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THE HOLOCENE VEGETATION RECONSTRUCTION FROM MIRE AND LAKE SEDIMENTS IN NORTH EASTERN LATVIA USING POLLEN RECORDS

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SUMMARY

The significant changes in vegetation composition during the Holocene can be traced by pollen delivered into sedimentary archives, such as bogs and lakes. They are ideal archives for investigating these changes, as pollen usually is well preserved in lake and bog sediments and can be used as proxy data for vegetation reconstructions. Earlier palaeoenvironmental studies were mainly based on pollen percentages and did not reflect pollen-vegetation relationships. Therefore, the REVEALS (Regional Estimates of Vegetation Abundance from Large Sites) model was applied to obtain quantitative reconstruction of the past vegetation composition for the north eastern area of Latvia. The results of REVEALS modelling are compared with previous reconstructions.

KEY WORDS: pollen, mire, lake, REVEALS model

INTRODUCTION

Instrumental measures can give information about vegetation changes in the most recent time period; therefore, it is essential to use palaeoecological data that reflect environmental conditions in the time period when it was impossible to make instrumental measures. Researchers have been trying to obtain the method for quantitative vegetation reconstruction from fossil pollen data since the first investigations using pollen analysis. To create such a tool, it is essential to understand how pollen composition from lake and bog sediments reflects vegetation around the site. Recently, many scientists have created different models that help to reconstruct vegetation changes in the past.

Considering the fact that the relationship between the pollen and vegetation composition or land cover is not linear, one of the recently developed models – REVEAL (Regional Estimates of Vegetation Abundance from Large Sites) – was applied to pollen data to obtain a more exact reconstruction of vegetation in the North Eastern Latvia during the Holocene.

MATERIALS AND METHODS

Latvia is situated on the east Coast of the Baltic Sea between 56ºN and 58ºN (Fig. 1), within the transitional zone between the two principal forest zones of Europe – boreal and nemoral. Transition from oceanic to continental air masses takes place in Latvia, causing a noticeable decline of flora in the whole eastern Baltic region (Draveniece, 2007; Rūsiņa, 2007). The mean annual temperature in Latvia (Riga) is 7.2ºC, ranging from -1.6 ºC (the mean temperature in February) to 17.7ºC (in July). The mean annual precipitation in Latvia (Riga) is 681 mm (Krauklis and Draveniece, 2004).

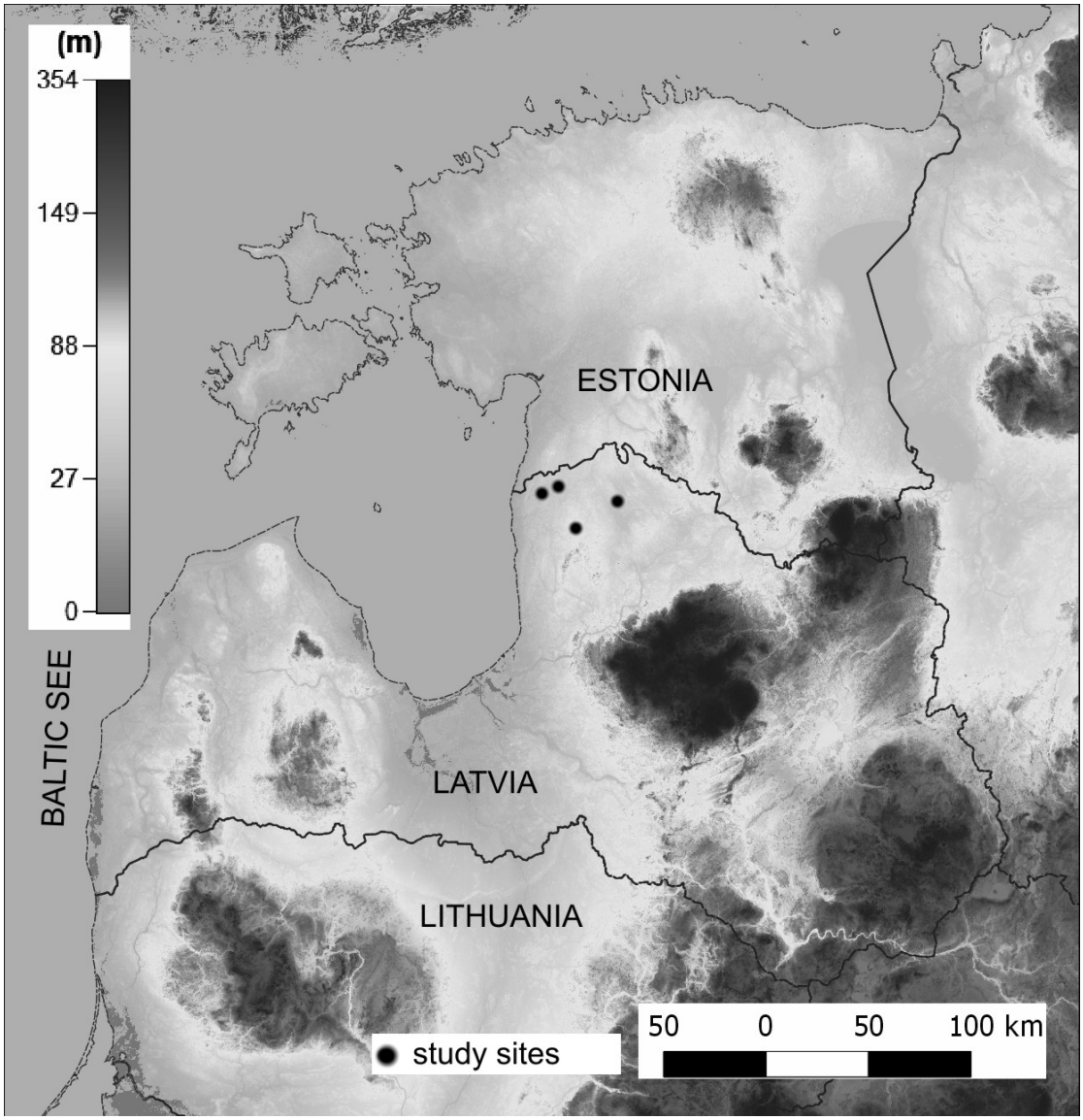

Fig.1. Study area.

The study sites (two fens and three raised bogs) are located in north eastern Latvia, which can be characterised by a rather flat surface topography (approx. 40-85 m a.s.l.). At present, forests cover approx. 30% of the North Vidzeme territory. In the western part of it, mainly spruce forests are distributed. There are small fragments of oak forests on the steepest slopes of hillocks. Ash forests can be found on the gently sloped hillsides and foothills as well in the

river valleys. There are widely distributed birch forests in this region. In relief depressions, typically moist pine forests are spread. Large areas in North Vidzeme are covered by dry and moist meadows and bogs (especially in the northern part) (Kabucis, 1998).

Pantene Fen is situated nearby to Burtnieks Lake and is formed in the place of one of its ancient inlets. The European-scale Stone Age archaeological complex of Zvejnieki is also located in this area. Puikule Bog is situated close to the eastern slope of Aloja-Puikule wall and covers about 2200 ha. Zilais Bog and Kalna Bog lie far away from populated areas, between the northern part of Coastal Lowland and the northern part of Vidzeme, close to the border of Latvia and Estonia. Sediments comprised mainly Sphagnum, Sphagnum-cotton grass, grass-sedge, sedge-wood, sedge peat, gyttja, peaty gyttja, sand, clayey silt and clay. The multidisciplinary study includes pollen analysis, plant macroremain analysis, ^{14}C dating, loss-on-ignition, non-pollen analysis, age-depth modelling and vegetation reconstruction using the REVEALS model.

REVEALS requires raw pollen counts, site radius, pollen productivity estimates and pollen fall speed to estimate vegetation cover in percentages. Pollen productivity estimates and fall speed are currently available for 34 taxa in NW Europe (Broström et al, 2008). To estimate regional vegetation composition with the REVEALS model, large sites (>100-500 ha) should be chosen and preferably lakes as well. Although there are many lakes that are even larger than 500 ha, just a few of them have been palinologically investigated and ^{14}C-dated. Due to many reasons, mires have been more explored in Latvia; therefore, we applied the REVEALS model to data from fens and bogs.

The REVEALS model assumes that (1) pollen is transported by wind above the vegetation; (2) wind transport is uniform from all directions (wind speed was set to 3 m s^{-1}); (3) sedimentary basins are circular; (4) basins are large enough to be dominated by background pollen; (5) most of the pollen derive from within the chosen size of the region (100 km) and (6) pollen productivity can be estimated from present-day vegetation and is constant through time and space (Kuneš et al., 2011). For more details about REVEALS, see Sugita (2007) and Hellman et al. (2008).

RESULTS AND DISCUSSION

Pollen records from all 4 sites show significant vegetation changes during the past 10,200 cal. yr BP. In the REVEALS model, results are shown as average sums in 500-year time windows. In North Vidzeme, like in the entire eastern Baltic region, *Pinus* and grasslands were distributed in the Early Holocene *Betula*. Reconstruction from pollen proportions (Fig. 2) shows the distribution of forest and grasslands as ~72% and ~28% respectively. Forests reached their maximal expansion (~96%) before 5200-5700 cal. yr BP, when broadleaved trees dominated and shade-tolerant trees *Tilia* and *Ulmus* reached their maximum. After that (5200-700 cal. yr BP), forests covered 85-90% of the territory. Pollen percentages suggest that, in the last 100 years, forests covered 72% of North Vidzeme and meadows, pastures, crop fields and mires – just 28%. This result raises a question whether it is possible to have 72% of forest distribution at the time when human influence is so significant? Does this proportion reflect the real situation? As it was mentioned above, today forests (consisting of spruce, birch, pine and oak) cover 30% of North Vidzeme.

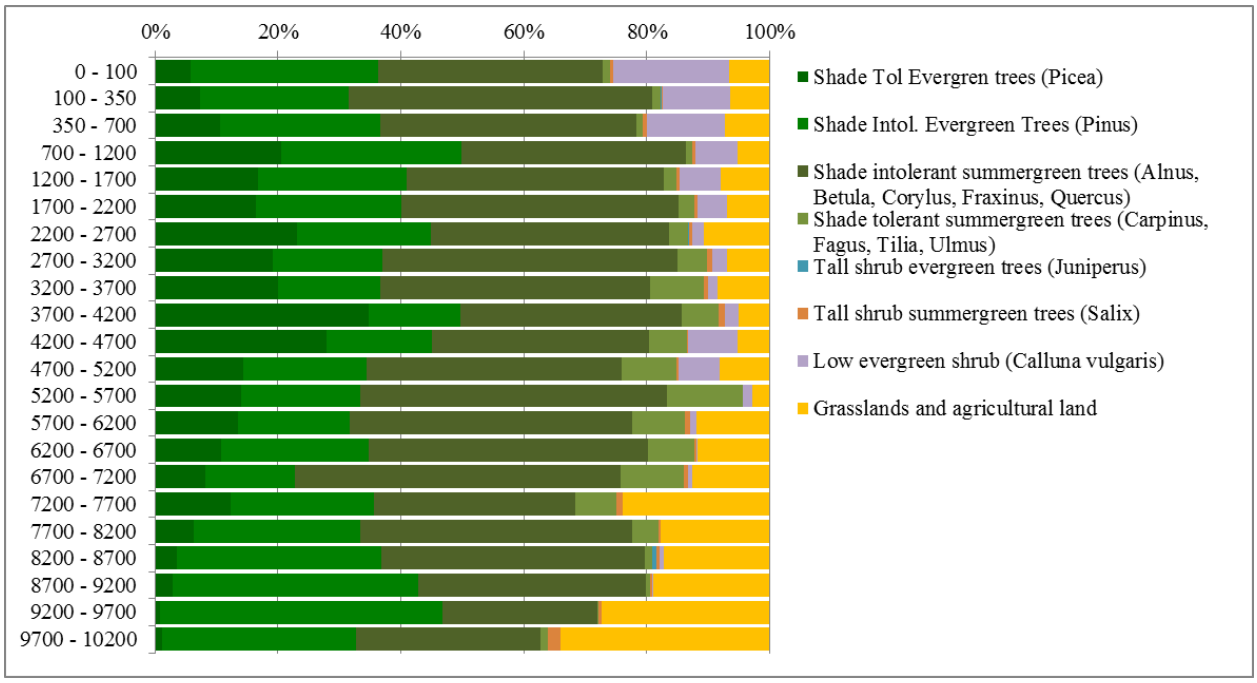

Figure 2. Plant functional types - reconstruction using pollen percentages.

On this account, it is particularly interesting to look at the REVEALS values. They show that forests covered ~38% of the area, conifers – 22%, broadleaved trees – 16%, while all the remaining percentage represents grasslands, meadows, bogs and pastures.
For the beginning of the Holocene (10,200-9200 cal. yr BP), the model shows a completely opposite situation for grassland distribution than in the vegetation reconstruction from pollen percentages: they covered 72% of the territory (Fig. 3). *Betula* and *Pinus* dominated in the forests.

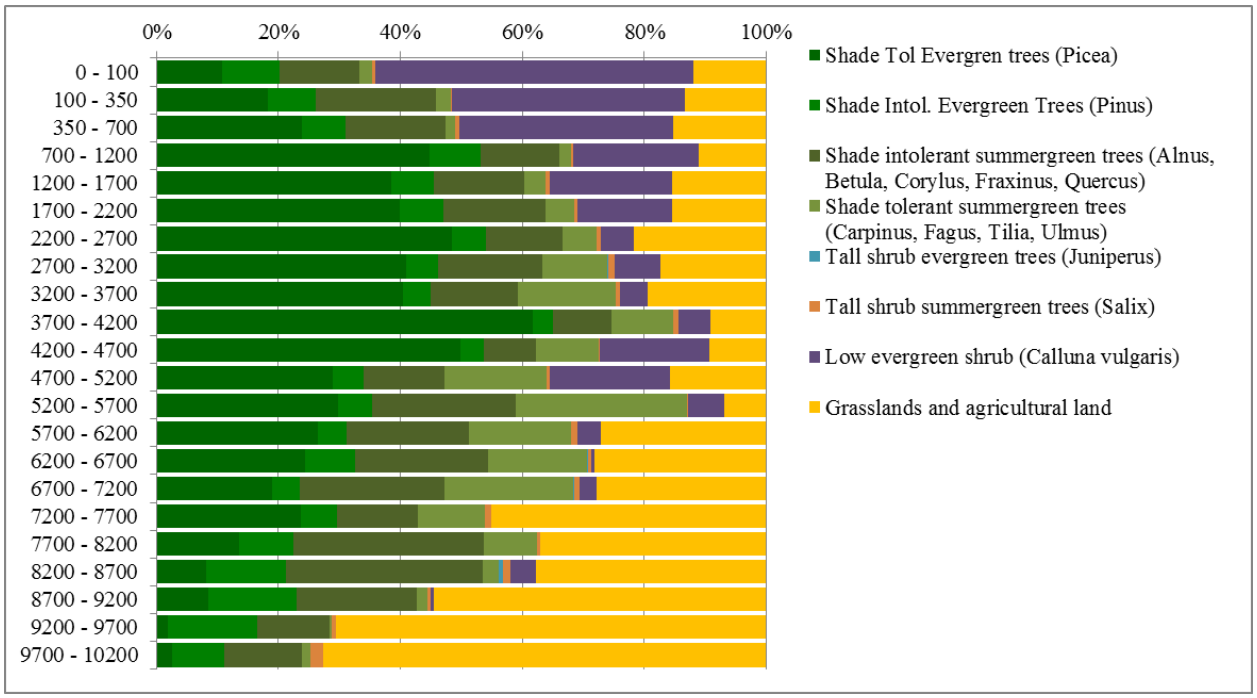

Figure 3. Plant functional types - REVEALS model reconstruction.

It can thus be assumed that the REVEALS model shows more reliable results of past vegetation reconstruction. Below is a more detailed description of vegetation reconstructed using the REVEALS model.

In the time window 8700-9200 cal. yr BP, the grassland proportion decreased, and shade-tolerant summer green trees as well as conifers spread out. This process can be explained by climate amelioration.

Due to the 8.2 ca event – cooling in the Northern Hemisphere (Alley et al., 2005) during the next five hundred years (8200-8700 cal. yr BP; the REVEALS model gives an average sum of 500 years) – there was a sharp increase in the distribution of *Betula*, covering almost 30% of the territory. At the same time, conifers covered 22% and grasslands decreased to 39%. *Calluna vulgaris* appear in territory covering ~2% of area.

During the next 500 years (7700-8200 cal. yr BP), the distribution of *Betula* decreased to 17%, giving space to *Corylus* that reached its maximum density of 13%, and shade-tolerant summer green trees in general became increasingly prevalent in the landscape.

In the time window 7200-7700 cal. yr BP, the distribution of shade-intolerant broadleaved trees declined – at the expense of conifer and grassland expansion. During the period 7200-5700 cal. yr BP, shade-tolerant trees continued to increase, reaching their maximum (almost 25%) in the time window 5200-5700. Consequently, grassland values in this period were strikingly low (~8%), pointing to a more closed landscape. These changes in vegetation proportions can be explained by the Holocene Thermal Maximum (HTM), when climate was warm and dry and temperatures in the southern Latvia rose ~2.5-3.5ºC higher than present-day temperatures (Heikkilä and Seppä, 2010). Following that, broadleaved spreading sharply decreased and grasslands expanded.

Before 4700 cal. yr BP, the forest structure started to change due to the increase of *Picea* and decrease of broadleaved trees, although the values of the latter still remained high (~20%). Increase of *Picea* corresponds to the end of HTM. *Picea* reached its maximum (65%) in the next time window of 3700-4200 cal. yr BP, when forest distribution had its maximum of 85%. Then, the forest distribution gradually decreased to 65-75%. When temperatures began to approach those of today, forests changed correspondingly. Starting from 700 cal. yr BP, grasslands expanded, covering 50% of North Vidzeme. The composition of vegetation in the last 100 years is described at the beginning of this chapter.

Although model more likely gives better reconstruction of vegetation in past, distribution of *Calluna vulgaris* is controversial – model shows that it covers ~50% of present-day landscape what obviously is not true.

CONCLUSION

The results of REVEALS modelling allow us to reconstruct more correct vegetation composition and distribution patterns in comparison with the results obtained from pollen percentages. In the Early Holocene, the territory was more open than previously assumed. However, the pollen diagram shows that the territory of northern Latvia was covered by dense forests. Even for the last 100 years, diagram reconstruction shows that forests have expanded

to 72% and grasslands, agricultural land and mires – to 28%. Estimates of the present landscape and comparison with data obviously show that the situation is just the opposite, and the model yields the same results. *Picea* values are underestimated in pollen diagrams, while those of *Pinus, Alnus, Betula* and *Quercus* are overestimated. *Corylus* has the same values in the pollen diagrams and in the REVEALS model.

It is necessary to obtain pollen data and radiocarbon datings from lakes in North Vidzeme in order to verify results of this study.

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