(SS07) Quantitative reconstructions of past vegetation/land cover at local to continental spatial scales using pollen records– potentials and limits

Date: August 25
Place: Room 5235 (oral), Room 6302 (poster)
Organizers: Marie-José Gaillard, Shinya Sugita & Jack Williams
Contact email address: marie-jose.gaillard-lemdahl@lnu.se
Purpose: 1. Gather together all scientists developing methods to describe past land-cover changes at the regional-continental and local spatial scales
2. Gather together scientists who attempt quantitative reconstruction of past vegetation/land-cover in order to answer specific research questions
3. Review the progress in quantitative reconstructions of past vegetation in different parts of the world
4. Discuss collaborative strategies to achieve high quality, quantitative descriptions of past land-cover over the globe for the purpose of climate modeling and a better understanding of past environmental changes and their causes
5. Discuss the potential of quantitative reconstructions of vegetation at the local spatial scale for research questions at the palaeoecology-ecology/conservation/landscape management interface.

Oral Presentation

Aug. 25 [AM1] Room: 5235

Chair: Marie-José Gaillard

9:00-9:05 **[Introduction]** SS07-O01

Marie-José Gaillard

9:05-9:40 **[Keynote] A pseudo-biomisation approach to anthropogenic land cover change** SS07-O02 (138)

Ralph M. Fyfe, Neil Roberts, Jessie Woodbridge, Sean Downey, Kevan Edinborough, Stephen Shennan

9:40-10:00 **Reconstruction of historical land cover change for climate modeling** SS07-O03 (430)

Christian H. Reick, Julia Pongratz (Cancelled)

10:00-10:20 **From forest to farmland and moraine to meadow: Integrated modeling of Holocene land cover change** SS07-O04 (228)

Jed O. Kaplan, Kristen M. Krumhardt, Mirjam Pfeiffer, Basil A. S. Davis, Marco Zanon

Aug. 25 [AM2] Room: 5235

Chair: Marie-José Gaillard

10:50-11:10 **Regional changes in Estonian vegetation during the Holocene based on the REVEALS reconstruction approach** SS07-O05 (225)

Mihkel Kangur, Shinya Sugita, Tiiu Koff, Eve Avel, Anneli Poska, Anna-Kari Trondman

11:10-11:30 **Quantitative reconstructions of past vegetation cover; development of the cultural landscape by the Hardangerfjord of western Norway** SS07-O06 (326)

Ingvild Kristine Mehl, Kari Loe Hjelle

11:30-11:50 **Developing the data and models needed for Bayesian-based inferences of late-Holocene variations in forest composition and density in the northeastern US** SS07-O07 (572)

John W. Williams, Simon Goring, Zuofeng Shang, Andrew Thurman, Chris Paciorek, Jun Zhu, Charlie Cogbill, David Mladenoff, Stephen T. Jackson, Michael Dietze, Jason McLachlan, PalEON Participants

11:50-12:10 **Pollen records for the validation of vegetation-climate feedbacks** SS07-O08 (289)

Guo Liu, Hongyan Liu, Yi Yin

Aug. 25 [PM2] Room: 5235

Chair: Shinya Sugita

14:30-14:50 **Estimating source area of pollen from topsoil and lake sediments using remote sensing data of regional vegetation** SS07-O09 (592)

Yi Yin, Hongyan Liu, Guo Liu

14:50-15:10 **Estimating relevant source area of pollen and relative pollen productivity in the Hakkoda Mountains, northeastern Japan** SS07-O10 (362)

Takuma Nakamura, Hikaru Takahara, Keiichi Ohno

15:10-15:30 ***Corylus* expansion and persistent openness in the early Holocene vegetation of northern central Europe** SS07-O11 (522)

Martin Theuerkauf, Hans Joosten

15:30-15:50 **Signals of tree volume and temperature in a high-resolution record of pollen accumulation rates in northern Finland** SS07-O12 (324)

F. Mazier, A.B. Nielsen, A. Broström, S. Sugita, S. Hicks

Aug. 25 [PM3] Room: 5235

Chair: Jack Williams

16:20-16:40 **Vegetation analysis and modern pollen distribution in surface sediments of coastal mangrove swamps of Sundarbans, India** SS07-O13 (460)

Swati Sen, Prasanta Kumar Sen, Manju Banerjee

16:40-17:00 **Land cover-climate interactions in NW Europe, 6000 BP and 200 BP – first results of the Swedish LANDCLIM project** SS07-O14 (530)

Anna-Kari Trondman, Marie-José Gaillard, Shinya Sugita, Ralph Fyfe, Jed Kaplan, Anne Birgitte Nielsen, Laurent Marquer, Florence Mazier, Anneli Poska, Gustav Strandberg

17:00-17:20 **REVEALS-based reconstruction of regional vegetation and land cover along climatically-sensitive transects in NW Europe: new insights into Holocene dynamics of plant-climate-human interactions** SS07-O15 (312)

Laurent Marquer, Marie-José Gaillard, Anna-Kari Trondman, Anne Birgitte Nielsen, Florence Mazier, Ralph Fyfe, Bent Odgaard, Teija Alenius, John Birks, Anne E. Bjune, Jörg Christiansen, Thomas Giesecke, Mihkel Kangur, Anneli Poska, Heikki Seppä, Shinya Sugita

17:20-17:40 **Pollen-inferred quantitative reconstructions of past plant abundance for evaluation and**

development of dynamic vegetation models SS07-O16 (411)

Anneli Poska, Ben Smith, Dörte Lehsten, Laurent Marquer, Shinya Sugita, Marie-Jose Gaillard

Poster Presentation

Aug. 25 [PM1] Room: 6302

13:30-14:30 **Quantification of past regional vegetation of Britain: a first attempt** SS07-P01 (139)

Ralph Fyfe, Claire Twiddle, Shinya Sugita, Marie-José Gaillard, Data Contributors

Changing abundance gradients of major pollen taxa in Europe over the last 15000 years – a result of climate change and human activity SS07-P02 (47)

Simon Brewer, Thomas Giesecke, Basil A.S. Davis, Walter Finsinger

Regional vegetation cover reconstructions using the REVEALS model; a comparison of estimates using pollen records from one large and several small lakes SS07-P03 (190)

Kari Loe Hjelle, Ingvild Kristine Mehl

Quantitative reconstruction of local Holocene vegetation in southern Sweden using the Landscape Reconstruction Algorithm: potentials and limits SS07-P04 (83)

Qiaoyu Cui, Marie-José Gaillard, Geoffrey Lemdahl, Shinya Sugita

Reconstruction of land-use change within the catchment area of Lake Vomb in southern Sweden using the REVEALS model: potential for the study of past nutrient load from land to sea SS07-P05 (370)

Wenxin Ning, Anna Broström, Karl Ljung, Ian Snowball

Comparison of proxy reconstructions and model simulations of Arctic treeline dynamics across Fennoscandia and European Russia SS07-P06 (351)

Jesse Morris, Keyan Fang, Heikki Seppä

Tracing source areas of marine pollen in South China Sea SS07-P07 (568)

Chengyu Weng, Lu Dai

Lichens as objects of surface polllen spectra research SS07-P08 (117)

Ekaterina Ershova, Anna Demidova, Natalia Berezina, Zoya Petrash, Nikolay Prilepsky, Lev Bogatyrev

SS07-O02 (138)

A pseudo-biomisation approach to anthropogenic land cover change

Ralph M. Fyfe[1], Neil Roberts[1], Jessie Woodbridge[1], Sean Downey[2], Kevan Edinborough[2], Stephen Shennan[2]

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The degree of anthropogenic modification of land cover through the mid to late Holocene is of significant interest for archaeologists, climate modellers and conservation ecologists, amongst others. Spatially extensive pollen data provide an appropriate resource for the reconstruction of land-cover change. This paper presents a method of intermediate complexity by which major land-cover changes can be assessed for individual sites and regions. Pollen taxa are assigned to different land-cover classes (LCC), and the sum of adjusted pollen proportions for each class used to determine an LCC affinity score for individual pollen samples within stratigraphic pollen sequences (Fyfe et al., 2010). The approach is demonstrated using 42 pollen records from Britain to assess the degree of transformation of the landscape across the transition to agriculture (broadly from 9000-3400 cal BP). Results are compared with ^{14}C date probability density functions for the same time period from archaeological sites, which are used to inferred shifts in population density. By 6000-5300 cal. BP early Neolithic population growth is clearly evident in the archaeological record with significant impacts on woodland cover, reaching a maximum between 5700-5400 cal. BP. Between 5300-4400 cal. BP the archaeological record shows reduced mid-late Neolithic landscape impact, with indications of woodland re-establishment in the pollen record. Between 4400-3400 cal. BP renewed late Neolithic woodland clearance coincided with further population increase, which continued into the early Bronze Age. This pollen-based method is potentially applicable to the reconstruction of long-term land-cover change across temperate-zone regions.

Keywords: land cover change, archaeology, human impact, UK.

SS07-O03 (430)

Reconstruction of historical land cover change for climate modeling

Christian H. Reick, Julia Pongratz

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The talk introduces to the role of land cover reconstructions for the simulation of past climates with ESMs (Earth System Models). In the first part the various biogeophysical and biogeochemical effects of vegetation on climate and the carbon cycle are discussed. The second part shows how land cover change and its climatic effects are represented in ESMs. The question is tackled what information land cover reconstructions must provide to be useful in climate and carbon cycle simulations. ESMs usually use maps of broad plant functional types of to simulate the land surface properties that influence climate; but it is also perceivable that surface properties such as biomass density are directly prescribed. In particular the necessity for a clear distinction between anthropogenic and natural changes in vegetation is stressed. Finally, we show results from the application of a global land cover reconstruction in paleoclimate simulations over the last millennium. The simulation results indicate that regional climate has not been altered by land use activity before the industrial era, but that the atmospheric CO_2 concentration shows an increase larger than explicable by natural variability by late medieval times, long before the Industrial Revolution.

Keywords: climate simulation, Earth System Model, carbon cycle, land use change.

SS07-O04 (228)

From forest to farmland and moraine to meadow: Integrated modeling of Holocene land cover change

Jed O. Kaplan, Kristen M. Krumhardt, Mirjam Pfeiffer, Basil A. S. Davis, Marco Zanon

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Did humans affect global climate over the preindustrial Holocene? While this question is still debated, the co-evolution of human-environment interactions over the last 11,700 years had an undisputed role in influencing the development and present state of terrestrial ecosystems, many of which are highly valued today as ecological, cultural, and scenic resources. Yet we still have a very incomplete picture of human-environment interactions over the Holocene, both spatially and temporally. In order to address this problem, we combined a global dynamic vegetation model with a new model of preindustrial demographic, technological, and economic development. We drive this model with paleoclimate from GCM scenarios to simulate land cover and land use change, fire, soil erosion, and emissions of CO_2 and CH_4 from 11 ka BP to AD 1850. We evaluate our simulations in part with a new set of continental-scale reconstructions of land cover based on records from the Global Pollen Database. Our model results show that climate and tectonic change controlled global land cover in the early Holocene, e.g., shifts in forest biomes in northern continents show an expansion of temperate tree types far to the north of their present day limits, but that by 3 ka, humans in Europe, east Asia, and Mesoamerica had a larger influence than natural processes on the landscape. At 3 ka, anthropogenic deforestation was widespread with most areas of temperate Europe and southwest Asia, east-central China, northern India, and Mesoamerica occupied by a matrix of natural vegetation, cropland and pastures. Burned area and emissions of CO_2, CH_4 from wildfires declined slowly over the entire Holocene, as landscape fragmentation and changing agricultural practices led to decreases in burned area. In contrast, soil erosion increased with increasing human pressure over the last 11 ka, except in areas where topsoils became exhausted, e.g., in the Andes and the eastern and southern Mediterranean. While we simulate fluctuations in human impact on the landscape, including periods of land abandonment, approaching the Industrial Revolution nearly all of Europe and East Asia is dominated by anthropogenic activities. In contrast, the collapse of the aboriginal populations of the Americas following 15th century European contact leads to a period of ecosystem recovery. Our results highlight the importance of the long histories of both climate change and human land use on the development of continental-scale landscapes. We emphasize the utility of combining paleo-archives with remote sensing-based datasets for land cover reconstruction and model evaluation.

Keywords: anthropogenic land cover change, Holocene.

SS07-O05 (225)

Regional changes in Estonian vegetation during the Holocene based on the REVEALS reconstruction approach

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Contemporary vegetation zones in Estonia reflect both the north-south gradient of the major soil types (i.e. the Ordovician limestone to the north and Devonian sandstone to the south) and east-west climate gradient from Baltic Sea to the interior Estonia. The regional dynamics and spatial structure of vegetation in the Holocene are assumed to differ along these two gradients. We evaluate the extent to which the regional environmental factors and the vegetation development correlate, using fossil

pollen records from 18 lakes in three distinctive geographical regions in Estonia. This study applies the REVEALS model (Sugita 2007) for quantitative reconstruction of regional vegetation and land cover using fossil pollen from 7 lakes in the northwest region, 5 lakes in the northeast and 6 lakes in the south. Lake size varies from 2 ha to 456 ha. Pollen productivity estimates, critical parameters for the REVEALS applications, are the same as those used in the LANDCLIM project (Gaillard et al. 2010) for reconstruction of land cover in Western Europe. The REVEALS-based vegetation estimates using pollen records from the uppermost sediments of those lakes and the contemporary forest inventory data are compared to evaluate the model reliability in all three regions. The preliminary results indicate that there are differences in the regional vegetation composition, particularly early successional tree taxa such as *Betula*, *Alnus*, and *Corylus*, and herbaceous plants such as Cyperaceae and Poaceae, at the beginning of the Holocene. However, the differences among the regions are not significant between 8500 and 1500 cal yr BP. Over the last 1500 years the differences become apparent as the modern vegetation zones show. The extent of anthropogenic impact on land cover indicated by Cerealia and other herbaceous pollen types is significantly higher in the south than that in the north. During the last millennium the percentage cover of *Pinus* and *Picea*, two of the dominant tree taxa in the second half of the Holocene, becomes lower in the south than in the north. The results suggest that, in the regional scale, the differences in vegetation composition were insignificant among the three regions before the era of human impact, and that the influence of the climate and geological factors on the regional vegetation appears minimal in most of the Holocene.

SS07-O06 (326)

Quantitative reconstructions of past vegetation cover; development of the cultural landscape by the Hardangerfjord of western Norway

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The development of cultural landscapes has changed the vegetation enormously since the Neolithic time period in western Norway. The development of cultural landscapes in the fjords of western Norway is not well known, due to the lack of suitable localities for pollen analysis, because the terrain in the fjords is quite steep on both sides. In addition, most prior pollen analytical studies have mainly focused on sites near the coast and in the mountains. This research project presents for the first time the vegetation and land-use development in this historically important farming area. In the village Herand there is a small lake suitable for pollen analysis. Based on the pollen diagram from Lake Herandsvatn and pollen samples from peat/soil profiles, vegetation development over the last c. 6000 years is reconstructed. The regional pollen rain for the area is estimated using REVEALS (Sugita 2007a) for a pollen record from a large lake, c. 55 km from Herand. This large lake (radius 1040 m) is found to give comparable regional land cover to the results using a combination of several lakes within a radius of 50 km surrounding Lake Herandsvatn. Both data-sets suggest regional vegetation cover using REVEALS that is comparable to the regional cover estimated from CORINE land cover data. Based on this, we use the pollen record from the Lake Kalandsvatn to estimate regional vegetation cover using REVEALS, and we estimate the local vegetation development in Herand using LOVE (Sugita 2007b). The opening up of the vegetation from the Late Neolithic (c. 2000 cal BC) is registered, and there is a marked difference in the reconstructed openness of the landscape compared to that indicated from the original non-arboreal pollen (NAP) percentages. The peat/soil profiles have generally higher NAP percentages than the Herandsvatn record. These profiles thus may permit inferring local vegetation types, which is further refined using a simulation approach within HUMPOL (Bunting and Middleton 2005). The results show

knowledge of local cultural landscape development can be improved by combining pollen data from different depositional environments reflecting different spatial scales and combining REVEALS/LOVE with the HUMPOL to identify local to regional characteristics of the landscape.

SS07-O07 (572)

Developing the data and models needed for Bayesian-based inferences of late-Holocene variations in forest composition and density in the northeastern US

John W. Williams[1], Simon Goring[1], Zuofeng Shang[2], Andrew Thurman[1], Chris Paciorek[3], Jun Zhu[1], Charlie Cogbill[4], David Mladenoff[1], Stephen T. Jackson[5], Michael Dietze[6], Jason McLachlan[2], PalEON Participants

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Here we report on initial efforts to reconstruct forest composition, stem density, and basal area from historical land survey data and apply these to calibrating Bayesian models that will be applied to reconstruct forest variations over the last 2000 years. Palynologists have long recognized the value of historic land survey data for studying pollen-vegetation relationships at a moment just prior to the accelerated transformation of terrestrial ecosystems by intensified human land use. However, most such work has been carried out at local to landscape scales, due to the difficulty of assembling and standardizing the historical 'witness tree' data, which in raw form consists of surveyor journal notes. Here we build on intensive efforts by historical ecologists to assemble these datasets, refine quality-assurance methods, and reconstruct the patterns and processes governing forest composition prior to Euroamerican land clearance. We are building two main products: 1) a series of gridded data layers at 5-minute spatial resolution of relative tree abundances, for northeastern US forests, and 2) gridded data layers for stem density and basal area for the upper Midwest (Minnesota, Wisconsin, and Michigan). Spatiotemporal Bayesian models are applied to the PLS data to generate uncertainty estimates for all inferred forest variables. Stem density in the forested regions has a 95% confidence interval of 0 to 289 stems/ha and a basal area of 0 to 66.5 m2/ha. Our reconstructions of tree density for the upper Midwest are roughly similar to the Ramankutty and Foley maps, but show much greater spatial detail and compositional heterogeneity than available in these earlier efforts. The heterogeneity of the transitional region between prairie and forest is clearly shown that extends more than 200 km in some places. The next step, now underway, is to develop a second statistical model, called STEPPS2, that combines the PLS-based forest data layer with fossil pollen records drawn from the Neotoma Paleoecology Database. STEPPS2 is a Bayesian hierarchical model that treats past forest composition as a latent and spatial process, and models inferences about that process conditionally upon the pollen data. STEPPS2 is based on an earlier version developed by Paciorek and McLachlan (2009) for southern New England, but is now being expanded to reconstruct variations in forest composition and density over the past 2,000 years in the upper Midwest.

Keywords: Bayesian hierarchical models, Holocene, land cover reconstruction, pollen-vegetation modeling, Public Land Survey.

SS07-O08 (289)
Pollen records for the validation of vegetation-climate feedbacks

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Previous simulations of deforestation resulting in climatic cooling due to an increase in surface albedo currently lack validation with long-term climate and forest-cover data. Here, using approaches from palynology, we present for the first time the relationship between vegetation cover and temperature during the Holocene, and validate the cooling effect of deforestation. By using pollen data from multiple sediment cores to reconstruct the Holocene normalized difference vegetation index (NDVI), we reconstructed the vegetation changes and analyzed their feedback effects on climate in northern China. Using well distributed surface soil samples for pollen-NDVI models construction and lake-surface sediment samples for validation, we combined pollen assemblages in both surface-soil and surface-sediment samples and ensured the reliability of the reconstruction. We found that vegetation in northern China was controlled by the Pacific monsoon intensity that declined significantly during the last 6000 cal yr BP. These changes are attributed to a decline in forest cover and subsequent substitution of forest by steppe, which has led to a cooling of up to 1.4 K throughout the north-south trend in reconstructed temperature. Southern China, dominated by evergreen forests and under the influence of the same climate system, has not experienced any clear forest decline, and thus a very small temperature decrease. Our results confirm GCM model predictions and support the cooling effect of the replacement of forests by steppe vegetation found in previous studies. Although the spatial difference between northern and southern China could have other explanations, and the causal relation cannot be proved rigorously when based solely on current data, we argue that the agreement between reconstruction data and model results increases confidence in the existence of a cooling effect caused by a decrease in the cover of forests.

Keywords: the Holocene, cooling effect, vegetation decline, Asian Monsoon region.

SS07-O09 (592)
Estimating source area of pollen from topsoil and lake sediments using remote sensing data of regional vegetation

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A better understanding of the relationship between modern vegetation and pollen assemblages from topsoil and lake surface sediments is important for objective pollen-based vegetation reconstruction. However, the source area of pollen for local vegetation reconstruction is hard to define; there are noticeable discrepancies in the scales of source areas (several kilometers) and transportation distances of pollen grains (over hundreds of kilometers) among previous studies. There are many possible reasons including the scale limitation of field vegetation investigation and large inter-annual fluctuation in pollen production and dispersal. We used satellite TM image (30×30 m² in resolution) to estimate the representative areas of pollen from topsoil and lake sediments in the woodland-steppe ecotone of semi-arid China. We calculated correlation coefficients between vegetation types extracted from the TM image and corresponding pollen assemblages from 43 sites, where samples from topsoil and lake surface were compared to the plant abundances of major taxa within ten radii ranging from 1 km to 100 km. The results showed that the representative range of topsoil pollen is

around 20×20 km², while that of lake surface pollen is around 100×100 km² in the region. Tree Cover Index (1×1 km²) extracted from MODIS image was used to cross-validate the TM results with a similar conclusion (soil: 24×24 km², lake: 120×120 km²). Therefore, pollen from lacustrine sediments represents vegetation in a much larger area than the very local scale assumed in previous studies, which challenged the previous reconstruction of vegetation dynamics in the forest-steppe ecotone. Pollen source areas should be considered in modern pollen-vegetation index model for quantitative reconstruction of past vegetation using pollen from lacustrine sediments.

Keywords: source area, pollen indication, quantitative reconstruction, remote sensing.

SS07-O10 (362)

Estimating relevant source area of pollen and relative pollen productivity in the Hakkoda Mountains, northeastern Japan

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Pollen assemblages are hard to compare with vegetation composition because of the difference in pollen productions, pollen dispersal and other factors among plants. Especially in mountainous terrains, pollen from lowlands can be easily transported by orographic wind and distorts the local pollen assemblage. Therefore, interpretation of pollen data from mountainous regions needs special attention. Establishing the pollen-vegetation relationship of surface sediments is one of the most effective ways to interpret the pollen assemblage. We analyzed surface samples collected from 122 bog sites to estimate the relevant source area of pollen (RSAP) and relative pollen productivity (PPEs) at the Hakkoda Mountains in northeastern Japan. The surveyed areas cover from deciduous broadleaved forest at 480 m to 1550m a.s.l. in the subalpine conifer forest. All sampling sites are identified in the GIS based vegetation map to calculate the plant abundances using the phytosociological survey data. To calculate the RSAP, the Extended R-value models are used with the Prentice-Sugita pollen dispersal functions (Prentice 1985, Sugita 1993, 1994) is used. The RSAP estimates for small bogs vary from 680m in the subalpine zone to 750m in the secondary forest. These estimates are comparable with those in Europe, North America and Africa. PPEs of individual taxa relative to *Betula* are as follows: in the subalpine zone *Abies* has the highest PPE (3.4-2.1) and *Pinus* (Haploxylon type) the second highest (0.7-0.4). Alnus PPE is unreliable because of the large uncertainties. In the secondary forest, the PPE of *Cryptomeria* (Japanese cedar) is the highest (8.6-6.0) and *Fagus* the second (1.9-1.3). PPEs for Gramineae and *Artemisi*a are relatively high (2.9-1.3 and 2.6-1.6, respectively). *Quercu*s, *Alnus* and Gramineae have large uncertainties in the PPEs, however.

Keywords: relevant source area of pollen, relative pollen productivity, vegetation distribution, the Hakkoda Mountains, quantitative reconstruction of past vegetation.

SS07-O11 (522)

***Corylus* expansion and persistent openness in the early Holocene vegetation of northern central Europe**

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The warming at the Younger Dryas - Holocene transition (~11,600 cal. BP) triggered the rearrangement of vegetation across Europe. To improve the understanding of forests patterns, migrational pathways and openness of the early Holocene vegetation we here combine a data-model comparison approach designed to translate pollen percentage values into past plant abundances, and a downscaling approach to detect small-scale vegetation patterns related to robust patterns in landscape parameters. We apply these approaches to pollen percentage and pollen accumulation rate data from NE Germany to explore 1) what kind of forest communities existed during the early Holocene, 2) whether and where initial populations of temperate woody taxa, e.g. *Corylus avellana*, existed, and 3) where open, grass-rich vegetation types were situated. We hypothesize that, in contrast to the common view of uniform *Betula-Pinus* (-*Corylus*) forests, rather distinct vegetation types at specific site types existed. A major parameter in the model calculations is a function describing the dispersal capabilities of pollen. We additionally explore the effects of various dispersal models on the reconstruction.

Keywords: early Holocene, dispersal, modeling, palynology, quantitative.

SS07-O12 (324)

Signals of tree volume and temperature in a high-resolution record of pollen accumulation rates in northern Finland

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Reconstructions of past vegetation from fossil pollen assemblages are increasingly being based on Pollen Accumulation Rates (PARs, grains cm^{-2} yr^{-1}) (Seppä and Hicks, 2006; Kuoppamaa *et al.*, 2009). PARs provide a potential proxy for quantitative stand volume (m^3 ha^{-1}) reconstruction when reliable absolute pollen productivity estimates (APPEs) are available. However, pollen monitoring data in Finland show that there is a strong correlation between both *Pinus* and *Picea* pollen deposition and July temperature of the year before pollen emission in the same region (Huusko and Hicks, 2009). Here we will present APPEs obtained for three major taxa (pine, spruce and birch) at their range limits in northern Finland under two climate periods ("warm" and "cold") over the last 30 years, based on the long-term pollen trap and stand volume records within a 14 km radius of each trap (Sugita et al, 2010; Mazier et al. 2012). APPEs (mean ± SE; x 10^8 grains m^{-3} yr^{-1}) tend to be higher for the "warm" periods (pine 123.8 ± 24.4, birch 528.0 ± 398.4, spruce 434.3 ± 113.7) compared to the "cold" periods (pine 95.5 ± 37.3, birch 317.3 ± 282.6, spruce 119.6 ± 37.6); but the difference is statistically significant only for spruce. Using an independent regional temperature record, based on a combined set of 9 tree-growth parameters, and the obtained APPEs, a low frequency record of pine volume changes over the last 1000 years at Palomaa mire is reconstructed. Five phases are distinguished in the reconstruction: moderate pine volume AD 1080 – 1170; high volume AD 1170 – 1340, low volume AD 1340 – 1630; very low volume AD 1630 – 1810, and rising pine volume AD 1810 - 1950. These phases do not coincide with periods of high or low JJA temperatures, and thus appear to reflect regional variations in stand volume, while high frequency

changes within each time-period block show variations in PARs in response to temperature.

Keywords: pollen accumulation rates, absolute pollen productivity, northern boreal forest, *Pinus sylvestris*, pine volume reconstruction.

SS07-O13 (460)

Vegetation analysis and modern pollen distribution in surface sediments of coastal mangrove swamps of Sundarbans, India

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Studies on present pollen-vegetation-environment relationship play a key role in the reconstruction of past vegetation and palaeoenvironment. Pollen analyses of surface sediments collected from mangrove swamps of Lothian and Prentice islands, Sundarbans, India were undertaken in order to reveal the relationship between modern pollen deposition and the vegetation from which they are derived. Thirty quadrats (10m. x 10m. plots) from Lothian Island and ten quadrats from Prentice Island were established to examine the local vegetational composition along intertidal zones. Data about the dominance/abundance of taxa around each island were taken following the Bran- Blanquet scale. Three surface samples from each quadrat plot were studied for pollen analysis. Samples from both islands reveal an overall dominance of mangrove pollen which shows close linkage between pollen and present day vegetation of the area. Percentages of Rhizophoraceae pollen were highest, the other mangrove pollen, i.e. *Avicennia, Sonneratia, Nypa, Excoecaria, Xylocarpus* were poorly represented in the pollen assemblage. The non-arboreal vegetation was represented by good frequencies of Poaceae and Chenopodiaceae. *Acanthus ilicifolius* pollen and monolete and trilete spores were also abundant. Vegetation and surface sediment analysis from the same location since 25 years ago (Banerjee et al, 1986) reveal significant enrichment of mangrove vegetation in the islands, while the microbiota namely algal remains, zoo plankton and microforaminifera in the surface sediments were much poorly represented in the present assemblages compared to the earlier study. The present study is helpful in reconstructing the past changes in vegetation, ecology, sea level and other environmental factors in the mangrove swamps.

Keywords: pollen-vegetation-environment relationship, vegetational composition, modern pollen deposition, mangrove swamps of Sundarbans, India.

SS07-O14 (530)

Land cover-climate interactions in NW Europe, 6000 BP and 200 BP – first results of the Swedish LANDCLIM project

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Terrestrial vegetation is an important part of the earth system that is influenced by, as well as affecting, climate through biogeochemical and biogeophysical feedbacks. Human-induced changes in land cover would have impacted climate. Hence, it is important to incorporate land-cover information in climate models for reliable predictions of future climate and related impacts (Gaillard et al. 2010, *CP* 6). Previous attempts at describing past anthropogenic land-cover change (ALCC) based on the historical estimates of human populations and land suitability for agriculture and grazing are inconsistent for several key time periods of the past. Therefore, pollen-inferred quantitative reconstruction of land cover changes is important to evaluate ALCC scenarios and evaluate the past land cover-climate feedbacks over long temporal scales. The model-data comparison approach used in the Swedish project LANDCLIM (LAND cover – CLIMate interactions in NW Europe during the Holocene) comprises five steps: 1) reconstruct Holocene land cover using fossil pollen data and the REVEALS model (Sugita 2007, *The Holocene* 17), 2) compare the REVEALS reconstructions with ALCC scenarios and simulations of a dynamic vegetation model LPJ-GUESS (Smith et al. 2001, *Global Ecol. Biogeogr.* 10), 3) use the alternative land-cover descriptions to simulate past climate with a regional climate model RCA3 (Samuelsson et al. 2011, *Tellus* 63A), 4) compare the RCA3 outputs with palaeoclimate proxies, and 5) evaluate land cover-climate feedbacks in the past for a better understanding of the effects of land-cover change on past climate, and implications for model predictions. The REVEALS reconstruction of ten plant functional types (PFTs) and three major land-cover types (LCTs) for five time-windows of the Holocene show that there are substantial differences between REVEALS estimates and pollen percentages in terms of land-cover change. Comparison of the REVEALS estimates of cereal and herbs % cover (PFTs agricultural land (AL) and grassland (GL)) with the deforested fractions of the ALCC scenarios suggests that REVEALS estimates are closest to the KK10 scenarios (Kaplan et al. 2009, *Quaternary Sci. Rev.* 28). First RCA3 simulations using the potential vegetation (LPJ-GUESS simulations) and ALCC scenarios indicate that deforestation produce a negative feedback in winter of ca. >0-1.5 °C colder, and a mixture of negative ca. (>0-1.5 °C colder) and positive (ca. >0-1 °C warmer) feedbacks depending on the area, in summer.

Keywords: land-cover reconstructions, REVEALS model, pollen data, Holocene, climate-vegetation feedbacks.

SS07-O15 (312)

REVEALS-based reconstruction of regional vegetation and land cover along climatically-sensitive transects in NW Europe: new insights into Holocene dynamics of plant-climate-human interactions

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Fossil pollen records remain one of the primary sources for understanding the Holocene vegetation dynamics. Although various factors, such as inter-taxonomic differences in pollen productivity and dispersal, make the pollen-vegetation relationships complex, the Landscape Reconstruction Algorithm (LRA) (Sugita 2007, Holocene 17, 229-241) can reduce biases caused by those factors and improve quantitative reconstruction of vegetation and land cover. We use the REVEALS (Regional Estimates of VEgetation Abundance from Large Sites) model - the first step of the LRA - to estimate the changes in percentage cover of the regional vegetation and land cover in NW Europe in the Holocene. REVEALS has been previously tested in Europe and North America using modern pollen-vegetation data sets (Hellman 2008, JQS 23.1, 21-42; Sugita et al. 2010, QR 74, 289-300) and applied to the Holocene records (Sugita et al. 2008, Proceedings of the CAA, 385-391; Gaillard et al. 2010, Clim Past 6, 483-499; Nielsen and Odgaard 2010, VHA19, 375-387; Soepboer et al. 2010, QSR 29, 472-483). Here we present continuous time series of the Holocene REVEALS estimates using pollen records from 18 sites in NW Europe for evaluating the extent to which the patterns and timing of the changes in the regional vegetation differ from those based on pollen percentages alone. On the basis of statistical analyses we have defined four types of time trajectories of the REVEALS-based vegetation changes and pollen percentages, i.e. (1) Deciduous forest of Central Europe, (2) Deciduous forest of NW Europe, (3) Mixed forest of N Europe, and (4) Boreal forest and taiga. The statistical analyses show a better separation of the time trajectories of the REVEALS-based vegetation changes than those based on pollen percentages. Further, the timing of the major shifts differs between the REVEALS-based vegetation estimates and the pollen percentages. In Central Europe, the expansions of temperate forest taxa at the beginning of the Holocene appear to occur earlier for the REVEALS estimates than for pollen percentages. The significant opening of the landscape due to human-induced deforestation and the related, significant increase in anthropogenic indicators in the second half of the Holocene occur earlier and is more profound in the REVEALS estimates than the pollen percentages. Thus the REVEALS-based regional vegetation reconstructions may improve our understanding of the role of climate and human activities on the Holocene vegetation dynamics and their feedbacks.

SS07-O16 (411)

Pollen-inferred quantitative reconstructions of past plant abundance for evaluation and development of dynamic vegetation models

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Climate-driven vegetation changes may exert significant feedbacks on climate through changes in carbon sinks, albedo, and energy partitioning. These feedbacks are poorly represented in current Global Climate Models (GCMs) that mostly use the static current-day vegetation distribution as the vegetation input. In contrast, the Dynamic Vegetation Models (DVMs) attempt to describe patterns and trends in vegetation structure and functions by including basic ecosystem processes and their interactions and response to abiotic drivers. DVMs simulate natural vegetation dynamics on different spatial and temporal scales, which makes the assessment of vegetation-climate feedbacks using

climate models possible. However, DVM-based vegetation dynamics itself is hard to evaluate. The climatic envelopes of the Plant Functional Types (PFTs) used in DVMs assume equilibrium conditions between plant distribution and climate, which would not be valid in times of heavy anthropogenic land-use and rapid climate change. One of the ways to test DVMs is to compare the model simulations with independently obtained estimates of past plant cover and vegetation. We use pollen-based quantitative land-cover reconstructions for northwestern Europe, produced by the LANDCLIM project (Gaillard et al., 2010 *Clim Past* 6), for evaluating the Holocene potential natural vegetation dynamics simulated by LPJ-GUESS (Smith *et al*., 2001 *Global Ecology and Biogeog.* 10). This is - a generalized, process-based model of vegetation dynamics and biochemistry that uses an individual-based ”gap model” approach, optimized to study regional changes on decennial to centennial timescales. The largest discrepancies found are caused by the current inability of the model to reproduce migrational time-lags and human-induced vegetation. In order to improve simulation outcomes we apply a post-processing method using data on i) anthropogenic land-cover change from scenarios based on other modeling approaches (e.g. Kaplan *et al.*, 2012 *Global Change Biol.* 18), and ii) the migration pathways of *Picea abies* and *Fagus sylvatica* provided by the ECOCHANGE project (http://www.ecochange-project.eu/). In this way, LPJ-GUESS-based estimates for the Holocene vegetation dynamics are evaluated and compared with the pollen-based reconstruction in NW Europe.

Keywords: climate change, vegetation dynamics, Dynamic Vegetation Models, Holocene.

SS07-P01 (139)

Quantification of past regional vegetation of Britain: a first attempt

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Significant methodological developments to enable the quantification of vegetation from pollen have been made over the last decade. These have focussed on advancing empirical measurements of the pollen-vegetation relationship, and mathematical models that account for the dispersal and distribution of pollen. The result of this is the Landscape Reconstruction Algorithm (LRA) proposed by Sugita (2007a,b). The LRA is a two stage process, the first of which aims to make estimates of regional vegetation from pollen records. This paper presents the application of this first stage to pollen records from Britain and Ireland, using the REVEALS model (Sugita, 2007). We explore the challenges that the modelling approach presents in ‘non-ideal’ landscapes, namely those within which networks of large lake sites are not available. A data compilation exercise has resulted in a database of over 100 pollen records from Britain and Ireland. These have been grouped, where appropriate, and the pollen data transformed into estimated regional vegetation in 500-year windows. The results show differences in regional vegetation patterns in different parts of Britain and Ireland. Reasons for these differences are discussed, and may include bias in site types used in the analysis, the character of the landscapes of different regions and gradients in vegetation patterning.

Keywords: vegetation modelling, Landscape Reconstruction Algorithm, Britain.

SS07-P02 (47)

Changing abundance gradients of major pollen taxa in Europe over the last 15000 years – a result of climate change and human activity

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Late-Quaternary pollen analysis provides a picture of vegetation change driven primarily by both climatic changes and human activity. Disentangling the relative impacts of these factors is problematic, especially in Europe, where the duration and magnitude of activity is extensive. We present a new set of maps depicting past spatial changes in the abundance of common pollen types based on pollen diagrams held in the European Pollen Database. This dataset is used to explore changes in the spatial gradients in abundance through time, and explore potential forcing parameters through comparison with climate gradients and human land use change. We show that continentality is a dominant influence on the abundance gradients of several taxa throughout the last 15000 years. For example, Pinus pollen were most abundant in continental areas during the late Glacial, but secondary abundance peaks develop with Holocene warming in oceanic areas of northern Europe. Similarly, Juniperus pollen shows peaks in cold as well as in dry regions and illustrates shifts in climate as well as in human activity in north and southern Europe. We examine how warming during the late Glacial and early Holocene determined the abundance gradients or modified the strength of the influence of continentality on the abundance patterns. In the late Holocene, human land use became a mayor determining factor influencing abundance gradients. Using Poaceae as an example, we demonstrate how human land use enhances a naturally occurring gradient.

SS07-P03 (190)

Regional vegetation cover reconstructions using the REVEALS model; a comparison of estimates using pollen records from one large and several small lakes

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The Landscape Reconstruction Algorithm (Sugita 2007a, b) requires the use of large lakes (>100 ha) to reconstruct regional vegetation using REVEALS. In areas lacking large lakes, several small lakes may be used (Sugita et al. 2010). In Western Norway there are few large lakes and a topography ranging from sea level to more than 900 m asl in short distances. Is it possible to use small lakes to estimate regional vegetation in such a landscape? The applicability of small lakes is tested by comparing vegetation reconstructions using REVEALS and pollen data from surface samples from one large lake and several small lakes (7 lakes within a radius of 10 km, 14 lakes within 20 km, 18 lakes within 30 km, 24 lakes within 50 km and 41 lakes within 100 km of the large lake, respectively). Generally, the different datasets give comparable results. The differences observed are between the large lake and the small lakes, whereas the reconstructions based on the small lakes are quite similar for all species and small-lakes datasets. When the vegetation within a radius of 50 km is

reconstructed, the coniferous forest and especially *Picea* show higher values in reconstructions based on the pollen data from the large lake than from the small lakes. *Picea* was planted in the area during the last c. 100 years and the reconstructions based on the large lake provides values of *Picea* cover comparable to the cover estimated using six small lakes from the single region with old *Picea* forest that is located outside the 50 km radius from the large lake. *Fagus* is a rare species in the region, and is better reflected in vegetation reconstructions based on small lakes than on the large lake. Overall, the relationship between forest and open vegetation is similar whatever lake dataset is used, and similar to the vegetation cover using the CORINE Land Cover data. The investigation indicates that pollen data from small lakes may substitute those from a large lake also in a landscape of varied topography; nevertheless, there are challenges that need to be further investigated. The pollen diagram from the large lake is used to reconstruct the regional vegetation cover through Holocene and can be used for local vegetation reconstructions in the region using LOVE (Sugita 2007b).

SS07-P04 (83)

Quantitative reconstruction of local Holocene vegetation in southern Sweden using the Landscape Reconstruction Algorithm: potentials and limits

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Questions or hypothesis testing related to past environmental changes may require quantitative reconstruction of vegetation (e.g. % cover). The Landscape Reconstruction Algorithm (LRA, Sugita 2007 a and b, *The Holocene*) was applied on Holocene fossil pollen records from two small bogs to test the following hypotheses: 1) contrasting long-term fire histories are related to between-site differences in the relative abundance of birch and pine, 2) between-site differences in the extent of deforested land were significant. The LRA was applied for 25 taxa (with available pollen productivity estimates). The performance of LRA reconstructions was first evaluated for historical time. We used historical maps to extract vegetation information around the study sites within a 3000m radius circle (approximate mean size of the relevant source area of pollen, RSAP, *sensu* Sugita 1994, *Journal of Ecology*). The vegetation data was harmonized into four land-cover types (Forest, Wetland, Grassland, Cultivated land) and grouped into three time windows (AD1950-2000, AD1925-1950, AD1825-1925, and AD1700-1825). The LRA was applied for the same time windows and the model-estimates for 25 taxa were grouped into four land-cover types. Because *Calluna* may represent several land-cover types, three alternative groupings were used for the comparison, i.e. *Calluna* included in "Forest", "Wetland", or "Grassland". The comparison between LRA estimates and actual vegetation suggest that, in general, the model performs relatively well. However, because some pollen taxa can represent different land-cover types, and because historical maps seldom have information on the species distribution and composition of landscape units, it is not possible to test the performance of the model with high precision. The LRA estimates of local vegetation composition during the entire Holocene were compared with the pollen percentages (PPs) and the results from plant macrofossil and insect analyses in terms of local presence of plant taxa. There are large differences between the LRA estimates and the PPs for most tree taxa and anthropogenic indicators. The LRA estimates of pine are significantly higher at one site, which was not clearly demonstrated by PPs and pollen accumulation rates. The periods of local presence of plant taxa as indicated by the LRA estimates generally correspond to times with regular occurrences of beetle and/or plant macroremains of the corresponding taxa. If we assume *Calluna* was mainly growing in the pine forest at the site dominated by pine, the spatial extent of deforestation was significantly different between the two sites during the last ca. 2500 cal. years BP.

Keywords: Landscape Reconstruction Algorithm, local plant abundance, forest dynamics, Holocene, southern Sweden.

SS07-P05 (370)

Reconstruction of land-use change within the catchment area of Lake Vomb in southern Sweden using the REVEALS model: potential for the study of past nutrient load from land to sea

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Nutrient transport from land in terrestrial surface waters to coastal areas affects the marine ecosystem. We know that agricultural land-use increases the nutrient load to coastal marine areas today, but we have little insight on how it has varied in the past. There is a potential to study the variation in nutrient load by comparing records of past land-use change within the catchment area of a lake river-system and records of the adjacent coastal marine environment. We here present the land-use change reconstruction within the large catchment area of lake Vomb and the related Kävlinge river-system inferred from a fossil pollen record covering the last three millennia, using the REVEALS (Regional Estimates of Vegetation Abundance from Large Sites) model. The model results show that the percentage cover of grasslands and cultivated fields increased during the last three millennia from 20 % to 40 % and from 2% to 20% of an area of 100x100 km, respectively percent. The woodland composition changed from mixed-broadleaved woodland dominated by *Corylus* to woodland dominated by *Fagus*. The next step will be to obtain sediment records of dinoflagellate cysts reflecting the nutrient status in the coastal areas where the river meets the sea.

Keywords: REVEALS, human activity, last two millennium, land-use change, coastal area.

SS07-P06 (351)

Comparison of proxy reconstructions and model simulations of Arctic treeline dynamics across Fennoscandia and European Russia

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The northern high latitudes are currently experiencing rapid climatic and ecological reorganization and have received much attention in recent decades due to a pronounced rate of warming compared to global averages. Here we explore key uncertainties in Arctic land cover-atmosphere feedbacks. The Arctic forest/tundra ecotone existed north of its historical location during the Holocene thermal

maximum. However, the feedback contribution of this land cover change to climate warming is not well constrained and requires further quantitative evaluation. In this study, we focus on the major drivers of treeline dynamics over regions of the northern Fennoscandia and northern European Russia. We use the dynamic, process-based LPJ-GUESS model to simulate regional vegetation dynamics for dominant coniferous species with mechanistic representations of plant physiological and biogeochemical attributes. These simulations were compared with Holocene treeline reconstructions using sedimentary pollen and preserved plant remains. We provide reconstructed limits of treeline in northern Fennoscandia and European Russia and estimate the net change in surface albedo, surface roughness, and radiative properties based on reconstructed vegetation cover. Exploring the fundamental architecture of past forest/tundra ecotone dynamics in this region will help resolve similar questions in high latitude landscapes elsewhere in the Northern Hemisphere and will also enhance predictability of land cover-derived biogeophysical feedbacks in the climate forecast models.

Keywords: arctic amplification, boreal treeline, high latitude warming, albedo, forest-tundra ecotone.

SS07-P07 (568)
Tracing source areas of marine pollen in South China Sea

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Pollen in marine sediments originates from terrestrial plants, and so marine pollen records provide excellent opportunities for comparing environment change between marine and terrestrial systems. However, the deposition basins are usually very large and both sediments and pollen are transported to the ocean depositional sites in different ways (e.g. by air, rivers, or by ocean currents). Knowing the source area is crucial to interpreting the pollen data. South China Sea is a margin sea between Asia and the Pacific Ocean, and its sediments are mainly sourced from south China and the surrounding SE Asian lands. In order to better interpret the pollen data recovered from the sediments, we have designed a series of surveys to trace the pollen source and possible transportation paths. We have collected pollen from atmospheric, water, and sediment samples from different locations (land, rivers, and the sea) in different seasons. From this we are describing the general distribution patterns and using this to infer pollen transportation paths and possible source areas. In this talk, we will report the general methods and preliminary results.

Keywords: palynology, marine, dispersal.

SS07-P08 (117)
Lichens as objects of surface polllen spectra research

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Understanding the processes influencing pollen accumulation and preservation in different

depositional environments is of great importance for interpretation of pollen analysis data and contributes to reconstructions of past vegetation. In this research, we study pollen and spore accumulation and the degree of pollen and spore preservation in lichen communities. We are developing a method of surface pollen spectra study using *Cladonia* lichen species and layer-by-layer analysis of forest litter, including the uppermost humus-accumulation horizon, as the material for pollen analysis. Sampling for pollen analysis was made in September, 2011, at a local spatial scale in the Meshchera lowland near the town of Petushki (Vladimir region, Central Russia). When calculating the number of pollen grains, their taxonomic identity and degree of preservation were determined. The following conclusions were made: **1.** Lichens accumulate pollen and spores of both regional and local origin at their surface. Pollen-grains in the studied samples of lichens have a high capacity for preservation. Pollen spectra of lichens better reflect the composition of surrounding plant communities compared to soil spectra. In soil spectra, the percent of tree pollen from regional sources is lower. **2.** The lichen spectra contain mainly tree pollen rather than herbs. Herbs with higher pollen productivity and capacity for preservation are present in pollen spectra even when absent at the sampling plot. Pollen of local herb species is poorly reflected in pollen spectra. Hence, during data interpretation even single pollen-grains of herbaceous species with low pollen productivity should be taken into consideration. **3.** Pine needles of trees and forest litter accumulate pollen-grains sourced from the local community and from the regional vegetation. Pollen grains and spores accumulated on needles and lichens with forest tree litter are found in surface pollen spectra. There is a high percent of preserved pollen, including in the upper soil horizons, with a predominance of tree pollen. The many-year accumulation of pollen and its good preservation in lichens make them a valuable substrate for study of surface pollen spectra.

Keywords: spore and pollen spectra, reconstruction of past vegetation, forest litter, *Cladonia* spp., lichen.