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Tree pollen representation in surface pollen assemblages from different vegetation zones of European Russia

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Abstract. The paper presents the results of studies of 270 modern pollen assemblages from different vegetation zones of the East European plain. According to obtained data the ratio of the main components in pollen assemblages from forest and forest-steppe localities is characterized by higher proportion of the regional components (e.g., *Betula, Alnus, Pinus*) and significantly lower participation of *Picea* pollen and one of deciduous trees then the proportions of these species in the surrounding vegetation. Steppe vegetation is determined by higher share of non- arboreal pollen and specific floristic composition. The comparison between geographical range of tree species and maps showing distribution of their pollen show a possibility a long distance transfer of *Carpinus* and *Fagus* pollen while pollen of *Quercus* and *Tilia* occurred close to their modern geographical ranges.

Keywords: pollen analysis, modern pollen assemblages, arboreal pollen, the East European Plain

1. Introduction

Pollen analysis for a long time used for reconstructions of palaeolandscapes, the Pleistocene and Holocene ecosystem dynamics and human – environment interaction. The studies of modern pollen assemblages, beginning with works of M. Davis (1963) and S. Andersen (1970) until the last decades (e.g. Seppä et al. 2004; Bennet & Hicks 2005; Bjune et al. 2005, Giesecke 2005; Mokhova et al. 2009; Lisitsyna et al. 2011; *etc*), have shown the importance of a regional approach to data interpretation in pollen analysis. However, a lot of questions of pollen and vegetation relationships, human impact on vegetation and palaeoclimate still remain open.

The aim of this paper is to show a relationship between pollen assemblages and vegetation of the East European Plain and to assess the possibility of the pollen transfer by wind outside the geographical ranges of arboreal species.

2. Material and methods

The studies of arboreal pollen representation in surface pollen assemblages from different vegetation zone is based on analyses of 270 surface samples from different regions of European Russia and adjacent countries, 65 samples were analysed by authors and pollen counting from others was derived from the European Pollen Database (EPD) (http://www.europeanpollendatabase.net) and from the Russian pollen database (http://pollendata.org). Taiga and mixed broadleaf-coniferous forest zones are represented by 120 and 96 samples respectively. Forest steppe and steppe vegetation zones were characterised per 20 samples. 14 pollen assemblages were revealed from tundra.

Samples for pollen analysis were prepared following Moore et al. (1991), pollen diagrams (Figs. 1, 2) were constructed using Tilia 2.0.2 and TGView (Grimm 1990). Relative pollen frequency was calculated based on total terrestrial pollen, which included arboreal pollen (AP) and non-arboreal pollen (NAP), but excluded spores.

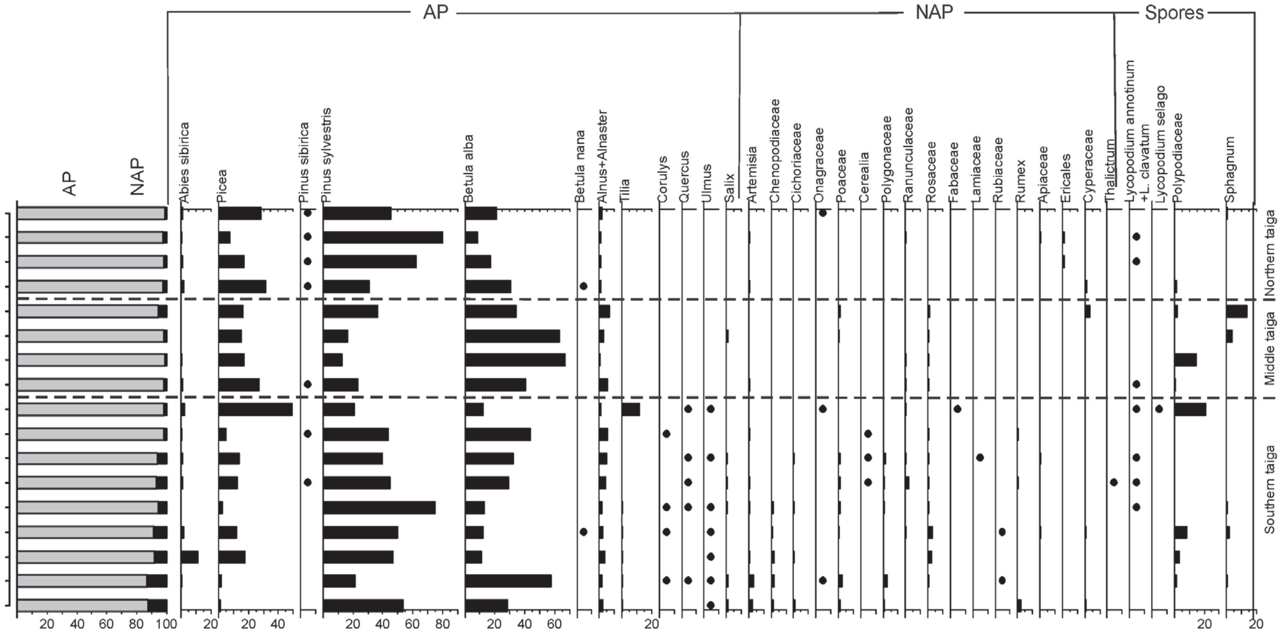

Figure 1. Pollen diagram of selected surface samples from taiga vegetation zone (modified after Novenko at al., 2017)

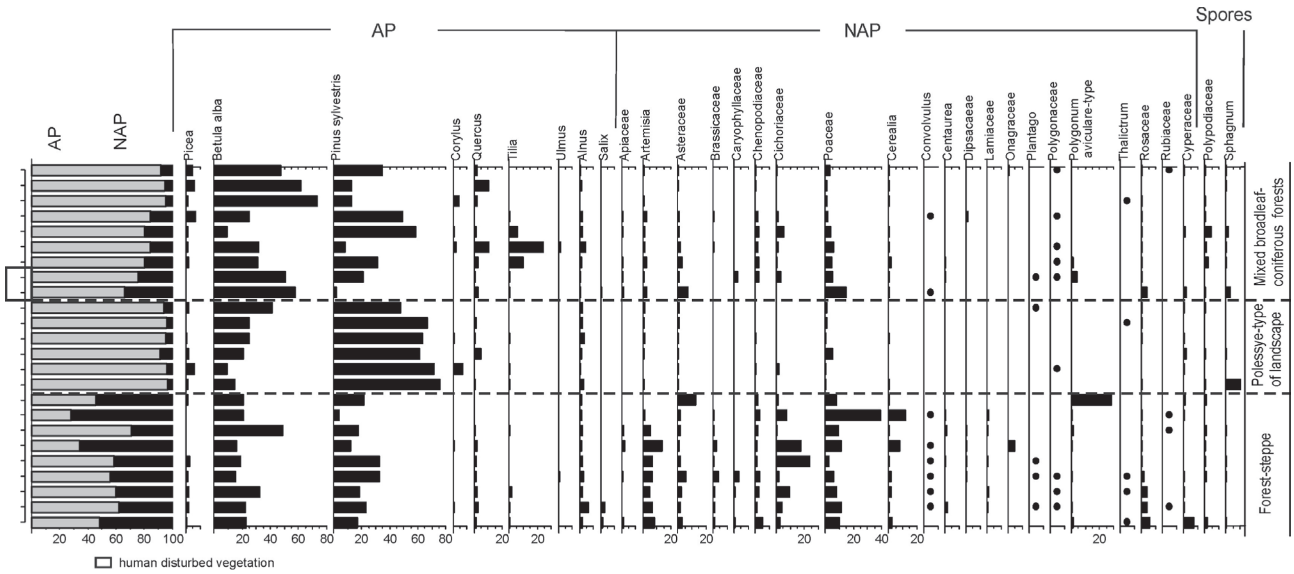

Figure 2. Pollen diagram of selected surface samples from mixed broadleaf-coniferous forest and forest steppe zones (modified after Novenko at al., 2017)

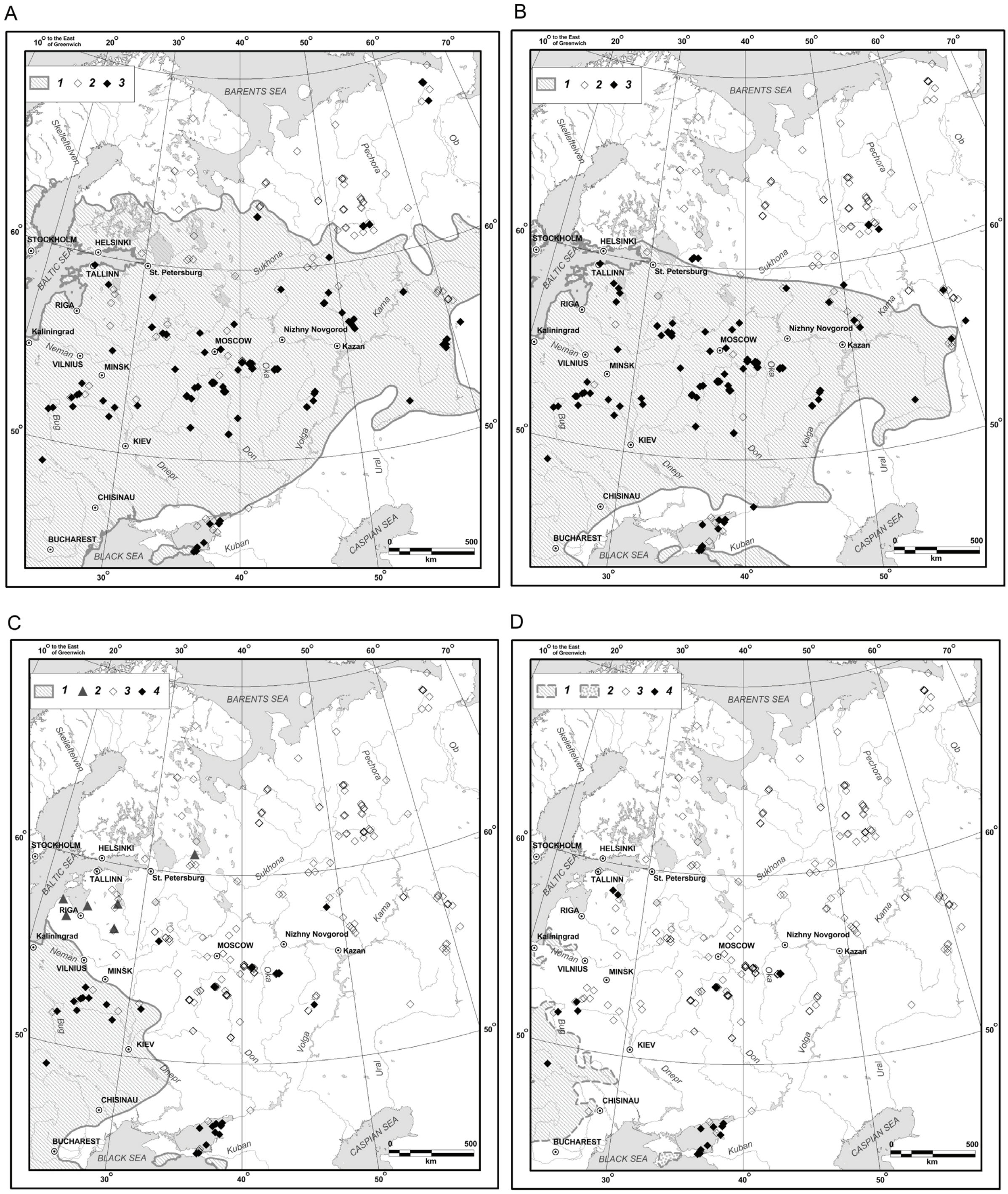

Figure 3. Modern distribution of *Tilia, Quercus, Carpinus* and *Fagus* and presence of their pollen in surface pollen assemblages

A. *Tilia*: 1 – geographical range of *Tilia cordata*, 2 – location of surface pollen samples, 3 – occurrence of *Tilia* pollen.

B. *Quercus*: 1 – geographical range of *Quercus robur*, 2 – location of surface pollen samples, 3 – occurrence of *Qurcus* pollen.

C. *Carpinus*: 1 – geographical range of *Carpinus betulus*, 2 – places, where *Carpinus* was introduced and naturalized (synanthropic), 3 – location of surface pollen samples, 4 – occurrence of *Carpinus* pollen.

D. *Fagus*: 1 – geographical range of *Fagus sylvatica, 2* – area of growing of *Fagus sylvatica and F. orientalis,* 3 – location of surface pollen samples, 4 – occurrence of *Fagus* pollen.

To assess the possibility of the pollen transfer by wind outside of the geographical range of tree species maps showing modern distribution of species and occurrence of pollen in surface samples were created (Fig. 3, A-D). Lime, oak, beech and hornbeam were chosen for analyses as these trees are represented on the East European Plain by single species: *Quercus robur, Tilia cordata, Carpinus betulus, Fagus sylvatica.* Isolated localities of *Fagus orientalis* in the Black sea region were shown additionally. The present day geographical ranges of species were derived from "Areals of trees and shrubs in the USSR" (1977) with corrections of modern distribution and places of the introduction of plant species by San-Miguel-Ayanz et al. (2016).

3. Results and discussion

Pollen assemblages from taiga and mixed broadleaf-coniferous forest zones are dominated by arboreal pollen, coniferous trees, alder and birch are most abundant. *Picea abies* is a permanent component of pollen assemblages from taiga forest, the percentages of *Picea* vary from 15 to 50% (Fig. 1). In the north-eastern part of the study region pollen assemblages include *Pinus sibirica*, *Abies sibirica* and *Betula nana*. Broadleaf trees (*Quercus, Ulmus, Tilia, Acer*) are rare in vegetation of taiga zone of European Russia, however their pollen permanently occurred in small amount (<1%), among them *Quercus* pollen is most frequent. In places, where broadleaf trees occur in forest stands under canopy of spruce or pine, their percentages increase to 2–3% of AP+NAP sum.

In pollen assemblages from mixed broadleaf-coniferous forest contribution of *Quercus* and *Tilia* is 30–40% in places within broadleaf forests and 5–10% in mixed broadleaf-pine communities (Fig. 2). The share of *Ulmus* and *Acer* does not exceed 5%, pollen of *Fraxinus* is rare. Pollen values of *Corylus* vary from 3 to 15%. Rare pollen of *Carpinus* and *Fagus* is registered mainly in western part of the region. The extensive areas in the centre of the East European Plain are occupied by sandy plains formed by fluvio-glacial sediments and covered by pine forests, so-called Polessye type of landscapes. Pollen assemblages from these regions are dominated by *Pinus* pollen with very small participation of other arboreal taxa (Fig. 2).

Pollen assemblages from forest-steppe zone differ notably from spectra formed in forest vegetation. The proportion of herb pollen increased to 40–60%. *Artemisia* and Poaceae are the most abundant; species typical for meadow-steppe vegetation take a conspicuous part in the spectra. Among trees the permanent components of pollen assemblages are *Betula, Alnus* and *Pinus*. The share of broadleaf trees does not exceed 3%. The comparison of composition of pollen assemblage with spatial pattern of vegetation show that arboreal pollen percentages could be in 1.8–4.5 times higher then share of woodlands in plant cover. In pollen assemblages from steppe zone, taken from treeless localities, the proportions of arboreal pollen decrease to 20%, that is represented mainly by *Pinus, Betula* and *Alnus*, wind pollinated tress with high pollen productivity. Pollen of broadleaf tress occurred sporadically. In marine sediments of the Sea of Azov an amount and diversity of tree pollen increased obviously due to pollen transport by rivers (Matishov et al. 2013).

According to obtained data the ratio of the main components in pollen assemblages from forest localities is distorted due to the high share of the regional component represented by plants with high pollen productivity and dispersal (e.g., *Betula, Alnus, Pinus*). At the same time, the participation of spruce and deciduous broadleaf tree species in the spectra is lower than the share of these samples in the surrounding forest. Besides, the proportion of regional pollen component in assemblages is much higher in samples taken from treeless areas and in floodplains than in samples taken under the forest canopy.

The comparison between geographical range of tree species and maps showing the distribution of their pollen show that pollen of *Quercus*, *Tilia, Carpinus* and *Fagus* is present in the most sites within their geographical ranges. Pollen of *Tilia* is present in area about 150 km around its geographical distribution, with exception of two sites in Polar Ural, about 850 km from its northern boundary (Fig. 3 – A). Outside range pollen of *Quercus* occurs in a few sites not far from the boundary of its range (Fig. 3 – B). Pollen of *Quercus* in sites near St. Petersburg is probably belonging to planting oak trees. One isolated finding of *Quercus* pollen is located in Komi Republic, in 400 km north from its modern range.

Pollen of *Carpinus* was recorded beyond its distribution in several sites in the Sea of Asov region (plantation of hornbeam), and in a number of sites in Tver', Tula, Kirov and Ryazan' region and Mordovia Republic (Fig. 3 – C). The maximal distance, which *Carpinus* pollen was transported to the East, is about 720 km. Pollen of *Fagus* was found in marine sediments of the Sea of Azov (probably, *Fagus orientalis*), in several sites in Belarus and Estonia, where it could be produce by beach planting in parks. Remote places of occurrences of *Fagus* in surface pollen assemblages are located in Tula and Moscow regions and the most distant – in Mordovia Republic, about 1200 km to the East (Fig. 3 – D). The obtained results allow us to conclude that pollen of *Carpinus* and *Fagus* can be transported by wind over long distances that that should be considered by interpreting fossil pollen assemblages.

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