analysis are old-growth forests (150–300 years). 45 species were examined, which constitutes about half of the total amount of species in the manual. Indicators and habitat specialist were described for Myrtillus- and Oxalis-types forests. Indicator species have more than 20% frequency, and the latter increases with biotope quality. More than half of the species have less than 5% frequency. These species are found in sites with high numbers of common and indicator species. Epixylic bryophytes, such as *Anastrophyllum hellerianum*, *Lophozia guttulata*, etc., form the core of the indicator complex in Myrtillus-type forest. Ground species, for example, *Mnium stellare*, are significant in Oxalis-type. Where old trees *Populus tremula* are present, many epiphytic species enrich the community, for example, *Orthotrichum obtusifolium*, *Homalia trichomanoides*. Identification of indicator species is more difficult in forests with broadleaved trees. Communities with broadleaved trees are very rare in this area, and all related species have less than 5% frequency. Specific complexes are represented by epixylic bryophytes for *Picea abies – Alnus glutinosa* type forests growing on mineral water springs, and by epiphytes on bark of broadleaved trees for forests growing in deep, canyon-shape river valleys, with *Ulmus glabra* and *Acer platanoides*. The numbers of species corresponding to substantially valuable forests were determined for each forest type. New species were described which may be considered as type-specific.

Kushnevskaya, E. 2014. Assessment of value of indicator species by survey of biologically valuable forests.– Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 114.

Poster C3

Seasonal variations in photosynthetic activity of three *Sphagnum* species in drained wooded peatlands

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Increased mean annual temperatures in Europe have prolonged the snow-free period over the last century. Snow provides a protective insulation for vegetation. Decreased snow depth and coverage could therefore affect the ability of plants to survive the winter and complete their life cycles, as well as altering the duration of the growing season. *Sphagnum* mosses are the primary builders of peat and the soil organic layer in temperate drained wooded peatlands. Therefore *Sphagna* play an important part in the carbon balance of wooded peatlands. Mosses are generally more freeze-tolerant than vascular plants and comparatively more resistant to freeze-thaw cycles. These traits lengthen their growth period compared to most tracheophytes.

The aim of our study was to follow the seasonal variations in chlorophyll fluorescence of *Sphagna* and to detect their possible winter activity under snow. Although the winter dormancy of mosses is usually assumed, we hypothesised that their photosynthetic activity is variable, but continuous. The chlorophyll fluorescence (F_m & F_v/F_m) of three *Sphagnum* mosses (*S. angustifolium, S. fuscum* and *S. magellanicum*) was periodically measured in two unequally drained Estonian pine bogs throughout the winter (from October to May). The chlorophyll fluorescence values were compared with those of surrounding vegetation and meteorological data.

Preliminary results indicate that both F_m and F_v/F_m values correlate significantly with air temperatures. All the measured species still maintained their photosynthetic activity during the whole winter, especially shade-tolerant *S. angustifolium*, which also had the highest coverage in both sites. The light intensity under the snow seemed to be sufficient and even if the air temperature fell as low as –20 °C, the temperature within the moss carpet remained around 0 °C. Without snow cover, F_v/F_m values for *S. magellanicum* were higher in the shade, but while covered with snow, the mosses were less stressed in the openings. *S. angustifolium* was most effective in the shade, irrespective of the snow cover. *S. fuscum* did not significantly depend on shading. The findings of this study support our hypothesis that the three *Sphagnum* species are photosynthetically active during the winter and the main environmental factors affecting photosynthetic activity are the snow cover and air temperature.

Küttim, M., Umbleja, L. 2014. Seasonal variations in photosynthetic activity of three *Sphagnum* species in drained wooded peatlands. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 115.

Poster B6

Ex situ methods as a tool in forest plant conservation under climate change

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(2) University of Oulu, Finland
(3) Finnish Environment Institute, Finland

Recent estimates of the enhanced rate of the anthropogenic climate changes cause increased concern for biodiversity loss. The impact of global warming on threatened plant species in the North-Western range of the European taiga region are not yet fully understood. Species distribution modelling does, however, provide estimates for where the suitable environments of species will be situated in the future. However, it is uncertain to what degree species can actually disperse to these new habitats or adapt to the changes within their current ranges. Rapid forest fragmentation and other human-caused disturbances underline the active and even proactive conservation measures. A combination of ex situ based methods, like seed banking and cryopreservation may be a solution at least for some species. We argue that climate change conscious forest biodiversity conservation would profit by integrating ex situ conservation of plants, including bryophytes, in the management efforts.

Laaka-Lindberg, S., Hyvärinen, M., Hällfors, M., Miranto, M., Ruotsalainen, A.-L., Ryttäri, T., Väre, H. 2014. Ex situ methods as a tool in forest plant conservation under climate change. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 116.

Poster G2

Structure and dynamics of boreal ecosystems: a new sight from Landsat

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Forest Research Institute, Russia

Another approach to information extraction from TM/ETM+ imagery is proposed. It involves transforming multi-dimensional image space into visible 3D form and localizing in this space the segments of the main ecosystem types found in the territory (in this case, the north taiga zone of Eastern Fennoscandia). The method can thus be named "spectral space modeling". The model is built in *xyz*-axes, where *x* and *y* are the first two principal components of the image matrix in logarithmic form, and *z* is the moisture stress index (MSI). The transformation somewhat resembles a Tasseled Cap transformation, but is more suitable for this region.

The spectral segments of mature and old-growth pine (*P. sylvestris*) forests, which dominate in the region, line up from the ecological optimum (moraine ridges - myrtillus type) along two main environmental gradients: a) automorphic - lack of water and nutrition (fluvioglacial sands -> bedrock); and b) hydromorphic - degree of paludification (lacustrine plains). Thus, the biogeocenotic complexes (Quaternary deposits - soil - vegetation) are identified.

In the spectral space one can clearly trace the succession trajectories of forest regeneration (new clear-cut –> young -> middle age –> sub-climax), which are also associated with the type of Quaternary deposits.

For mire ecosystems spectral classes accurately reflect the type of water and mineral nutrients (oligotrophic/mesotrophic). Systems with some ambiguity (e.g., some types of non-closed canopy stands) were identified by using the geomorphometric model and time series imagery. All basic classes of primary ecosystems, as well as various variants and stages of their natural and anthropogenic disturbances, for a total of several dozen categories, were distinguished as a result.

Accuracy was assessed by comparison with the georeferenced database of biotopes, yielding almost 100 percent. This accuracy rate proves that the approach significantly enhances reliability compared to the traditional method of supervised classification by training sites data.

Space vegetation model (~1:25,000 scale) can be useful in forest management for monitoring the dynamics of landscape mosaics. But the more important fundamental purpose of the model is to integrate discrete fragmentary in situ observations into the holistic space-time continuum - a comprehensive structural-functional model.

Preliminary analysis shows that spectral models are very similar in all TM/ETM+ images of Fennoscandia, Siberia.

Litinsky, P. 2014. Structure and dynamics of boreal ecosystems: a new sight from Landsat. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 117.

Poster A2

Fifty year eco-hydrological dynamics of the treed bog ecotopes: cluster for conceptual models of the bog dynamics

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(2) Tallinn University, Estonia

Bogs are unique ecosystems where tree coverage is a common feature. In the middle of the last century, it was accounted that 1/3, i.e. ~280 000 ha of Estonian mires were open bogs. According to the inventory in 2011, the area of open bogs were ~133 000 ha, and together with habitats of other types, bogs accounted for 152 000 ha.

In spite of limited nutrient conditions and high groundwater (GW) levels, the tree coverage is expected to increase in bogs due to the climate change. Our study on wetland conditions showed that 75% of the bog catchments were affected by the man-induced drainage, causing increment of the tree cover on these areas.

Conceptual models built up in telmatology were used mainly for description of the peat growth in the massif, water and C transfer or GHG fluxes; usually in daily temporal scale with maximum length up to a couple of years, - snow free and frozen periods included.

The general aim of our study was, to create a conceptual model of 50 year eco-hydrological relationships for the intact Linnusaare and moderately affected Männikjärve bog ecosystems in centre of Estonia on a monthly temporal scale. Statistical analyses of correspondingly structured values were carried out for the warm and cold periods of the years 1961–2011. Used data were collected by Tooma mire station and software for statistical analysis was JMP9. The bog catchment modelling and plant cover study was made by ArcMap10.1.

Our presentation demonstrates statistically highly relevant results of updated data sets of more than 30 variables for 4 sites in Linnusaare and 6 sites in Männikjärve bog. Sites were eco-hydrologically classified to the pool-ridge, ridge-lawn and wooded ecotopes. The long term trends of the air temperature were about 3 °C warming and about 50 mm higher precipitation for the cold period of the bog areas. Details in snow cover characteristics and soil freezing behaviour reflected the same trends correspondingly.

Different approaches for multiple regressions were used for analyses of moderately influenced ecotopes in comparison with intact ecotopes. So far the forested ecotopes differ significantly both by the long-term GW distributions, correlations and other statistical descriptions in comparison with other studied ecotopes. Analysis of wooded ecotopes showed significant increment in biomass in the sites with heavy drainage. Wooded ecotopes with thicker bog peat in marginal slopes showed clear horizontal expansion trend toward the open bog.

Lode, E., Küttim, M., Sepp, I.-K. 2014. Fifty year eco-hydrological dynamics of the treed bog ecotopes: cluster for conceptual models of the bog dynamics. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 118.

Poster A3

Patterns of forest dynamics in Switzerland over past 160 years

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The trend of expanding forest area after decades of decline is taking place in many countries around the globe. In Switzerland, the forest cover is increasing since the mid-19th century. Little is known about the patterns of forest dynamics on a long-term, national scale as well as about the precise time of forest transition, due to limited availability of spatial and temporal data. Historical maps provide a suitable source to visualize and quantify changes in forest area for a time series. We reconstruct forest cover over the past 160 years to analyze the change in forest area for six periods in time. On a regular grid with more than 20.000 points across Switzerland we extract forest information. The identified patterns of forest dynamic vary according to the spatial and temporal scale. Some regions show a net forest growth at least since 1850, while others stand out due to a strong net decline in forest area between 1850 to 1880 or even decades later. For several Swiss regions the turning point from decreasing to increasing forest area can be determined based on the results. To investigate the driving forces of these forest dynamic patterns we will extract further information from the historical maps which will serve for statistical analysis.

Loran, C. 2014. Patterns of forest dynamics in Switzerland over past 160 years. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 119.

Poster F5

Survival and growth of Norway spruce regeneration following bark-beetle outbreak

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(2) Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, Czech Republic
(3) Department of Ecology and Ecosystem Management, Technische Universität München, Germany

Bark beetle outbreaks are an integral part of natural development in mountain spruce forests. After the dieback of canopy trees diaspore supply rapidly decreases and young seedlings face an intense competition with grasses and herbs. On the other hand, already established tree recruits remains almost undisturbed after the outbreak. Seedling establishment before and during the disturbance event and growth of all recruits after disturbance are thus key processes with long-lasting effects on future forest structure. However, quantification of these processes in temperate spruce forest is still rarely addressed due to lack of natural stands in this region and need for long-term observations. Rate of spontaneous forest regeneration after disturbance thus remains a challenging ecological question with practical implications for forest conservation and management.

We assessed individual sapling mortality and growth functions with emphasis to the fine-scale stand variation from repeated observations of labelled saplings during twelve years of development after the bark beetle outbreak in Bavarian Forest National Park, Germany. Generalized and non-linear mixed effect modelling approach was applied to deal with hierarchical, spatio-temporally dependent sampling design.

We found significant differences in mortality rates among particular microsites, with lower mortality on decaying wood and close to the tree bases. Sapling densities at microsites, as well as age and height distribution change over time due to non-random mortality. Selection against smaller saplings eliminates slowly growing individuals in the course of the years, but difference in mortality at microsites could not be attributed to this mechanism. Uneven mortality contributes to formation of clumped spatial pattern at fine scale. In contrast to observation of decreasing sapling densities with increasing altitude, mortality don't depend on altitude.

Macek, M., Wild, J., Kopecký, M., Červenka, J., Svoboda, M., Brůna, J., Fischer, A. 2014. Survival and growth of Norway spruce regeneration following bark-beetle outbreak. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 120.

Poster G3

Evaluation of spatially and non-spatially explicit measures of neighborhood competition for diameter increment prediction of silver birch

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Competition is a fundamental ecological process that plays a major role in population dynamics, survival, growth and species replacement. The longevity of trees and forest stands makes it difficult to investigate them under controlled and managed environmental conditions. Researchers often must rely on theoretical and experimentally derived relationships instead and the integrate them into different growth models. For this study several competition indices including spatially explicit indices combined with different competitor selection approaches and non-spatially explicit competition indices, were calculated to quantify the neighborhood effects on diameter increment of silver birch in Estonia. The best combination of spatial indices and neighbor selection methods and non-spatial indices were selected from those studied and separately incorporated into a growth model as an independent variable to assess the utility of the diameter growth model before and after adding competition measures. Statistical analyses of these growth models indicated that the best selection of competitive neighbors acquired were based on the concepts of zone of influence and competition elimination angles. Diameter growth was shown to be a function of neighborhood interactions and spatially explicit indices were better growth predictors than non-spatial indices although the differences were negligible .

Key words: competition indices, zone of influence, diameter increment, growth model.

Maleki, K. 2014. Evaluation of spatially and non-spatially explicit measures of neighborhood competition for diameter increment prediction of silver birch. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 121.

Poster C4

Assessment of tree mortality in managed and unmanaged forest stands in Estonia

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Estonian University of Life Sciences, Estonia

Assessment of tree mortality provides deeper understanding of forest structure and functioning. This enables evaluation of stand sustainability and provides information on stand productivity, diversity and health condition. Tree mortality can be assessed by spatiotemporal patterns as well as by studying the processes and causes of mortality. Tree mortality is caused by specific disturbance agents or by the complex effect of various disturbances.

The purpose of this study is to examine tree mortality of Estonian forests, determine the causes of tree death, and estimate whether different management regimes affect tree mortality and its causes. This study is based on 586 sample plots measured in the early summer of 2001–2005 and 2006–2010. The sample plots were divided into managed (70) and unmanaged (516) sample plots based on forest management regime. In total 90,940 trees were measured, of which 11,013 were on managed and 79,927 on unmanaged sample plots.

The tree mortality for 5-year period was 0.9% on managed sample plots and 1.8% on unmanaged sample plots. Main cause of tree mortality in both stands was competition, which attributes to 37.9% in managed and 45.7% in unmanaged sample plots. Analysis of the tree mortality indicated that increase in relative tree diameter in managed stand types contributes to the increase in mortality due to insects outbrake and in unmanaged stands due to insects, fungi and game damage. In managed stands contrasting results were received with respect to wind storms – the smaller the tree relative diameter, the more probable it is that a tree will die because of wind damage. In unmanaged stands, trees with smaller relative diameter die because of the competition. Analysis of game damage, fungi, growth-dependent and other causes of tree mortality showed that these were not dependent from relative diameter of trees in managed stands. Contrary in unmanaged stands there were no significant relationship between relative diameter and mortality groups wind and others. Analysis of overall probability of tree mortality revealed that relatively smaller trees have higher probability of mortality than larger trees. Probability of survival of smaller trees is higher in managed stands compared with unmanaged stands.

Mändma, R., Laarmann, D., Korjus, H., Sims, A. 2014. Assessment of tree mortality in managed and unmanaged forest stands in Estonia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 122.

Poster D3

Impact of oil shale deposition depth and climatic factors on Scots pine (*Pinus sylvestris* L.) stand growth on reclaimed post-mining areas in Estonia

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Surface mining in oil shale quarry is conducted in places were deposit lies below the surface up to 30 meters. With increasing mining depth, the amount of soft sediments removed from the top burden part is declining while stoniness is gradually increasing in the spoil heaps, where forest stands are established after mining has ceased. Afforestation of exhausted mining areas is the most common practice for reclaiming open cast pits of oil shale in Estonia. Scots pine (*Pinus sylvestris* L.) cultures comprise 85% of the species growing on leveled oil shale mines. The aim of this study is to analyze the relationship between tree growth of tree diameter, height and climate variables. We also investigated the impact of oil shale layer depth on Scots pine stands growth. Four study areas were located in stands with different age (10–40 years) along oil shale depth gradient. Two types of data sets were used: stem analysis data from 13 felled trees and tree measurement data from 14 sample plots established on the reclaimed mining area. Correlation analysis between climatic variables and index chronologies resulted in a moderate negative correlation between beginning of vegetation period and end of active vegetation period. According to tentative results, higher than average temperature during the growing season (DD5) revealed a negative effect on radial increment growth. There was a negative correlation between height growth and beginning of frost-free period and total amount of rainfall during the vegetation. However it was not significantly important. Growth variation in pine trees was detected both within the same age group and between different age groups, which confirmed that tree growth was not dependent on the depth of oil shale layer occurrence.

Key words: climate variables, oil shale mining, radial and height growth, reclamation, Scots pine, stem analysis.

Metslaid, S., Hordo, M., Korjus, H., Laarmann, D., Promet, J., Kiviste, A. 2014. Impact of oil shale deposition depth and climatic factors on Scots pine (*Pinus sylvestris* L.) stand growth on reclaimed post-mining areas in Estonia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 123.

Poster A4

Forest fires in space and time – A study of fire frequencies and human impact in a northern boreal forest

Jonas Orelund, Bengt Gunnar Jonsson

Mid Sweden University, Sweden

Forest fire is historically a dominant disturbance in boreal forest landscapes. During the last 150 years fire suppression has basically removed this disturbance from Fennoscandia. To mediate this restoration fires are commonly used in protected areas as a conservation method. However, its application require understanding of past fire frequencies in both inhabited and uninhabited areas of importance. In this study, fires of the past 700 hundred years are dated in both space and time in a ca 35 000 ha boreal forest landscape in the middle of Sweden. In total more than 700 fires scarred wood samples have been collected representing more than 1500 individual fire scars. The spatial and temporal patterns of these fires are combined with information on history of local slash and burn settlements. Together with information on forest management history the results indicates clear links between size and frequencies of fires and human land use during most of the studied time period. Only in the very early phases of the time sequence studied, fires may be considered controlled by natural dynamics and climate. Implications for the design of restoration fires are discussed.

Orelund, J., Jonsson, B. G. 2014. Forest fires in space and time – A study of fire frequencies and human impact in a northern boreal forest. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 124.

Poster H2

Origin and status of peatland forests in Estonia – a retrospectiv view

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At present the most part of pristine peatland forests is lost because of extensive amelioration, and therefore only small fraction (ca 10–15%) of previously widely distributed mire forests are still on favorable conditions in Estonia. In 2007–2009 ca 400 peatland forest sites were inventoried, aimed to find unprotected mire forests still valuable by their natural state. Stand and understorey parameters, species composition, environmental parameters (pH, electric conductivity and depth of water level; peat type, bulk density, N, P content) were measured and human impacts and state of mire forest habitat were assessed on each site. Sites landscape character on 1900–1935 A.D. were reconstructed using historical maps.

Of the studied peatland forests area belonged 5% to *minerotrophic swamp forests with moving water*, 20% to *minerotrophic swamp forests with stagnant water*, 12% to *transitional (mixotrophic) mire forests*, 26% to *ombrotrophic bog forests* and 38% to *drained peatland forests* (degraded mire forests). Historical map analyses indicated that larger portion of "natural-looking" mire forests is not pristine but have secondary origin as developed from open mires during last century. Previous pristine mire forests have degraded and transformed to the drained peatland forests in most cases.

Retrospective analyses revealed differences in origination of peatland forest types. *Swamp forests with stagnant water* originated in most cases (95%) from open or sparsely treed mires (fens). *Swamp forests with moving water* sites were 80–110 years ago in most cases (50%) forested or cowered by sparse tree layer (40%). *Bog forests* originated mostly (71%) from open or treed bog and *mixotrophic mire forests* in 54% of cases from open or treed mires.

Highest proportion of secondary forests in *minerotrophic stagnant water* type reflecting sensitivity of the type to drainage and higher nutrient pool in the fen peat that enable better tree growth. Forestation of the fens was also supported by cessation of the mowing and grazing as traditional agricultural use of large part of fens. Peatland forests that formed through forestation of open mires supported by weak to moderate drainage are at present in better natural conditions than "primary" mire forests, as rule. The natural state and succession trends of the mire forest communities is site specific and imporantly related with age and intensity of drainage.

Pajula, R., Sepp, K., Truus, L., Ilomets, M. 2014. Origin and status of peatland forests in Estonia – a retrospectiv view. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 125.

Poster E1

Effects of forest fires and post-fire management activities on soil carbon pools in northwestern Estonia

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(2) University of Helsinki, Department of Forest Sciences, Finland

Forest fires have been the dominant disturbance regime in boreal and dry hemiboreal forests since the last Ice Age. Fire is the primary process which organizes the physical and biological attributes of the boreal biome and influences energy flows and biogeochemical cycles, particularly the carbon and nitrogen cycle. Forest fire activity is expected to increase significantly with changing climate, acting as a catalyst to a wide range of ecosystem processes controlling carbon storage in boreal and hemiboreal forests.

We compared the initial recovery of carbon (C) and nitrogen (N) pools and dynamics following fire disturbance in Scots pine *(Pinus sylvesteris)* stands on *Calluna* and *Vaccinium uliginosum* site types in the hemiboreal forests of northwestern Estonia, where fire occurred in 1992 and 2008. Measurements were done on 12 permanent study plots (20×40 m). Three management activities were represented: 1) burned and cleaned areas, where trees were removed from the area after fire disturbance (BC); 2) burned and uncleared areas, where no management had been applied after fire disturbance (BU); and 3) control areas, with no fire or management (CO).

To characterize soil C and N content, three soil cores were taken from every sample plot. Soil cores were divided according to morphological soil horizons; fine roots were separated. Soil CO_2 flux was measured with a portable soil-respiration system on four permanent collars on every sample plot. Plants were not removed from the collar. Measurements were carried out twice a month from July to September 2013. Soil temperatures at 5 cm depth were measured adjacent to each collar at the time of respiration measurements.

Total C and N contents in the first 50 cm of the topsoil was highest on CO areas and lowest on new areas (2 years after fire). Highest C pools were on CO areas from the top soil horizons (consisting of decomposing litter). Similar patterns occurred in total N pools, with the lowest values on recently burned and highest values in CO areas. Results correlate with the soil respiration measurements; the lowest values were found in areas where fire was 2 years ago.

Our preliminary results show that forest fire has a substantial effect on C and N pools in the litter layer decaying on the forest top soil layer, but not in the humus and in mineral soil layers. Soil respiration was lowest shortly after fire, indicating that a substantial proportion of respiration was originating from the very top of the soil.

Parro, K., Seglinš, K., Köster, K. 2014. Effects of forest fires and post-fire management activities on soil carbon pools in northwestern Estonia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 126.

Poster B7

The habitat preferences of wood-inhabiting fungi

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Human induced changes in the forested ecosystems are the primary cause of threat to a massive amount of species worldwide. Especially, for the species associated with old-growth forest and coarse woody debris, there is a hurry to gain knowledge in order to design their conservation and management, since their habitat is globally rare and one of the most threatened ecosystems in the world due to fragmentation, habitat destruction and forest management.

Wood-inhabiting fungi are a highly diverse species group and *inter alia* key providers of ecosystem functions and forest biodiversity. This group also includes many species that are sensitive to the changes in their environment. Thus, wood-inhabiting fungi serve a practical tool for studying effects of environmental changes in forests. In addition, new species specific knowledge is certain to be gained, since, despite their undisputable importance, majority of wood-inhabiting fungal species are still ecologically and taxonomically poorly known.

The aim of this study was to investigate habitat requirements and biodiversity of wood-inhabiting fungi in boreal forests. Special focus was given on the most poorly known groups, namely Ascomycetes, Heterobasidiomycetes, Corticioids and Agarics. The study was accomplished by comparing fungal communities of fungal species on large decaying logs in unmanaged and previously managed forests. We used especially accurate repeated survey method where the occurrences were recorded for all wood-inhabiting fungal species that produced fruit bodies visible to the naked eye. We expect to gain new information especially on ecology, distribution and causes for endangerment of poorly known wood-inhabiting fungi and discuss the usage of this information in the evaluation of their threat statuses.

Purhonen, J., Halme, P., Abrego, N. 2014. The habitat preferences of wood-inhabiting fungi. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 127.

Poster C5

Dynamics of retention trees and their potential value for wildlife. Twelve-year long study from Estonia

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Retention trees on clearcuts try to emulate legacy elements remaining after natural disturbances. Many studies over the world confirm the effectiveness of green-tree retention in supplying valuable habitats for different biota. However, weak wind-firmness of retention trees could diminish their efficiency. Little is known about the long-term dynamics of retention trees. Additionally, the quality of a single retention tree could be very different for wildlife, and this aspect has received little attention. The study was based on a network of 104 clearcut sites (cut 2001 or 2002), where altogether 3261 live and 760 dead trees or snags were retained. The dynamics of retained elements is measured annually on these plots since 2002. During 12 years, 55% of live trees remained standing. The average mortality was initially 10% per year, but this decreased to 3% in year 2013. The best survivors were hardwood deciduous species (*Fraxinus*, *Quercus*, *Acer*, *Ulmus*) – 72% of them were remained standing, and the worst survivors were thick birches (*Betula*), whose survival rate was 36%. Only 30% was remained standing from initially retained dead trees and snags during 12 years; their falling was initially low – 3% per year but reached to 15% in year 2013. Dead conifers (*Pinus, Picea*) remained standing longest and fine alders (*Alnus*) shortest. Also the viability of crowns of live retention trees was evaluated in the last five years. Viability was higher for trees growing near edges of cuts and differed between tree species, being lowest for birches and hardwood deciduous species. Viability of crowns was stable over 5 years, only ashes viability seems to decrease, because of Ash dieback (*Hymenoscyphus pseudoalbidus*). The increment of diameter during 12 year was significantly greater for vital trees compared to weak trees: 8 cm vs 3.5 cm, respectively. In 2013, the potential value of retention trees for wildlife was assessed as the potential amount of habitats for different biota. Almost half of retained live trees had very low vale for wildlife (class 1), and only less than 10% of trees were very beneficial for wildlife (classes 4–5). The most valuable tree species for wildlife were aspens (*Populus*) and pines. The mortality did not differed between retention trees with different wildlife value.

Rosenvald, R. 2014. Dynamics of retention trees and their potential value for wildlife. Twelve-year long study from Estonia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 128.

Poster E2

Circadian rhythm of water regime trends in silver birch and Karelian birch in the North-West of Russia

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Increased temperatures in the northern regions projected under climate change may raise questions about maintaining and activating forests' regulatory functions within the hydrologic cycle. In the North-West of Russia, *Betula* spp., *Pinus* spp., and *Picea* spp. make up much of the forest land. Forests dominated by birch covered 11.3% of the total forest area (Volkov, 1989). Karelian birch (*Betula pendula* var. carelica) is a specific form of the the silver birch (*Betula pendula* Roth) and is characterized by an abnormal structure of the xylem (i.e., thickenings on the trunk, a marble-like pattern and texture of the wood) that results in considerably reduced number of vessels in xylem and an increased number of parenchyma cell number (Novitsky, 2008). We hypothesized that the water supply availble to different tissues, including leaf tissue, of Karelian birch is greater than in Silver birch.

To test this hypothesis we studied water regime parameters in Karelian birch and silver birch. The transpiration rate of the leaves (E) was determined using the portable photosynthesis system Li-6400XTP (Li-Cor, USA). Leaf water potential of photosynthesizing leaves (Y) was measured using a pressure chamber. Amount of available water in leaves (WC_f), water deficit (WSD) and leaf water content at saturation (WCs) were calculated using the following equations: $WC_f = W_f - W_d / W_d$ (g water g^{-1}dry weight, $WSD = W_s - W_f / W_s - W_d$ (%), $WC_s = W_s - W_f / W_d$ (g water g^{-1} dry weight), where W_f and W_d – fresh and dried leaf biomass, W_s – weight of the leaves at saturation. Analysis of daily and seasonal dynamics study involved statistical data processing including ANOVA, Cosinor- and correlation analyses. Cross-correlation matrixes were calculated between amplitudes and mean values of water regime parameters obtained in Cosinor-analysis process. The results showed no linear association between the mean values of water regime parameters and seasonal fluctuations of circadian rhythm amplitudes. This indicates the stationary character of the process providing water regime in Karelian birch. In contrast the mean day values of Silver birch parameters demonstrated strong linear association with its amplitudes changing that makes the whole system less resistant to external disturbances and environmental adverse effects.

The study was supported by grant (13-04-00827-a) of the Russian Foundation of Basic Research (RFBR).

Sazonova, T., Tikhova, G., Pridacha, V. 2014. Circadian rhythm of water regime trends in silver birch and Karelian birch in the North-West of Russia. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 129.

Poster E3

Effects of natural factors on carbon and water exchange of woody plants in boreal forest ecosystems

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The principal aim of the research was quantification of the natural variation in the ecophysiological parameters (CO_2 gas exchange, water exchange, mineral nutrition) of Scots pine (*Pinus sylvestris* L.), Norway spruce (*Picea abies* (L.) Karst.) and silver birch (*Betula pendula* L.) which reflect their capacity to adapt to the modern climate. By studying the patterns in the basic physiological processes against the background of variable hydrometeorological parameters, we found the ranges of environmental factors (temperature, relative air humidity, and solar radiation rate) within which the metabolism in pine, spruce, and birch is greatest. It was shown that the high rate of these processes was observed in a large range of hydrometeorological factors, suggesting that the species investigated were adapted to the wide range of growth conditions. The observed differences in the investigated parameters of coniferous and deciduous plants under varying external conditions are caused by specific features of the ecology, biology, and behavioral strategy of these species.

Leaf photosynthesis, respiration, stomatal conductance and transpiration data were used in the process-based Mixfor-SVAT model (Olchev et al., 2002, 2008) to derive the possible response of CO_2/H_2O budgets of forest ecosystems of Northwest Russia to future changes in the climate and vegetation structure. Calculations show that the forecasted climate change by the late 21st century may significantly influence the value and among-year variation of net primary productivity (NPP) and evaporation from tree stands, as well as net CO_2 exchange (NEE) between forest ecosystems and the atmosphere. According to our estimates, even the moderate A1B scenario climate change and build-up of CO_2 in the atmosphere by the late 21st century would cause NPP to rise by 30%, and NEE by 38%. The projected change in evaporation, however, would be minor. The projected reduction of solar radiation may cause a slight decrease in tree stand transpiration, in spite of an increase in the growing season duration and temperature. The projected rise in soil moisture content and surface runoff due to increased precipitation and slightly modified evaporation late in the 21st century would also reduce the impact of atmospheric droughts on forest ecosystems.

The study was supported by grant (13-04-00827-a) of the Russian Foundation of Basic Research (RFBR).

Sazonova, T., Pridacha, V., Olchev, A. 2014. Effects of natural factors on carbon and water exchange of woody plants in boreal forest ecosystems. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 130.

Poster B8

Flower colour polymorphism in fragrant orchid (*Gymnadenia conopsea*): reproductive success and its relations to flower colour and shoot density

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Orchids with their complex but rather easily observable reproduction mechanism are among the most studied plant groups. Some orchids offer nectar to their pollinators, others do not. *Gymnadenia conopsea* is a rewarding species that is actively pollinated by mainly *Lepidoptera* and it has high fruit set. The specie inhabits different types of grasslands but also forest glades.

The concept of flower-colour polymorphism and its relation to reproduction has previously been studied in several plant species. The fruit set may be related to growing density, which was found to increase effectiveness via smaller distance between pollinated plants or on inflorescence size, i.e. the number of flowers in inflorescence. However, it is not clear how different colour morphs set seeds, and what could be their potential reproductive success.

We hypothesized that fruit set in white- and pale-flowered plants differs significantly from fruit set of typically flowered plants, and that inflorescence size is positively correlated to fruit set in all colour morphs of *G. conopsea*. We also expected that plants in groups set fruits more than single ones. We studied 1030 *G. conopsea* plants of three colour morphs: typical (935), pale pink ones (70), and pure white flowered (25). The height, number of flowers and fruits of each plant were recorded, also whether it grew in a group or stayed single. The results showed that fruit set of colour morphs differed significantly. White and pink flowered plants had less fruits than typical colour morph. Inflorescence size nor height of the plant had effect on fruit set and single plants set fruits less than those ones in groups.

Lower fruit set of less pigmented plants may be affected by less attractive scent or more deterrent-containing nectar of those individuals as there is a connection between the production of pigments and the production of scent and nectar compounds in plant biochemical pathways. These plant traits need future investigations, with the aim to find reasons of lower reproductive success of less pigmented orchid plants.

Sootla, K., Kull, T. 2014. Flower colour polymorphism in fragrant orchid (*Gymnadenia conopsea*): reproductive success and its relations to flower colour shoot density. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 131.

Poster D4

Understorey vegetation in young and mid-term hybrid aspen stands: Do plantations with fast-growing trees support the restoration of forest flora on former agricultural lands?

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Due to the socio-economic changes, a considerable area of agricultural land has been abandoned in Eastern Europe since the 1990s. The establishment of forest plantations with fast-growing trees is seen as one way to reemploy these sites. The main aim of commercial forest plantations is the production of timber and woody biomass. However, questions concerning the ecological value of plantations should also be studied. Due to the agricultural legacy, the restoration of the unique forest understorey may be a long process in the new stands on former agricultural land. Nevertheless, some studies have shown that the establishment of plantations with fast-growing trees may accelerate the restoration of forest habitat. Our aim was to study understorey vascular plant and bryophyte vegetation and factors affecting it in young and mid-term hybrid aspen (*Populus tremula* L. × *P. tremuloides* Michx.) plantations, focusing on the aspect of forest understorey recovery. Floristic data were collected from 51 experimental plots located in 24 hybrid aspen plantations established on abandoned fields or grasslands in 1999 and 2000 across Estonia. All plantations were monitored twice: at the age of 7 to 8 years (young stands) and at the age of 13 to 14 years (mid-term stands). The observable trends in the understorey of young plantations were mostly driven by the former agricultural land use (field or grassland), site preparation method (whole area ploughing or strip tillage), and soil properties (pHKCl, concentrations of main mineral nutrients, drainage). The impact of overstorey-related factors on understorey was weak. Dominant species in the understorey were species typical to open communities. By the time of the second monitoring the number and cover of forest species had increased significantly in the understorey, however the share of forest species among all species was low and mid-term plantations were still dominated by grassland species. Vascular plants and bryophytes that are characteristic to closed forests were rarely found. According to the hemispherical photos, the canopy openness of mid-term plantations was high and plenty of transmitted solar radiation reached the understorey, supporting the persistence of open community species. As the predicted rotation period for hybrid aspen is 20 to 30 years and usually thinning is carried out in mid-term plantations, the dominance of open community species is likely to continue through the years preceding the clear-cut.

Tullus, T., Tullus, A., Roosaluste, E., Tullus, H. 2014. Understorey vegetation in young and mid-term hybrid aspen stands: Do plantations with fast-growing trees support the restoration of forest flora on former agricultural lands? – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 132.

Poster B9

Distribution and diversity of diatoms on *Sphagnum* mosses in hemiboreal drained wooded peatlands

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Resilience and stability of bogs are affected by long- and short-term disturbances of both anthropogenic and natural origins. Extensive drainage has caused a dramatic forest expansion to boreal peatlands. The response of tracheophytes and mosses to drainage is relatively well known, but less is known about the microflora, including diatoms, which react more rapidly to environmental changes. To date, the distribution and diversity of diatoms in hemiboreal wetlands, including drained wooded peatlands, has been poorly studied. *Sphagnum* mosses and their ability to hold water creates suitable habitats for diatoms. Analysis of diatom assemblages provides insights into the current status of peatlands and can be used during the restoration of these habitats.

The aims of this study were to examine the extent to which diatom communities on *Sphagnum* mosses differ, depending on 1) habitat preferences (WT, EC, pH, shading), 2) conditions in the study sites, such as different degrees of drainage, and 3) different *Sphagnum* species. Dominance, relative abundance, and redundancy patterns of the composition of diatom community are compared within and between hemiboreal drained wooded peatlands in Estonia. Correlations between abiotic environmental conditions and the composition of diatom communities were evaluated. Preliminary results show that the evenness of the diatom community is low and only a few dominant taxa are found. The effect of drainage is one of the main factors influencing the distribution of diatom species. The abundance, species richness and diversity of diatoms decrease with decreasing moisture in the habitat. The occurrence of some *Sphagnum* mosses and the composition of diatom species are correlated, independent from the measured moisture characteristics. Our preliminary results therefore indicate that diatoms on *Sphagnum* mosses are a good indicator of the changes in water level on drained wooded peatlands.

Umbleja, L., Küttim, M. 2014. Distribution and diversity of diatoms on *Sphagnum* mosses in hemiboreal drained wooded peatlands. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 133.

Poster C6

Damages of forest tree species in different ecoclimatic regions of Lithuania

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The damage description should focus on important factors which may influence the condition of the tree. The identification of damages could also be a reasonable tool aiming to adapt future forest management to the changing climatic conditions.

The climatic continentality increases going from west to east in Lithuania. The precipitation and temperature gradients show regional differences. The climate is considered as more continental when the amplitudes of annual and daily temperatures expand, also colder winters, longer duration of snow cover and drier weather is determined. Three main ecoclimatic regions were distinguished in Lithuanian territory: the Žemaičių highlands (continental index 25–27); the Middle Plain (continental index 28–30); and the South-East highlands (continental index 31–32) region.

It could be an assumption that climatic continentality could couple with the different frequency of damages of forest tree species that presumably occur in different ecoclimatic regions. The object of this study was to highlight the possible changes of the frequency of tree species damages in different ecoclimatic regions in Lithuania.

The data of damages symptoms and causal agents collected in the permanent observation plots on the national (4×4 km) grid established under the ICP-Forests Forest Monitoring Level I in 1991–2013 was analysed. The data was assigned to one of the ecoclimatic regions.

While evaluating damage types in three regions only the damage itself was analysed not the damage intensity. The results obtained from the preliminary analysis showed by 2–3 times higher frequency of damages for deciduous tree species compare to coniferous.

The inconsistent percentage of damages in relation to the ecoclimatic regions was apparent for most of the studied species. For example, the highest percentage of damages for deciduous trees was identified in the Middle Plain region, lower in the Žemaičių highlands, while in the South-East highlands this value was by 1.3–1.4 times lower. One of the reasons which caused such tendency was uneven distribution of sample trees by species. Similar tendency was found for the coniferous stands and it was mostly related to the frequency of wind damages. The most significant dependency of the damage frequency on the continentality was determined for Norway spruce stands. Overall, these damages mostly included the damages caused by stem insects (*Ips typographus*), wood decay and wind.

Varnagiryte-Kabasinskiene, I., Stakėnas, V., Beniušis, R., Čapkauskas, G., Žemaitis, P., Araminienė, V. 2014. Damages of forest tree species in different ecoclimatic regions of Lithuania. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 134.

Poster F6

Forest fires under human or climate control? – A case study from central Sweden

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The Fennoscandian forest has to a large extent been shaped by forest fires. The frequency, size and severity of past fires, however, has varied both temporally and spatially due to differences in vegetation, climate and human land use. During the last 150 years, efficient fire suppression has virtually excluded natural fires from the Fennoscandian forest landscapes. This is obviously caused by human activity. Further back in time fires were common and estimates suggest that up to one percent of the landscape burned on an annual basis. It is however, unclear to what extent these fires are to be considered regulated by climate (i.e. natural) or to what extent humans and human land use influenced fire patterns. We have in the 3000 hectare large nature reserve Jämtgaveln in central Sweden, established spatially explicit fire history for almost 600 years. The results show multiple shifts in the spatio-temporal patterns of fire activity, including a shift from less frequent more widespread fires in the 1600s and early 1700s to more frequent smaller fires in the late 1700s and early 1800s to near total fire exclusion since about 1850. Based on a climate reconstruction from a nearby landscape (Skuleskogen National Park) our preliminary results suggest that early summer drought explained to a larger extent the temporal distribution of large fires in times before the 18th century. This suggests that fire patterns were mostly under climate control at that time in history. It should however be noted, that settlement of people started to occur already in the early 17th century. These early, originally Finnish settlers practiced slash and burn agriculture in the area and hence we cannot exclude the role of humans in the observed fire history at that point in time. Upcoming analyses hope to disentangle the relative role of climate (dry years) from the role of humans in this landscape.

Yang, Y., Hjalmarsson, J., Larson, E., Jonsson, B. G. 2014. Forest fires under human or climate control? – A case study from central Sweden. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 135.

Poster C7

Natural regeneration three years after forest fire and after uniform shelterwood cutting in pine stands

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Forest fire is major natural disturbance agent in boreal forests. Shelterwood cutting can be used to mimic natural disturbance.

The objectives of the study were: 1) to determine whether forest fire disturbance indicators can be used to characterize the natural regeneration after fire; 2) to clarify whether uniform shelterwood cutting, as natural disturbance imitation, is able to provide comparable natural regeneration.

The study was carried out in 6 different intensity and size forest fires in 13 at least 70 years old pine stands in Vacciniosa and Myrtillosa forest types in different locations in Latvia. In post–fire stands were established a total of 42 circular plots of 500 m^2, where tree dimensions and a degree of fire damage to the trees were measured - trunk scorching minimum and maximum heights, tree roots exposures and combustions degrees, etc. 2–3 years after burning, in each sample plot were placed three circular 25 m^2 natural regeneration subplots. Natural regeneration was measured also in 8 pine stands in the 3rd year after shelterwood cutting. Soil scarification was done after cutting in 5 of these stands.

Higher density of naturally regenerated birch and pine seedlings and less zero subplots were found out in burnt stands with higher pine root exposure grades. The differences between gradation classes are mostly significant. At pine root mean exposure grade above 75% were counted 2347±464 pine seedlings per hectare, 29653±261 birch seedlings per hectare, and there were no zero subplots of birch. After the uniform shelterwood cutting as natural disturbance imitation mechanism the density of naturally regenerated pines were higher than at post-fires – 4838±1584 seedlings per hectare, but birch density were lower – 838±250 seedlings per hectare. In stands where soil scarification were done after shelterwood cutting, density of pines and birches were higher than without scarification – consequently – 8187±1177 seedlings per hectare and 2613±572 seedlings per hectare.

It can be concluded that the forest fire damage indicator – tree roots mean exposure – can be used to describe natural regeneration in post-fires. In pine stands in Vacciniosa and Myrtillosa forest types 2–3 years after forest burning is found higher density of naturally regenerated birch seedlings, but lower density of pine seedlings when compared with shelterwood cutting with or without soil scarification in similar growing conditions.

Zdors, L., Šņepsts, G., Donis, J. 2014. Natural regeneration three years after forest fire and after uniform shelterwood cutting in pine stands. – Transactions of the Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, 40, 136.

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