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Preliminary environmental historical results to reconstruct prehistoric human-environmental interactions in Eastern Hungary

Research Article

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Abstract: Palaeoenvironmental research is playing an important role in recent archaeological investigations. We present preliminary results of geoarchaeological analyses conducted at a palaeochannel located between two prehistoric archaeological sites in eastern Hungary. The study area lies within the Körös River Basin in Békés County, a region of intensive human occupation beginning in the Neolithic, ca. 7550 BP, and represents only the second palynological analysis done in conjunction with archaeological investigations and adjacent to an archaeological site in the Körös region. Pollen from an environmental monolith was used to reconstruct the local vegetation composition and the human impact on arboreal and non-arboreal vegetation near the archaeological sites. Sediment analyses helped to reconstruct hydrological activity and human impact on the local palaeochannel. Results indicate that activity from the Neolithic onwards played an important role in local environmental change, including increasing sedimentation and deposition of organic matter in the local waterway, some forest clearance and a shift from primarily arboreal vegetation to more grasses on elevated surfaces. The trophic status of the local channel changed several times during the Holocene. In addition, indications that groundwater levels may have been fluctuating during the period of human occupation, when combined with the other changes in the area, provide a possible partial explanation for changing settlement patterns.

Keywords: Palaeohydrology • palaeoecology • sedimentology • Holocene • Körös area

1. Introduction

The environment and hydrology of eastern Hungary have played a prominent role in discussions about prehistoric land use and settlement. Environmental phenomena, especially flooding, have been proposed as forcing prehistoric people to move or change their settlement systems, and as limiting factors in human subsistence [1–3]. Despite these discussions, very little geoarchaeological work has been done in the region to develop paleohydrological models or to reconstruct the ancient environment. Prior to this study, only one environmental core taken adjacent to a prehistoric habitation site has been analyzed for pollen in the Körös

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Region of eastern Hungary [4–6], along with a few studies in northeastern Hungary [7–10]. Studies in western Romania [11, 12], although not conducted in conjunction with archaeological research, provide useful regional comparative data. In addition, the old Sebes-Körös channel was hand-cored to produce geomorphological profiles of the palaeochannel and floodplain near the Vésztő-Mágor settlement mound [13], and a fluvial section was analyzed at an open clay mine near Körösladány [14], approximately 27 and 16 km east of our study area, respectively.

These studies suggest that a wooded-steppe environment persisted through most of the Holocene, and that increased human activity affects the pollen record with the arrival of agriculture in the early Neolithic. However, studies of this type have only begun to proliferate during the 21st century, so complementary comparative data from within regions is lacking. This paper, although the data is preliminary, will provide such data for the Körös region, and compare inter and intra-regional studies. In addition, we will begin to address questions such as how much influence prehistoric humans had on the environment, and how persistent this influence was over time.

During 2011-2012, a Hungarian-American geoarchaeological collaboration was carried out to gain a better understanding of vegetation, hydrology and prehistoric human activity around two archaeological sites in the Körös Basin, Békés County Hungary [15]. This study is part of the larger Neolithic Archaeology and Sediments Körös Area project, which seeks to clarify Neolithic cultural transitions and understand the role of the environment in these transitions, using sediments as a primary class of artifacts. A crucial component of this larger project is gaining insight into human-environmental interactions; that is, the degree of anthropogenic impact on the environment as well as how the environment impacts human activity at both the local and regional scales. To gain these insights, we collected pollen and sediment data from an environmental monolith taken from a defunct cut-off channel of the Old Triple Körös River to interpret changes to vegetation composition, sediments and hydrology. Unfortunately, we presently have only one radiocarbon date from the monolith, and thus the sedimentation rate and chronology of the sedimentological profile is hypothetical. As the project continues, we will collect additional organic samples from different parts of this profile for radiocarbon analyses, and with new C-14 data we can reconstruct the correct sedimentation rate and distinguish the late glacial/postglacial transition zone.

2. Study Area

The archaeological investigations were carried out at the sites of Csárdaszállás 8 and Csárdaszállás 26 in Békés County, Hungary (Figure 1). Prior to this research, the sites had been identified through pedestrian survey during the Archaeological Topography of Hungary projects [16]. The two sites are located approximately 600 m apart, each on the south side of relict meanders of the Triple Körös River (Figure 1). Csárdaszállás 26 is a small settlement covering about 60 x 60 m and belonging to the Tisza culture, a Late Neolithic group who lived in the eastern Carpathian Basin ca. 6950 calBP (5000 calBC) [16]. Csárdaszállás 8 is a larger site, covering approximately 7 ha and containing artifacts from several prehistoric periods, with the primary occupation also dating to the Late Neolithic Tisza culture [16]. Geochemical surveys were carried out in 2007-2008 at these and other small Late Neolithic sites in the Körös region as part of a doctoral dissertation project [17–19]. New research at Csárdaszállás began in 2011 with a campaign focusing on understanding the prehistoric environment and the relationship between human activity and environmental changes [15].

The study area is the flat and fertile Körös-Berettyó geomorphological region of the Hungarian Great Plain, east of the former Berettyó River channel, south of the Sárrét marshlands and north of the Maros fan (Figure 1). The Körös-Berettyó Basin forms a shallow depression with an extensive system of meandering channels and floodplains that lie a few meters below the alluvial fans of the Tisza and Maros Rivers. The ground is regularly saturated during the rainy seasons and excess surface water typically lies on the surface until it either soaks into the porous soil or evaporates [20].

The Körös River is a low-energy graded river, meaning that erosion and deposition are largely in balance. In the past, it was thought that the floods caused the rivers to dramatically change their course [3]. Detailed morphological and sedimentological studies [21–23] have provided new information indicating that although massive flooding was common, the river channels achieved their present courses within the last 10,000 years and have remained fairly consistent throughout the Holocene. Cyclostratigraphical and palaeoclimate analyses of sediments from a deep borehole at Vésztő, located approximately 15 km east of Csárdaszállás, shows continuous fluvial deposition of sediments and consistency with global paleoclimatic records during the middle to late Pleistocene [24].

During the Pleistocene the rivers meandered extensively, creating numerous oxbow lakes, meanders, backswamps

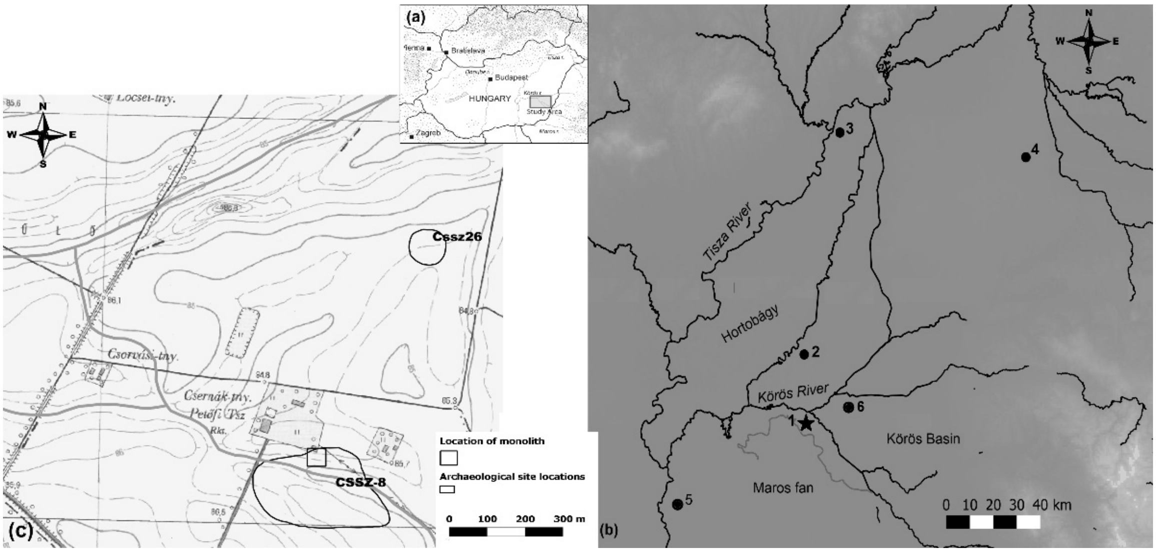

Figure 1. (a) Location of the study area in Central Europe. (b) Location of the Csárdaszállás case study in eastern Hungary with other key sites and regions mentioned in the text also shown. Key to sites: 1 Csárdaszállás (this study), 2 Ecsegfalva / Kiri-tó [4–6, 33–35], 3 Sarló-hát [9, 31], 4 Bátorliget [8, 64, 71], 5 Szegvár-Tűzköves [81], 6 Vésztő-Mágor [13]. (c) Map of the study area showing the location of the Late Neolithic sites of Csárdaszállás 8 and 26, the palaeomeanders and location of the monolith on 1:10,000 topographic map.

and palaeochannels, as well as elevated riverbanks and lag surfaces of alluvially redeposited loess [13, 22, 25, 26]. This process of natural levee formation enclosed small, undrained or slowly draining depressions that may have seasonally re-filled, and the mosaic of streams, back-swamps, ponds, loess ridges and islands, and annually inundated fields remained largely the same throughout later prehistory [4, 13].

The Holocene Great Plain was a temperate forest-steppe region with many different plant associations; gallery forests along waterways separate large areas of steppe meadows, all surrounded by deciduous forests on the lower slopes and coniferous forests in the mountains [1, 72]. Traces of former vegetation are preserved in filled-in oxbows, and pollen is well preserved under anaerobic conditions in Holocene backswamps. From this data, Pécsi and Sárfalvi [27], Gyulai [28] and Willis and colleagues [29] concluded that during the beginning of the Atlantic Phase, corresponding roughly with the spread of Neolithic cultures, a mosaic of mixed oak-hazelnut forest (i.e., *Quercus*, *Fraxinus*, *Ulmus*, *Corylus* and *Tilia*) and open meadows dominated the landscape. Shiel [30] concluded that vegetation in north-east Hungary varied from deciduous dry oak woodland to wet poplar (*Populus*) and willow (*Salix*) woodland, with open, coniferous woodland in hilly areas (c.f. [31]). Evidence from Tarnabod in northern Hungary [32] shows little or no vegetational change resulting from agricultural activity from the Middle Neolithic through the early-to-middle Copper Age.

The only other palaeoenvironmental reconstruction in the Körös region comes from the Early Neolithic site of Ecsegfalva 23 [33]. Ecsegfalva is situated on the Kiri-tó, a large palaeomeander of the Berettyó River. Like the relict channel at Csárdaszállás, this meander was cut off and formed an oxbow lake, but the Kiri-tó is much larger [5]. Results of paleoecological studies at Ecsegfalva indicate a significant amount of grass pollen as well as a number of tree types including *Quercus*, *Fagus*, *Corylus*, *Carpinus*, *Tilia* and *Betula*, suggesting an open forest-steppe environment [6, 34, 35].

3. Methods

Monoliths were taken from test pits ca. 85 m asl at the remains of the oxbow lake near the southern site in November 2011, when airborne pollen counts were negligible. Monoliths were split for pollen and sedimentary analyses, and the splits divided into 4 cm samples for analysis, so that 57 samples were tested from the 210 cm column. Sediment analyses included magnetic susceptibility, soil carbonates, organic matter and inorganic material. Pollen and microcharcoal were point-counted and the software package Psimpoll 4.26 [36] was used to create graphs of environmental data. One radiocarbon date was obtained by AMS (Accelerator Mass Spectrometry) analyses in Seattle (D-AMS 1217-093), giving us a date to build up from.

3.1. Sedimentology

The goal of sediment analysis was to identify anthropogenic influences on the trophic status of the oxbow lake, and to identify groundwater fluctuations. Relative proportions of calcium carbonate and organic matter relate to fluvial activity, water depth and human inputs. Carbonate and organic matter content were determined using loss on ignition (LOI), following Dean [37]. Graphical representation of the sequence was produced using Psimpoll, with lithostratigraphical description of the profiles following the Troels-Smith method of classification [38].

3.2. Pollen Analysis

The monolith was subsampled at 4-cm intervals for pollen analysis. A volumetric sampler was used to obtain 1 cm^3 samples, which were then processed for pollen [39]. Lycopodium spore tablets of known volume (supplied by Lund University, Sweden) were added to each sample to enable calculation of pollen concentrations and accumulation rates [40]. A minimum count of 300 grains per sample (excluding exotics) was made in order to ensure a statistically significant sample size [41]. Of the 57 samples tested, 37 samples contained statistically significant pollen grain values. The pollen types were identified and modified according to Moore *et al.* [42], Beug [43], Kozáková and Pokorny [44] and Punt *et al.* [45], supplemented by examination of photographs in Reille [46–48] and of reference material held in the Hungarian Geological Institute, Budapest. Percentages of terrestrial pollen taxa, excluding Cyperaceae, were calculated using the sum of all taxa. Percentages of Cyperaceae, aquatics and pteridophyte spores were calculated relative to the main sum plus the relevant sum for each taxon or taxon group. Microcharcoal (fly ash) abundances were determined using the point count method [49]. Calculations, numerical analyses and graphing of pollen diagrams were performed using Psimpoll [36]. Local pollen assemblage zones (LPAZs) were defined using optimal splitting of information content [50], zonation being performed using the 20 terrestrial pollen taxa that reached at least 5% in at least one sample.

Palaeovegetation was reconstructed following the work of Sugita [51], Soepboer *et al.* [52], Jacobson and Bradshaw [53], Prentice [54] and Magyari *et al.* [31] and then assigned to biomes. The different vegetation types, indicator elements and weeds types were classified based on the work of Allen *et al.* [55], Behre [56, 57], Elenga *et al.* [58], Magyari *et al.* [31], Prentice [59, 60] and Tarasov *et al.* [61, 62]. From these works, we distinguished elements of warm steppe, cool steppe, cool mixed wooded steppe, cool mixed forest, temperate deciduous forest and deciduous wooded steppe. The biomization procedure [59, 60, 63] is an objective method that translates pollen and plant macrofossil spectra into biome assignments by assigning taxa to one or more plant functional types.

4. Results

The environmental monolith collected from the palaeochannel near Csárdaszállás 8 revealed approximately 40 cm thick deposits from the Neolithic. The top 70 cm, representing approximately the past 2000 years, are badly disturbed. Vigorous seasonal cycles of saturation and drying, in conjunction with vertical mixing, have destroyed any trace of pollen in this part of the profile. However, we retain a record from the late Pleistocene into the Bronze Age.

Minerorganic, silt-rich lake sediment formed until ca. 12,000 calBP years on the Great Hungarian Plain [5, 64–67], and this minerorganic lake layer was found in the bottom of the Csárdaszállás profile. Furthermore, sedimentation rates in the region average 1 cm per 80-100 years, and these values were used in conjunction with parallels in the pollen changes [6] to extrapolate temporal periods from the AMS date. Therefore, we used sediment stratigraphy in conjunction with the C14 data to help reconstruct our chronology.

4.1. Palaeohydrology

Like most Neolithic settlements in the region, the sites are located on fossil river banks along cut-off water channels [5, 13]. In this case, analysis of historic maps and aerial imagery indicates that the sites were located near a prehistoric ox-bow lake that formed from a channel of the Ice Age Körös River that was cut-off when the river changed its course during the Pleistocene.

The sediment analyses revealed considerable quantities of layered organic matter, carbonate concretions and small ferrous concretions (Figure 2). These sediment markers, together with changes in magnetic susceptibility through the profile and ferrous stains indicative of oxidation and reduction cycles, are the consequences of slow moving water, developing floodplain sedimentation and intensive vertical groundwater movement. Overall, the results indicate fluctuating groundwater levels and increasing nutrient load over time. Based on Dean [37, 68], organic content change indicates the ancient trophic status of the oxbow lake. Our results suggest that the lake changed from oligotrophic in the early Holocene to eutrophic by the middle Neolithic. Sedimentation and deposition of organic matter increased until a marshland formed during the Bronze Age. Similar semi-open Holocene oxbow lakes with low organic content and a transformed uppermost layer can be found in alluvial regions of the Great Hungarian Plain [69].

4.2. Vegetation

Prehistoric pollen is preserved beneath the historic plough surfaces, despite the fact that the paleochannel has been dry for at least 100 years. The pollen data suggests a naturally patchy wooded steppe environment that predates archaeology in the region. There is a sharp increase in human effects (cultivation, clearance, cereals, weeds, long-term settlement) after ca. 7683 +/-30 calBP (5733 +/-24 calBC), based on an AMS radiocarbon date from 140-141 cm depth (Figure 3 and Figure 4), which increases continuously through time.

There is no simple relationship between the proportion of pollen of woody taxa in records from medium-sized lakes and the proportion of woodland cover on the surrounding landscape, and although such records may fail to reflect scattered openings when closed forest predominates, they can discriminate generally forested landscapes from those that are generally open with wooded patches, even when the lake lies in a wooded patch. Based on work of Allen [55] and Magyari [31], percentages of pollen of woody taxa are generally ¿90% and only rarely ¡80% in forest zones, they are frequently ¡70% in the wooded steppe zone and even lower, often ¡50%, in the steppe zone. However, surface samples originating from floodplains or fens in the wooded steppe or steppe zones, where enhanced moisture availability supports local forest development, often have ¿75% pollen of woody taxa, leading to uncertainty in discriminating forest from wooded steppe or steppe using the relative abundance of pollen of woody taxa alone. Nonetheless, percentages of pollen of woody taxa consistently ¡70% provide a conservative basis for inferring the predominance of wooded steppe rather than of closed forest in the surrounding landscape. Thus, when applying the biomization procedure [59, 60], we follow Allen [55], Willis [6, 70] and Magyari [31] in inferring wooded steppe rather than closed forest when woody taxa pollen dominance is ¡70%. The woody taxa pollen dominance before Neolithic human impact was between 73-48% in the analyzed pollen samples from the section of Csárdaszállás. Therefore, our pollen data suggest that some natural open terrestrial vegetation (steppe, wooded steppe) spots formed in the analyzed area during late glacial/postglacial transition and early postglacial.

The following steppe indicator pollen were identified in the Csárdaszállás sequence through comparison with the works cited above [31, 43, 44, 55, 59, 60]: *Ajuga*, *Allium*, *Artemisia*, Aster-type, *Astragalus*, Caryophyllaceae undiff., Chenopodiaceae (including Chenopodiaceae, *Atriplex*, *Kochia*), Compositae, subfamily Cichorioideae, Dianthus-type, *Euphorbia*, Poaceae, *Helianthemum*, *Inula*, Matricaria pollen type (including *Achillea*, *Anthemis*, *Matricaria*), *Plantago lanceolata*, *Plantago major/P.* media, *Thalictrum*, *Trifolium pratense* type, *Trifolium repens* type and *Verbascum*.

Figure 3 summarizes the woody and non-woody pollen taxa by palaeovegetation phase plotted against depth of the soil column and hypothesized years calBP, and correlates this with the Blytt-Sernander sequence. Seven general local pollen assemblage zones (LPAZ) are distinguished. Late Pleistocene and Early Holocene vegetation zones were well differentiated in the profile.

Percentage of woody and herbaceous pollen are plotted against depth in the soil column and hypothesized years calBP in Figure 4. A boreal taiga with mixed leaf forest and some open patches (LPAZ 1) trending over time to a boreal wooded steppe with warm and cool steppe elements (LPAZ 2) covered the area from the end of the Pleistocene to the beginning of the Early Holocene (210-185 cm, ca. 14,000–10,950 calBC). During the Early Holocene (185-172 cm, ca. 10,950–9500 calBP), Early Mesolithic populations lived in a forest steppe environment, with forest dominant [71, 72]. A humid floodplain forest expanded during the Late Mesolithic (172-140 cm, ca. 9500–7950 calBP), represented by LAPZ 4 with a mixed oak forest and developed marshy and steppe patches.

The Neolithic period (ca. 7750–6950 calBP) shows up in the profile from 140–130 cm, with more organic matter and fly ash (microcharcoal less than 2 mm in size) in the section (Figure 2 and Figure 4). This is LPAZ 5, with the first evidence for cultivated plants, including cereals (*Triticum* sp) and anthropogenic indicator weedy taxa. The data suggests relatively permanent settlement from about 7550–7450 calBP.

The section from 130–100 cm (LAPZ 6), containing the period from ca. 6950–4950 calBP, roughly from

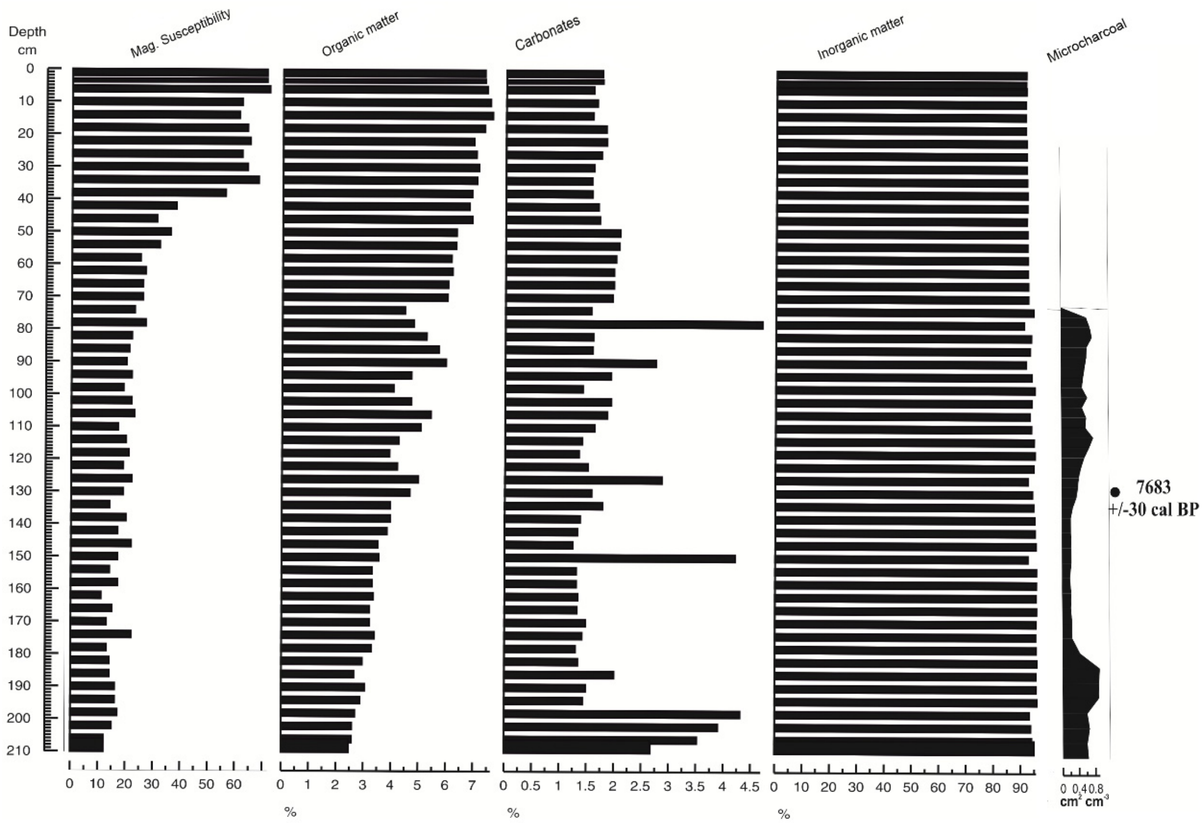

Figure 2. Sedimentological analysis of the Csárdaszállás group geological profiles. Magnetic susceptibility, organic matter, carbonates and inorganic matter percentage with microcharcoal ratio plotted against depth.

the Late Neolithic through the Late Copper Age, was one of increased anthropogenic impact. Fewer trees and more crops, sedges and ruderal weeds point to significant increases in human production and imply long-term intensive occupation of the landscape. The exception to this general decrease in tree pollen are beech (*Fagus*) and hornbeam (*Carpinus*), which both increase markedly following the arrival of early farmers, and linden (*Tilia*), pollen counts for which hold steady throughout the column. The lowest percentage of tree pollen is from the final 30 cm of preserved data, with a slight peak in non-arboreal pollen and relatively high levels of microcharcoal.

Anthropogenic impacts that we can demonstrate from the second half of Copper Age and the Early Bronze Age surpass the human effect of the second half of Neolithic. We can calculate extensive deforestation, with the percentage of the wooded vegetation decreasing below 10% (following 70% in the Mesolithic and 50% in the Neolithic). Human activity can also be implicated in increasing sedimentation and changes in the trophic status of the oxbow lake.

5. Discussion

Modeling and empirical studies [51, 52] indicate that for a oxbow lake (50-200 m diameter), the correlation between pollen abundances and vegetation composition is not improved by considering vegetation more than 400-600 m from the lake. The regionally uniform background pollen component, representing vegetation between 600 m and tens of kilometers from the lake, generally accounts for about 45% of the total pollen [52]. The pollen data from the oxbow lake at Csárdaszállás thus provide an integrated palaeovegetation record for the landscape around the lake and the surrounding region [53].

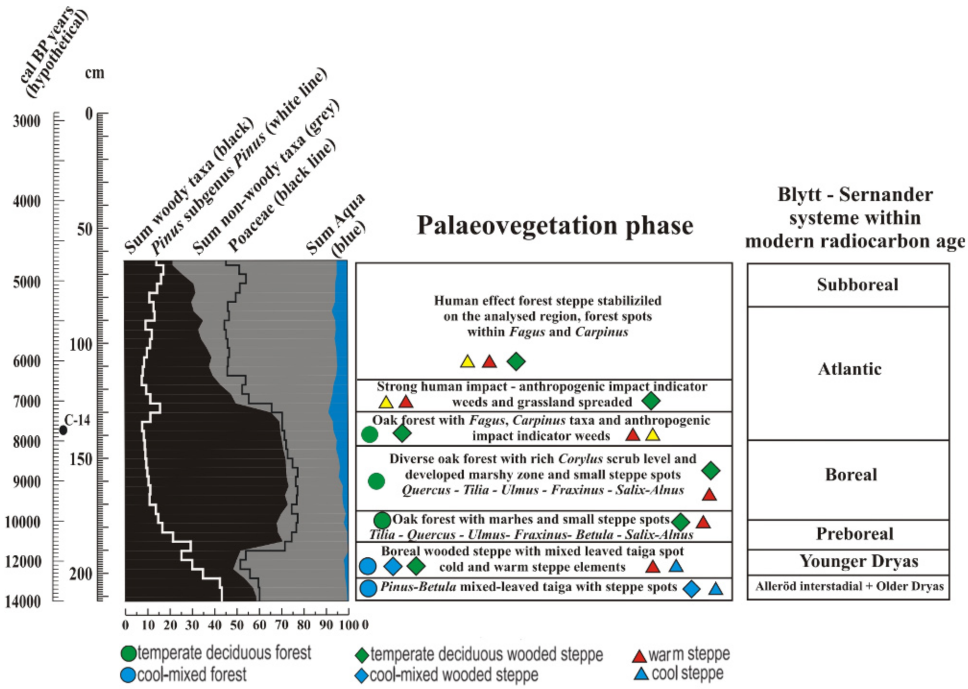

Figure 3. Summary of Csárdaszállás group woody and non-woody pollen taxa plotted against depth of the soil column and hypothesized years calBP, grouped by palaeovegetation phase and correlated with the Blytt-Sernander sequence.

5.1. Environmental and hydrological effects on prehistoric settlement

Environmental conditions are never static, and numerous studies [73–75] indicate that while the Holocene has been a period of stable environmental conditions over a large geographic scale relative to geologic time, there were numerous short-term climate fluctuations during the Neolithic. Data from complementary sources indicate that during the end of the Boreal period (ca. 9450–7950 calBP) and in the early Atlantic period (ca. 7950–6950 calBP), that is the period corresponding to the Early and Middle Neolithic in the Carpathian Basin, the climate was consistently warm and moist in the surrounding areas. During the period from roughly 7450–6850 BP, corresponding to the Hungarian Late Neolithic, the climate was warm and humid, but generally more stable, and during the years 6850– 6150 BP there was another transition to the cooler, drier Subboreal climate [74, 76]. Reconstruction of water levels based on plant macrofossils and diatoms from Lake Saint Ana indicate fluctuations in water depth in the eastern Carpathians throughout the Holocene [11]. As this lake is filled solely via rainfall, fluctuations in water levels should reflect fluctuations in weather patterns. These short-term fluctuations may have influenced prehistoric settlement and subsistence patterns.

Of particular interest for our project is that other data from Central Europe suggest that fluvial systems were affected by Holocene environmental fluctuations, especially flood frequencies. Gábris [77] reconstructed Holocene stream networks, erosion and deposition conditions in Hungary from sediment data; high standard deviations in discharge during the Atlantic indicate high variability in precipitation. Starkel [78] analyzed sediment deposits in southern Poland and found that during cool moist periods, there was an increase in rainfall and a concomitant increase in flooding along major waterways, while during warm dry periods decreased fluvial activity resulted in the development of marshy areas in formerly flooded channels. These data sets correspond with sediment data from archaeological sites that show increasing alkali soil development during the Neolithic [79], suggesting a drier, continental climate. Howard's sequencing of alluvial deposits in southern Romania indicate cycles of increased sedimentation

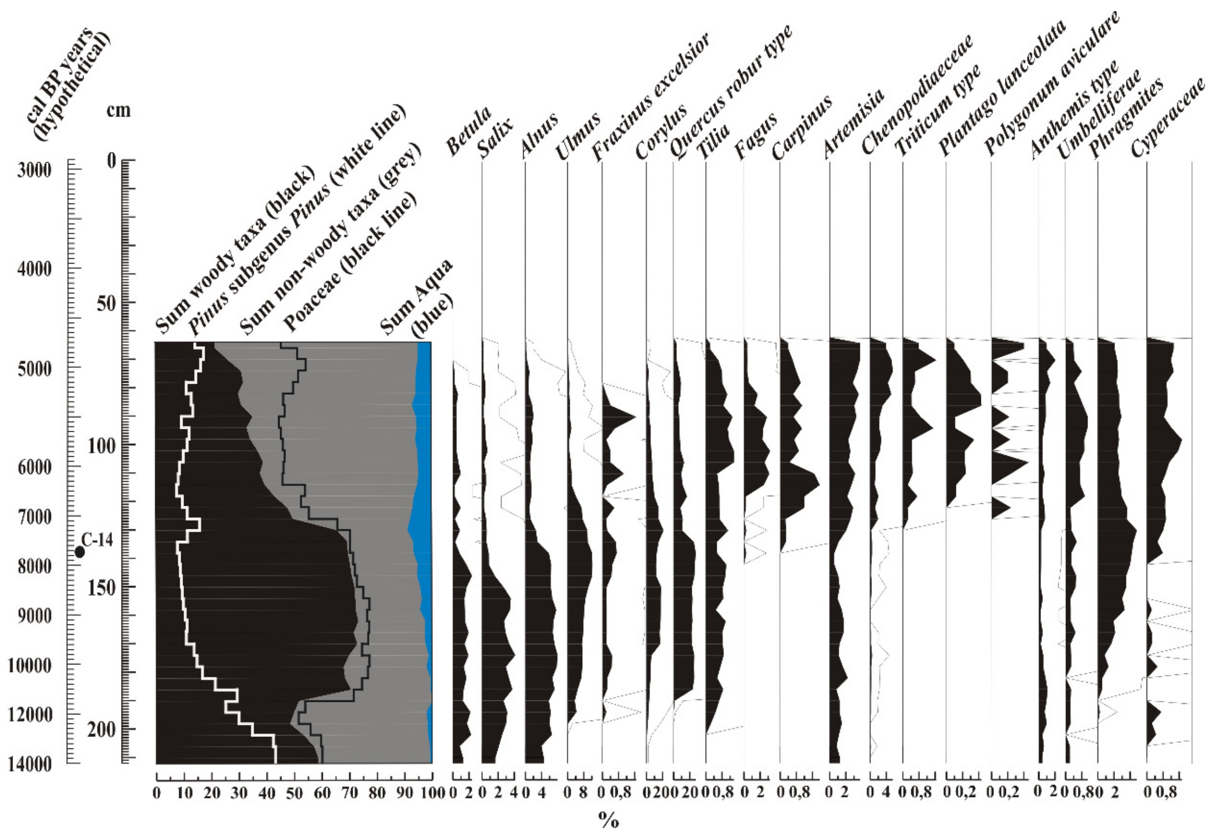

Figure 4. Csárdaszállás group diagram of woody and herbaceous pollen percentage plotted against depth in the soil column and hypothesized years calBP.

alternating with bed incision, beginning ca. 4900 calBP, with sedimentation corresponding with cool, humid climatic periods [80]. Our results suggest increasing sedimentation after 6000 calBP, and fluctuations in formation of carbonates suggest alternating wet and dry periods between ca. 8500-5300 BP.

Several effects of climate changes on regional hydrology, and therefore on vegetation and prehistoric habitation, resulted from this variability. First, fluctuating river water volume and discharge caused variation in the size of the meanders and oxbows and their associated lag surfaces and alluvial fans [81]. Second, the changing regimes of the rivers resulted in the formation of terraces and flood plain systems [81]. Because the Körös basin is several meters lower than the surrounding areas, it has been especially prone to inundation, which filled oxbow lakes, backswamps and meanders. Furthermore, macro-regional precipitation entering the catchment area of the Körös and Berettyó rivers determines local groundwater levels [5]. This has important ramifications for settlement systems, as people decide which possibilities they prefer and then alter the patterning of settlement and economy accordingly. However, palaeochannel reconstructions from elsewhere in the Körös area suggest that the Körös channels may not have responded to the relatively small Holocene events in a manner comparable to more dynamic rivers in Poland and elsewhere in Europe, and therefore may not contain an equally remarkable sedimentary record of hydrologic episodes [13]. Rather, changes in groundwater and surface water levels likely had a greater effect. Malacological and archaeological data from the Late Neolithic settlement mound at Szegvár-Tüzköves, southwest of Csárdaszállás, suggest a significant increase in water levels and a correlated increase in the use of shellfish and other riverine resources [82].

5.2. Human effects on palaeovegetation and palaeohydrology

Anthropogenic effects on the local environment are evident in our data, with evidence for human induced changes in vegetation and the trophic status of the local palaeochannel. The impact of the Early Neolithic Körös culture occupation was very small but noticeable, and human influence increased markedly after about 7550 calBP. This generally corresponds with findings from Ecsegfalva [6, 35], from Sarló-hát [9] and Bátorliget [72] to the north, and from Avrig in southern Transylvania [12]. The period from ca. 7000–6000 calBP saw the greatest impact from human production, with evidence for plant cultivation, the expansion of weedy plants, diminishing arboreal vegetation and changes in dominant tree species. *Alnus* and *Salix* pollen decreases sharply, whilst *Fagus*, *Fraxinus* and *Carpinus* increase (Figure 4). Most likely these are elements of the hardwood gallery forest (e.g. beech, ash, hornbeam) that occupied the slightly elevated and better-drained surface of the levee within the lakeside zone. Combined with archaeological data [18, 83], this new environmental data suggests continuous settlement and increasing intensity of land clearance and production along the palaeochannel from the end of the Middle Neolithic. Likewise, the earliest Neolithic farmers in southern Romania [80] and Poland [84] had relatively little effect on the environment prior to ca. 6650 BP. However, human impacts for the Polish case study increased markedly after ca. 6650 BP, showing intensive and sustained use of the landscape by Lengyel populations [84].

These effects may be localized, as was the case at Osłonki [84], which shows maximum human impact during the same period, but only within the immediate environs of the site. Furthermore, these effects were not necessarily permanent: cladoceran (water flea) analysis indicates that lake conditions as Osłonki, which had suffered eutrophication due to increased nutrient loading during the Neolithic occupation, returned to lower nutrient levels after site abandonment.

6. Conclusion

We were able to obtain valuable pollen data from a dry, plowed section of palaeochannel. The pollen composition after the end of the ice age is characterized by the initial development of Boreal steppe taiga, developing into a mosaic forest-steppe, with influences of Continental and sub-Mediterranean climates.

This rich mosaic structure of trees (*Alnus*, *Ulmus*, *Fraxinus*, *Corylus*, *Quercus*, *Tilia*), grasses (*Poaceae*), weeds (e.g. *Artemesia*) and reeds (*Phragmites*) was in place when the first farmers arrived ca. 7800 calBP. The influence of these Early Neolithic farmers is apparent but not extensive, and can be seen primarily in the appearance of plants associated with cultivation. However, no Early Neolithic artifacts have been recovered from the nearest archaeological sites, Csárdaszállás 8 and 26. The nature and extent of Early Neolithic activity is therefore ambiguous. More radiocarbon dates and better archaeological data for the Early Neolithic occupation around the Csárdaszállás oxbow lake are necessary to truly understand human-environmental interactions in the region.

While the chronology is predicted in these preliminary results, our project shows that reliable pollen data can be acquired from even dry, plowed-over former waterways. Anthropogenic affects on the environment began in the Early Neolithic and increased gradually over time. Human impact increased during the Middle and Late Neolithic, seen in both changing fly ash ratios and increasing grass and weed pollen. People were most likely part of, if not the primary cause, for changing trophic status of the local oxbow lake, which by the Bronze Age had become a marshland. However, since Holocene hydrologic events may not have been as extreme in the eastern Carpathian Basin as they were elsewhere in Europe, the focus of archaeological investigations into the relationships between prehistoric settlement and palaeohydrology should now be on how groundwater levels influenced human settlement patterns.

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