Dynamics of the biotopes at the edge of a medieval town: pollen analysis of Vltava river sediments in Prague, Czech Republic

Dynamika biotopů na okraji vznikající středověké Prahy ve světle pylové analýzy ze sedimentů slepého ramene Vltavy

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As part of an archaeological excavation in Valdštejnská street in the Lesser Town of Prague, flood sediments in an old channel of the river Vltava were studied by means of pollen analysis. Analyses were performed on a core taken before the archaeological excavation and samples from the layers uncovered by the excavation. The core includes deposits from the era that followed the construction of weirs in the second half of the 13th century up to approximately the 15th century. Some of the sediments are older and from Early Medieval times (the oldest from the end of the 10th century). For the pollen analysis, three types of sediment were studied: flood loams, cultural layers and material deposited on causeways. Thanks to the diversity in the sediments it was possible to study local and regional components of the pollen spectra in more detail. The vegetation growing in the old river channel consisted of ruderal and weed taxa with sedge stands surviving in less accessible places. This locality most probably did not serve as a dumping ground until at least the 14th century, and even then this is not directly indicated by the pollen analysis. The difficulty of interpreting the mixed-origin pollen spectra usually present in urban archaeobotanical deposits is a common problem. Using multivariate statistics, three groups of pollen taxa characteristic for each particular sediment type were separated, and the individual pollen sources (and corresponding taphonomical processes) partly separated. Therefore, it was possible to distinguish autochthonous and allochthonous sources of pollen and draw conclusions about the local vegetation at this site.

K e y w o r d s : archaeological research, cultural layer, flood sediments, floods, pollen analysis, river channel, species and habitat diversity

Introduction

Prague is a city in which natural and semi-natural habitats are still more or less represented (Sádlo 2001). It is located in a morphologically very diverse relief that has a complicated geological structure (Kovanda et al. 2001). Studying the medieval pollen record provides an opportunity to reveal how different the past environment was from that of today.

As a part of a rescue archaeological study in Valdštejnská street in Prague, Lesser Town (Malá Strana), flood sediments of an old river channel of the Vltava river were studied (Fig. 1). To obtain a continuous pollen record (and to compare this with information derived from archaeological layers), and thus study the environmental changes that occurred from the time before the permanent colonization of the Lesser Town basin, a core was taken in the old river channel. During subsequent archaeological research, strata containing Early Medieval causeways were excavated several meters to the north and lying below

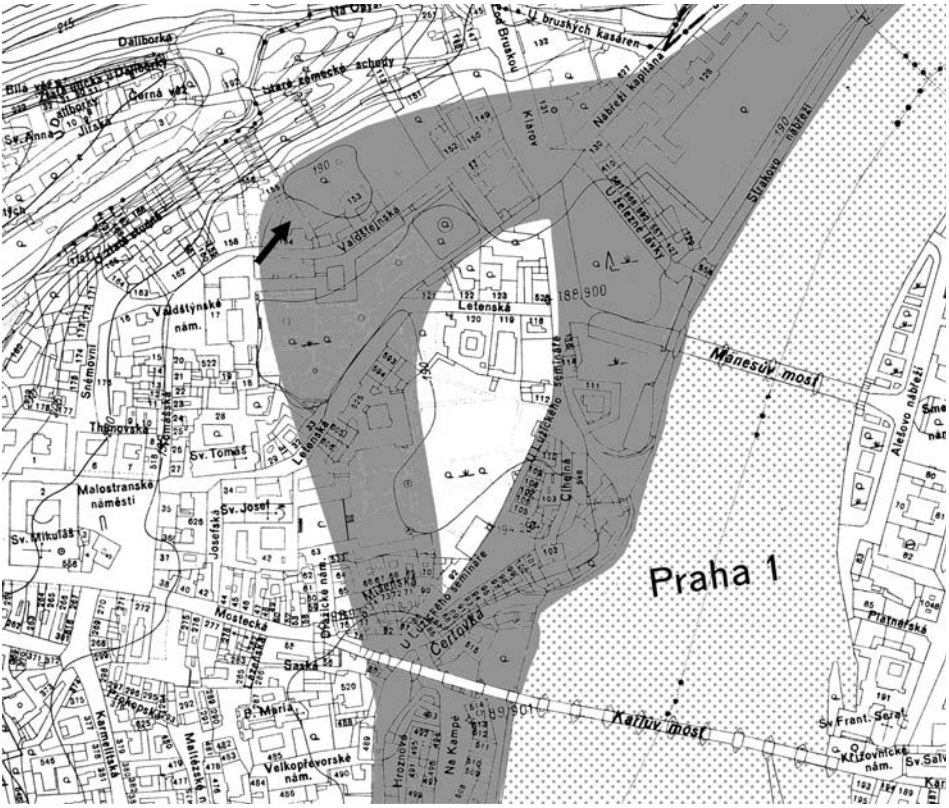

Fig 1. – The Lesser Town, with the location of the old river channel of the Vltava river. The arrow shows the site of the archaeological excavation.

the level of the bottom of the core. However, further coring to reach lower levels of the old river channel was not possible due to the constraints resulting from the building requirements at the study site.

Compared to pollen spectra from the cultural layers, which are typically analyzed for archaeological research in the area of Prague (Jankovská 1987, 1991, Břízová 1998, Pokorný 2000, Beneš et al. 2002), our results from Valdštejnská street are unique. In the old river channel, the pollen spectra come from three types of sediment: the surfaces of Early Medieval causeways (paths made of stones), flood loams and cultural layers deposited mostly on top of the flood loam strata in the profile. These diverse sediments indicate pollen from a high number of sources, which makes it possible to draw more general conclusions about the site and its vicinity.

The locality is within the present Lesser Town in Prague. From prehistory and Early Medieval to High Medieval, the environment in the Lesser Town basin experienced dramatic changes. Although the age of the old river channel is unknown it is certain that in the 10th century the river already flowed in its present-day riverbed (Hrdlička 2001). In the 9th century there was a fortified settlement with the centre at present-day Lesser Town

Square and an old river channel formed its western boundary. At that time, the valley had a very diverse morphology with rocks, ravines and marshes, and was shaped by several streams (Zavřel 2001). The end of the 9th century was a time of great urban changes in the area of Lesser Town that destroyed older layers. It is therefore extremely difficult to make a continuous study of local settlement throughout prehistory (Čiháková 1999). In medieval times (at least from the early 10th century), Prague quickly grew into an important business centre, which is evident from both written as well as archaeological sources (Čiháková & Zavřel 1997). The town was made up of an aggregation of settlements (more or less independent) whose distribution respected local environmental conditions. The conversion of Prague into a modern gothic town occurred in the middle of the 13th century and resulted in a radical change. In 1257, New Town (later renamed Lesser Town) was founded with streets at right angles to one another within new-built stone walls. Even at that time there was no important settlement in the area of the old river channel except on the so called "Island below the Prague Bridge" ("Ostrov pod mostem Pražským"). Here, the terrain was permanently above the level of floods since the settlement was on the prolluvial cone of Brusnice brook (Hrdlička 1984). The previous inhabitants were evicted and replaced by German merchants and craftsmen. This coincided with the beginning of a town dependent on business not agriculture (Mencl 1969). Based on written sources, the first weirs were constructed on the Vltava river in the second half of the 13th century. This resulted in severe floods and the accumulation of a huge amount of flood loams in the frequently flooded areas above the weirs. The old river channel studied is above one of the weirs and thus the level of the bed of the channel came up to that of the surrounding ground within several centuries. Flooding destroyed the settlement on the "Island below the Prague Bridge" in the area of present-day Klárov (Hrdlička 1972). Thus the floodplain (including the locality studied) was abandoned in the High Medieval period. Not until the 15th and mainly 16th centuries did people finish levelling the ground and start building along and around the old river channel (Hrdlička 1984).

Material and methods

Sedimentary context under study

Pollen analysis was carried out on a core (starting at 186 m above sea level) obtained before the start of the rescue archaeological excavations and from archaeological layers uncovered later. The core was 371 cm long and was dated archaeologically based on specific succession of sediments (thus the dating is not exact). The bottom of the core dates approximately to the second half of the 13th century, right after the construction of the weirs (Hrdlička 2001). The top layer dates approximately to the 15th century (J. Čiháková, pers. comm.). The second set of data comes from archaeological layers. These excavations were made several meters north of the core site. For our study four of the profiles (91, 93, 100, 104) were chosen and one to nine samples of organic sediment taken from each of the profiles (Table 1). Some of the archaeological layers analyzed are older than the base of the core. The oldest archaeological layer (1174, 180.2 m a.s.l.) was dated to the end of the 10th century (Table 1). These Early Medieval (up to the half of the 13th century) sediments represent causeways that crossed the old river channel (J. Čiháková, pers. comm.). About 11 such causeways lay on top of each other separated by flood loams, since the causeways were renewed after each flood.

Table 1. – List of the archaeological layers for which pollen samples were analyzed. Numbers of the layers and profiles were supplied by archaeologists (J. Čiháková, pers. comm.). The numbering of the profiles illustrates that the set of samples was not obtained from a single continuous profile.

Number of layer	Archaeological dating	Number of profile	Type of sediment
884	14th century	100	cultural layer
885	14th century	100	cultural layer
886	14th century	100	cultural layer
887	14th century	100	flood loam
921	14th century, possibly older	100	flood loam
855	14th century, possibly older	93	cultural layer
1134	14th century, younger	100	flood loam
877	13th century	93	cultural layer
1156	end of 13th – beginning of 14th century	91	flood loam
1183	end of 13th – beginning of 14th century	104	flood loam
952	end of 13th century	100	flood loam
1007	end of 13th century, corresponds to layer 952	91	flood loam
1195	2nd half of 13th century	100	flood loam
1122	1st half of 13th century	93	causeway
1025	2nd half of 12th – 1st half of 13th century	93	causeway
1113	12th century	93	flood loam
1044	12th century	93	causeway
1086	beginning of 11th – 12th century	93	causeway
1097	10th –1st half of 11th century	93	causeway
1174	end of 10th century	93	causeway

As mentioned above, pollen analysis was performed on three types of sediment: flood loams, cultural layers and material deposited on the causeways. The distribution of sediment types in the profile is not regular (Fig. 2, Table 1). The deposits mainly associated with the paths were found at the bottom, flood loams in the middle and cultural layers in the upper part of the profile. As it is likely that different taphonomical processes occurred in each sediment type, it is not easy to interpret the differences among pollen spectra with depth and determine the development of vegetation through time.

The very fine light-greyish loams had layers of fine sand of various thicknesses. Cultural sediments were very rich in organic matter, and in some parts stones were present. Material deposited on the causeways was dark organic matter mixed with the flood loams forming the base of all causeways.

Pollen analysis

Sediment was digested in 10% KOH, carbonates were removed by treatment with concentrated HCl, silicates diluted in concentrated HF and most of the organic material removed during acetolysis (using acetic acid anhydride and sulphuric acid in a 1:9 ratio according to Faegri–Iversen 1989)

There were relatively few pollen grains in the flood loams and even fewer in the causeway sediment, proving that they were short-lived. At least 300 grains were found in layers extremely poor in pollen; in other layers 500 was the minimum count.

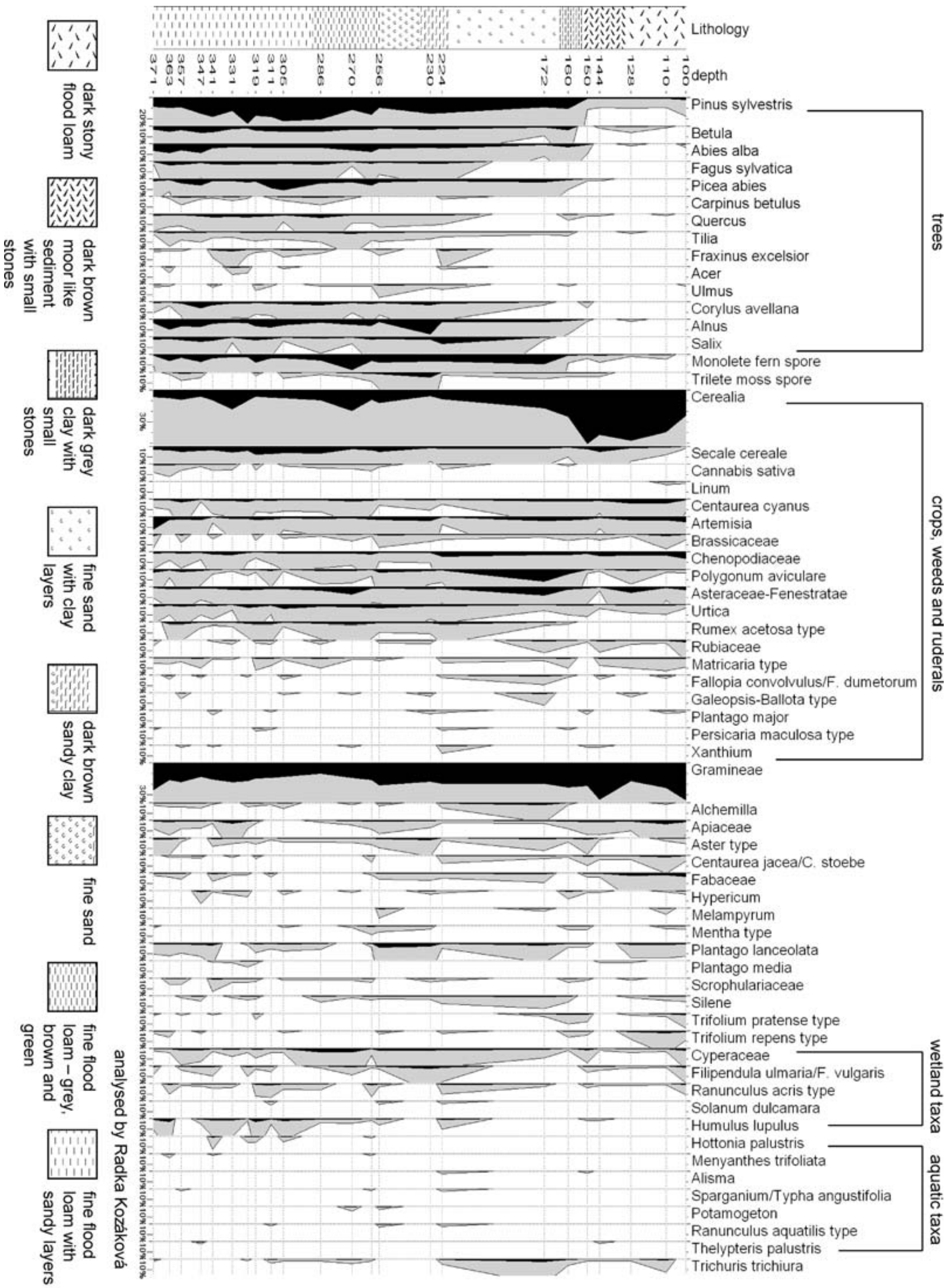

Fig 2. – Diagram of the percentages of selected pollen types. The top 100 cm are expected to be identical with the 100–152 cm layer.

Table 2. – List of pollen types with definitions based on species.

Pollen type	Species definition
Anemone type	genus *Anemone*, *Hepatica nobilis* and possibly some species of the pollen type *Ranunculus aquatilis*
Apiaceae	unspecified species of the family *Apiaceae*
Aster type	e.g. genera *Aster*, *Bellis*, *Bidens*, *Inula*, *Petasites*, *Senecio*, *Tussilago*
Asteraceae-Fenestratae	e.g. genera *Cichorium*, *Lactuca*, *Mycelis*, *Sonchus*, *Crepis*, *Hieracium*, *Hypochaeris*, *Lapsana*, *Leontodon*, *Picris*, *Taraxacum*, *Tragopogon*
Astragalus type	genera *Astragalus*, *Oxytropis*, *Melilotus* and *Ononis*
Bupleurum falcatum type	Bupleurum falcatum, *B. longifolium* and *B. rotundifolium*
Cerealia	*Triticum*, *Avena sativa*, *Panicum miliaceum*, *Hordeum* – size of *Hordeum* pollen can overlap with pollen of some wild grasses, e.g. *Glyceria*
Chenopodiaceae	genera *Chenopodium*, *Atriplex*, *Beta*, *Kochia*
Dryopteris filix-mas type	*Dryopteris filix-mas*, *D. carthusiana* and *D. dilatata*
Fabaceae	unspecified species of the family *Fabaceae*
Falcaria type	*Anethum graveolens*, *Torilis japonica* and *Falcaria vulgaris*
Galeopsis-Ballota type	genera *Ajuga*, *Ballota*, *Betonica*, *Galeopsis*, *Lamium*, *Leonurus*, *Scutellaria*, *Stachys*
Gnaphalium type	genera *Gnaphalium*, *Filago*, *Erigeron* and *Antennaria*
Gramineae	species of the family *Poaceae*, expecially wild grasses
Lysimachia vulgaris type	*Lysimachia vulgaris*, *L. nummularia* and *L. punctata*
Malva type	genera *Malva*, *Althaea* and *Lavatera*
Matricaria type	genera *Achillea*, *Anthemis*, *Leucanthemum*, *Matricaria*, *Tanacetum*, *Pyrethrum*, *Tripleurospermum*
Mentha type	genera *Acinos*, *Clinopodium*, *Lycopus*, *Mentha*, *Origanum*, *Thymus*
Odontites type	*Odontites* and possibly some species of the pollen types *Rhinanthus* and *Veronica*
Papaver rhoeas type	*Papaver dubium*, *P. rhoeas*, *P. somniferum*
Persicaria maculosa type	*Persicaria maculosa*, *P. lapathifolia*, *P. minor*, *P. hydropiper*
Prunus type	some trees and shrubs from *Rosaceae* family – *Prunus spinosa*, *Crataegus, Sorbus, Cotoneaster,* wild and cultivated fruit trees – *Malus*, *Pyrus* and *Cerasus*
Ranunculus acris type	e.g. *Ranunculus acris*, *R. bulbosus*, *R. illyricus*, *R. lanuginosus* and *R. repens*
Ranunculus aquatilis type	e.g. *R. sceleratus* and genus *Batrachium*
Rhinanthus type	genera *Rhinanthus*, *Euphrasia* and possibly some species of the pollen types *Veronica* and *Odontites*
Rumex acetosa type	e.g. *Rumex acetosa, R. acetosella, R. obtusifolius, R. conglomeratus* and *R. crispus*
Rumex aquaticus type	e.g. *Rumex aquaticus*, *R. hydrolapathum* and *R. longifolius*
Saxifraga hirculus type	*Saxifraga granulata*
Scabiosa columbaria type	*Scabiosa canescens*, *S. ochroleuca* and *S. columbaria*
Scrophulariaceae	genera *Scrophularia* and *Verbascum*
Spergularia type	genera *Spergula* and *Spergularia* excluding *Spergula arvensis*
Trifolium pratense type	e.g. *Trifolium pratense* and *T. medium*
Trifolium repens type	e.g. *Trifolium repens*, *T. arvense*, *T. aureum*, *T. campestre* and *T. dubium*
Veronica type	*Lamium album*, all the species of the genus *Veronica* and possibly some species of the pollen types *Rhinanthus* and *Odontites*
Vicia type	genera *Vicia*, *Lathyrus* and *Lens*
Non pollen objects:	
Thecaphora	fungal parasite expecially of the *Fabaceae* family
Trichuris trichiura	intestine parasite having two hosts – men and pig

The usual outcome of the pollen analysis is the classification of plant species into pollen types, which often include many species and even whole plant families in some cases. Pollen types were identified and modified according to Moore et al. (1991), Reille (1992), Beug (2004) and Punt (1980). Pollen nomenclature respects the following conventions: (1) The name of a pollen type is identical to a taxon name (of any rank) if the pollen type represents this taxon and no other. Examples: *Viburnum opulus*, *Salix*, *Cyperaceae*. (2) The name of a pollen type has the suffix "type" if it represents a taxon or taxa outside the taxon mentioned in the pollen type. Examples: *Trifolium repens* type, *Aster* type (Table 2). (3) The name of a pollen type representing two taxa only consists of both taxon names separated by a slash. Examples: *Sambucus nigra/S. racemosa*. (4) All these pollen-morphological considerations are restricted to taxa occurring in the Czech Republic at the altitude of the locality studied (Prague basin in the Czech Thermophyticum, up to approximately 300 m a.s.l.).
The nomenclature of plant taxa follows Kubát et al. (2002). The interpretation of pollen spectra given in the following chapter is consistent for the reasons mentioned above.

Numerical analyses

In order to detect the structure of the data and identify the role of particular parameters such as the type of sediment and species diversity, multivariate statistical methods (CANOCO; Lepš & Šmilauer, 2003) were used. Species diversity is expressed in terms of palynological diversity. Rarefaction analysis using the Polpal program was therefore performed on all the samples. Rarefaction recalculates the results correcting for unequal numbers of grains counted, so the abundances of taxa are comparable.

Principal component analysis (PCA) was used to detect the structure of the data, while redundancy analysis (RDA) tested the effect of particular environmental parameters. It was not possible to use age as one of the parameters to explain sediment and vegetation succession since sediment succession was used to estimate the age of layers. Data were square-root transformed and standardized over species and samples in order to strengthen the role of rare species and correct for the different numbers of pollen grains.

Results and discussion

Interpretation of pollen spectra

The main results of the pollen analysis are ratios of pollen grains of particular taxa in each layer. To interpret such results and draw conclusions about abundances of taxa the production and dispersal of pollen needs to be taken into account. The major difference is between anemophilous and entomophilous plants. Most herbs are entomophilous, which means their pollen is quite scarse in pollen spectra in general. Cereals, excluding *Secale cereale*, are very effective self-pollinating plants, so higher pollen sums for *Cerealia* indicate association with processing of a harvest. Wild grasses (*Gramineae*), *Chenopodiaceae*, *Cyperaceae*, *Artemisia*, *Rumex*, *Urtica*, *Plantago lanceolata* or *Secale cereale* are anemogamous taxa and the pollen of these species occur in higher ratios in pollen spectra compared to other herbs. Among entomophilous herbs, *Filipendula ulmaria/F. vulgaris* is a big pollen producer and its pollen often occurs in relatively high ratios in pollen spectra. As almost all the sites studied are wet biotopes, this pollen is considered to belong mostly to *Filipendula ulmaria*.

Trees generally produce much more pollen then herbs and their height provides a further advantage for long distance pollen transport. Of Central European trees, only *Tilia* and *Salix* are entomophilous. Their pollen is thus considered to reflect the local presence of both taxa, even though it is transported by wind and insects. *Pinus*, *Betula* and *Alnus* produce an abundance of pollen, which is easily transported very far from the source. *Picea*, *Abies* and *Fagus* are similar both in pollen production and transport, and *Abies* and *Fagus*, in particular, can be underrepresented in pollen diagrams. The representation of *Quercus* and *Fraxinus* is assumed to be similar in vegetation and pollen spectra. Amounts of *Carpinus* pollen fluctuate, but this species in general tends to be underrepresented in pollen diagrams. *Acer* produces very little pollen, and it is very scarce even in samples from sites where maples were common (for review see Ralska-Jasiewiczowa ed. 2004).

The above rules hold for natural sediments. Our results, however, are for deposits of mixed origin (Latałowa et al. 2003) resulting from different kinds of human activity, and from both local and distant flora (especially in the case of flood loams). Thus, the pollen spectra that are presented here represent thanatocoenoses, i.e. assemblages of pollen grains of both autochthonous and allochthonous origin. Taphonomical processes are all processes that led to the deposition of the pollen grains (Lityńska-Zając & Wasylikowa 2005).

In the case of Valdštejnská street, pollen grains were not highly corroded and thus complete pollen spectra were preserved, and several ecological groups can be distinguished. These are forest species, crops, cereal weeds and ruderals, and taxa of wetlands, xerophilous grasslands, meadows and pastures (Fig. 3).

Arboreal pollen, which is likely to have been transported over long distance (Sugita 1999), especially reflects the landscape in the vicinity of medieval Prague. In our data, forests are represented by many species belonging to ecologically more or less contrasting plant communities. Alluvial forests are represented by *Alnus* and *Salix*, scree woods by *Acer*, *Tilia* and *Fraxinus*, shady forests by *Fagus*, *Picea* and *Abies*, oak-hornbeam forests, and xerothermic oak forests by *Pinus* primarily growing on extremely rocky sites (Ellenberg 1988). The relative proportions of particular tree taxa indicate the degree of deforestation. Oak (*Quercus*) and hornbeam (*Carpinus*) are two important climax species in the area of Prague (Moravec & Neuhäusl 1991). Their relatively low ratios in the pollen spectra (below 5%; Fig. 2) reflect a high degree of deforestation. Moreover, very low pollen sums for *Carpinus* could be due to the fact that this species grew on gentle slopes that were deforested first. Low numbers of *Fagus* pollen and the relatively high proportion of *Abies* means that forest management must have been intensive (for more about spreading of *Fagus* see Kűster 1997 and Gardner-Willis 1999) but allowed the spread of *Abies*, which regenerates better in small openings rather than large clearings. The pollen data thus supports the suggestion that *Abies* used to flourish even in the lowlands strongly influenced by human impact, e.g. forest grazing (for more about *Abies* supported by human impact see Málek 1980, Pokorný 2002, Pokorný 2003, Sádlo & Pokorný 2003, Volařík 2006). Sites where *Abies*, *Fagus* and *Picea* may have grown together were northern and north-western slopes or gullies with an inverse microclimate (Neuhäuslová 1998). The closest such gully to the study site is Jelení příkop below the northern slope of Prague castle hill. Relatively high ratios of monolete fern spores (Fig. 2) could be connected with these shady forests, where ferns could have formed the undergrowth. Ferns also indicate the quite natural character of these communities. The spores in the samples mostly lacked their perine, which has a species- or at least genera-specific structure. Among the very rare

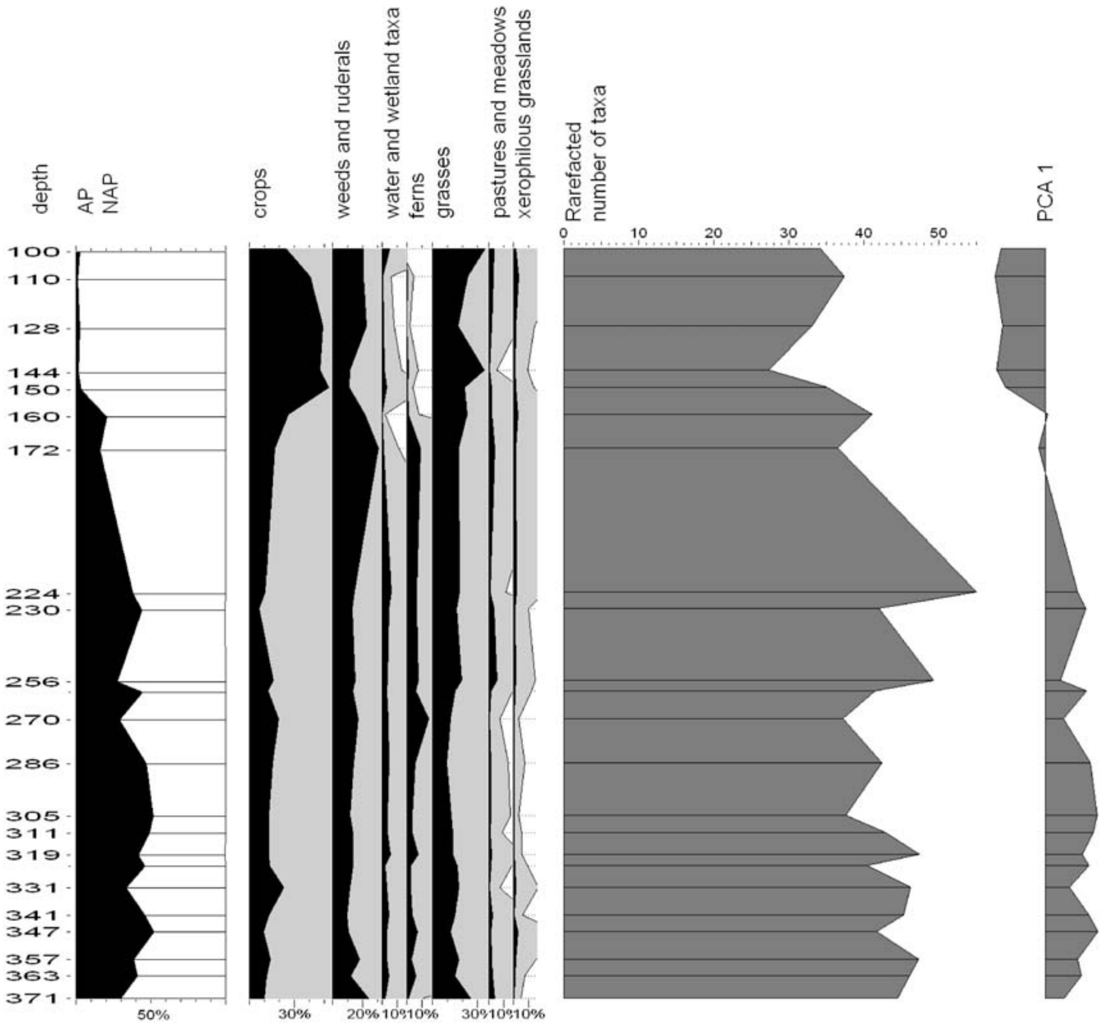

Fig 3. – Summary diagram with defined groups of species and the results of analyses. AP arboreal pollen, NAP – non-arboreal pollen, Rarefacted number of taxa – curve expressing pollen diversity, PCA1 – principal correspondence analysis curve expressing distribution of samples on the first axis. Pollen types included into the defined groups: Crops: *Cannabis sativa, Cerealia, Secale cereale*; Weeds and ruderals: *Adonis aestivalis/A. flammea*, *Agrostemma githago*, *Anchusa/Pulmonaria*, *Aphanes*, *Asteraceae-Fenestratae*, *Brassicaceae*, *Centaurea cyanus*, *Chenopodiaceae*, *Consolida regalis*, *Convolvulus arvensis*, *Fallopia convolvulus/F.dumetorum*, *Galeopsis-Ballota* type, *Matricaria* type, *Papaver rhoeas* type, *Persicaria maculosa* type, *Plantago major*, *Polygonum aviculare*, *Rubiaceae*, *Rumex acetosa* type, *Rumex aquaticus* type, *Sagina*, *Scandix pecten-veneris/Caucalis platycarpos*, *Solanum nigrum*, *Trifolium repens* type, *Turgenia latifolia*, *Urtica*, *Xanthium*; Water and wetland taxa: *Alisma*, *Butomus umbellatus*, *Caltha*, *Cyperaceae*, *Filipendula ulmaria/F. vulgaris*, *Hottonia palustris*, *Humulus lupulus*, *Lythrum*, *Menyanthes trifoliata*, *Ranunculus acris* type, *Ranunculus aquatilis* type, *Solanum dulcamara*, *Sparganium/Typha angustifolia*, *Thelypteris palustris*, *Valeriana officinalis*; Ferns: monolete fern spores together with *Athyrium filix-femina*, *Dryopteris filix-mas*, *Pteridium* and *Polypodium vulgare*; Grasses: pollen type *Gramineae*; Pastures and meadows: *Aconitum*, *Alchemilla*, *Astragalus* type, *Bistorta major*, *Campanula/Phyteuma*, *Cerastium*, *Gentianella*, *Knautia*, *Menta* type, *Odontites* type, *Pimpinella major/P. saxifraga*, *Plantago lanceolata*, *Plantago media*, *Potentilla/Fragaria* , *Rhinanthus* type, *Saxifraga hirculus* type, *Succisa pratensis*, *Trifolium pratense* type; Xerophilous grasslands: *Bupleurum falcatum* type, *Centaurea jacea/C. stoebe*, *Centaurea scabiosa*, *Falcaria* type, *Glaucium corniculatum*, *Helianthemum*, *Hypericum*, *Jasione montana*, *Lotus*, *Melampyrum*, *Orlaya grandiflora*, *Pulsatilla*, *Scabiosa columbaria* type, *Securigera varia*, *Silene*.

complete spores were those of *Athyrium filix-femina*, *Dryopteris* and one of *Polypodium vulgare*.

We conclude that all the tree species that formed the natural (or nearly natural) forest vegetation in the Prague basin survived until High Medieval times. The species composition was nevertheless influenced by intensive forest management, the degree of which is reflected in the still relatively common *Abies*. The only dominant taxa of highly degraded forests are *Pinus* and *Betula* (e.g. Sádlo et al. 2005), which is not the case at this site. The species spectrum of trees with relatively balanced ratios in most of the samples indicates the fine vegetation mosaic in the medieval landscape. The degradation of biotopes resulted in nearly natural plant communities existing alongside highly degraded ones in a relatively small area. Shaded forests with *Abies*, *Fagus* and *Picea* or scree woods with *Tilia* and *Acer* occurred close to oligotrophized forests with a dominance of *Pinus*, *Betula* and *Quercus*.

Large numbers of *Artemisia*, *Apiaceae*, *Brassicaceae*, *Chenopodiaceae* and *Fabaceae* pollen are common in sediments from medieval towns. These taxa were abundant and typical of medieval streets (mainly *Artemisia* and *Chenopodiaceae*) or of weeds transported into sediments together with *Cerealia* pollen (Greig 1982, Jankovská 1991, 1997). Their role in the local vegetation of the old river channel is discussed later. The main pollen grains in well-trodden places, such as roads and paths, are those of *Polygonum aviculare*. They occurred over the whole time span at this locality, and not just in the samples from causeways (compare Fig. 2 with Append. 2). Among the species of weeds during medieval times, *Centaurea cyanus* is one of particular interest (Greig 1991). Like *Secale cereale,* there are comparable ratios of *Centaurea cyanus* pollen in all the samples regardless of their age. This probably means that deep and intensive tillage occurred commonly around Prague at least from the end of the 10th century up to the High Medieval period (Greig 1982). Like *Centaurea cyanus*, other weeds identified in the sediments of the old river channel are annuals, such as *Adonis aestivalis*, *Agrostemma githago*, *Aphanes arvensis* and *Scleranthus annuus*, also adapted to intensive agricultural management.

The pollen of cereals (*Cerealia*) dominates the crop group. *Secale cereale* is thought to have been more widely grown during the High Medieval period (Behre 1992, Jankovská 1997). This is not obvious from the Valdštejnská street results, where *Secale cereale* pollen is relatively equally represented in all the samples including the Early Medieval period (compare Fig. 2 with Append. 2). Pollen analysis further indicates the growing of *Cannabis sativa* and *Linum*. The growing of other crops is impossible to detect by means of pollen analysis, as they belong to pollen types that contain more taxa or whole families (Table 2). Crops are better reflected by macroremain analyses, which has already resulted in a list of cultivated or imported taxa for the area of medieval Prague (Opravil 1986, 1994, Čulíková 1998a, 1998b, 2001).

The ratio of pollen grains coming from wetland and aquatic plant taxa is relatively low in general (Figs 2 and 3), indicating that these vegetation types were not dominant at the old river channel site. Flood sediments contained a few pollen grains of *Menyanthes trifoliata* or spores of *Thelypteris palustris* and *Hottonia palustris*, which prefer shaded pools. More eutrophic conditions are indicated by *Potamogeton* and *Alisma* as well as wetland taxa such as *Filipendula ulmaria/F. vulgaris*, *Cyperaceae*, *Lythrum*, *Solanum dulcamara*, *Caltha*, *Valeriana officinalis* and *Sparganium* type.

In the overall pollen spectrum, there are a relatively high numbers of taxa of xerophilous grassland (Fig. 2, Append. 1, 2). There were quite numerous findings of

Pulsatilla, *Centaurea jacea*/*C. stoebe*, *Hypericum*, *Helianthemum* and *Silene* pollen. In a few isolated cases, there are pollen grains of *Centaurea scabiosa*, *Securigera varia*, *Lotus*, *Sanguisorba minor*, *Scabiosa columbaria* type, *Echium vulgare*, *Sedum*, *Dianthus* and *Scleranthus perennis*. It is likely that these taxa formed a xerophilous community on the southern slope below the Prague Castle (Kozáková & Boháčová 2007 for details of this locality). Some of the taxa, such as *Centaurea jacea/C. scabiosa* or *Echium vulgare,* can survive even in ruderalized biotopes within built-up areas (Kubát et al. 2002).

Meadows and pastures are difficult to define on the basis of pollen indicators, as particular pollen types very often include species with different ecological characteristics (for examples see Table 2). Nevertheless, some of the pollen types are typical of mesophilous meadows: *Plantago lanceolata* and *Plantago media*, *Campanula/Phyteuma*, *Cerastium*, *Knautia* and *Saxifraga hirculus* type. The pollen types *Gentianella* and *Aconitum*, together with *Plantago lanceolata*, *P. media* and *Calluna vulgaris* indicate pastures (Greig 1982, Jankovská 1987, Pokorný 2000, Kubát et al. 2002).

Among the non-pollen material are empty egg shells of the intestinal parasite *Trichuris trichiura*. Their presence in the sediment reflects some faecal pollution. This endoparasite has two hosts – man and pig – and its occurrence during medieval times was probably very common (Greig 1982, Jankovská 1987). The relatively low number of egg shells found in the sediments in the old river channel does not indicate that the locality was used as a dump for faecal and other rubbish (when compared with the pollen and macroremains in a High Medieval moat filled with rubbish – Beneš et al. 2002).

It is interesting that almost the whole flora found in medieval pollen spectra can still be observed in the close vicinity of Prague, i.e. within approximately a 20 km circle around the city. Among the non-arboreal vegetation, several taxa that were probably common in the past are currently rare. *Glaucium corniculatum*, considered to be from the Mediterranean, is restricted to the warmest parts of the Czech Republic (Dostál 1950). There was only one pollen grain of this species in our samples (Append. 1), but its seeds are found, for instance, in sediments from medieval Cracow (A. Bieniek, pers. comm.). It seems that this species used to be a common weed even at higher latitudes. Several thermophilic species identified from flood loams are now considered to be very rare taxa. One such representative from steppe communities is *Orlaya grandiflora*, which is now restricted to the Pálava region in S Moravia (Kubát et al. 2002). Of the weeds, *Turgenia latifolia* is considered now to be extinct in central Bohemia, and *Scandix pecten-veneris*/*Caucalis platycarpos* are both rare. All these rare weed taxa – *Glaucium corniculatum*, *Orlaya grandiflora*, *Scandix pecten-veneris*/*Caucalis platycarpos* and *Turgenia latifolia* might indicate vineyards (Ellenberg 1988). Thus their disappearance at this site could be due to the absence of particular management to which these species are adapted. The alluvial environment around the Vltava river must have been very different from that of today. The presence of species preferring undisturbed shallow pools and wetlands, such as *Menyanthes trifoliata*, *Hottonia palustris* and *Thelypteris palustris*, show that such biotopes existed close to the rising medieval town.

Sediment types

Separating the pollen types characteristic of particular sediment types using multivariate statistical analyses (Figs 4 and 5) helped in the identification of the taphonomical processes that were important at this site and the interpretation of the local vegetation of the old river channel. Sediment type is a dominant factor structuring the data (Fig. 5). Sediment types were: flood loams, cultural layers, and causeways deposits.

Most of the samples from Valdštejnská street come from flood loams (Fig. 2, Table 1). All these samples are for the High Medieval period with only one exception, which is layer number 1113 (Table 1). Pollen spectra originating from flood loams are rich in pollen of almost all the trees (see Fig. 2, where AP pollen reaches even 50%), ferns, aquatic and wetland taxa, some weeds and ruderals (Fig. 4). It is assumed that the pollen of non-alluvial trees originated from remote areas. This is also likely for monolete fern spores and trilete moss spores. Their connection with the alluvial environment is well illustrated by their abundance, which abruptly declines to zero (trees excluding *Pinus* and *Betula*) when the sediment changes to a brown peat-like cultural sediment that must have been deposited locally (Fig. 2). It is likely that most of the *Alnus* and *Salix* grew outside the town, since a bush of *Alnus* or *Salix* close to the sample site would result in much more pollen (Fig. 2). Thus, the most of arboreal pollen together with moss and fern spores were probably transported to the site by the river. When interpreting local vegetation one must keep in mind that only a small part of the old river channel was sampled (Fig. 1). Some wetland plants that produce little pollen and grew at a distance from the sample site could be underrepresented or even absent in the pollen records. As mentioned above, aquatic and wetland vegetation was rather scarce, restricted to pools and their surroundings, but included demanding taxa such as *Hottonia palustris* and *Menyanthes trifoliata* (Fig. 6). The frequent flooding of the site resulted in some parts of the surface of newly formed flood loams probably remaining barren, covered only by tiny *Anthoceros punctatus*. The first successional stage on newly deposited sandy loams is usually dominated by annuals, often weeds of arable land (Ellenberg 1988). In our results they are represented by *Matricaria* type, *Papaver rhoeas* type, *Persicaria maculosa* type and *Chenopodiaceae*. Nitrophilous perennials such as *Urtica*, *Rumex acetosa* type or some species of *Asteraceae-Fenestratae* pollen type (Table 2) could form a rich river bank vegetation, colonizing the bare spaces later than the annuals (Ellenberg 1988).

Cultural layers were deposited mostly on the top of flood loams and represent thus the youngest deposits. Cultural layers are characterized by a low species diversity (Fig. 5). The typical pollen spectra of cultural deposits are dominated by *Cerealia* pollen together with weeds such as *Centaurea cyanus*, *Consolida regalis*, *Scleranthus annuus* and *Spergularia*. Other typical taxa such as *Vicia* type, *Rubiaceae*, *Convolvulus arvensis*, *Adonis aestivalis/A. flammea*, *Anchusa/Pulmonaria* or *Trifolium pratense* type may not be typical weeds, although all of them include some weed species (Table 2). The close relationship between *Gramineae* and *Cerealia* (Figs 5 and 6) is very important for the interpretation of the local vegetation at the study site. The strong correlation suggests that the majority of *Gramineae* pollen belongs to weed or ruderal species. Thus reeds (*Phragmites australis* is included in the *Gramineae* pollen type) were not an important component of the vegetation of the old river channel. Pollen grains dominating in the cultural deposits belong to an allochthonous human component (Greig 1982), which originated mostly from corn fields. The majority of the *Cerealia* pollen present in flood loams (see Fig. 2) must have been washed down from the streets where grain was threshed and manipulated in general (including consumption, since whole pollen grains can pass through the digestive tract; Jankovská & Kratochvílová 1988). The same is true for the pollen of *Polygonum*

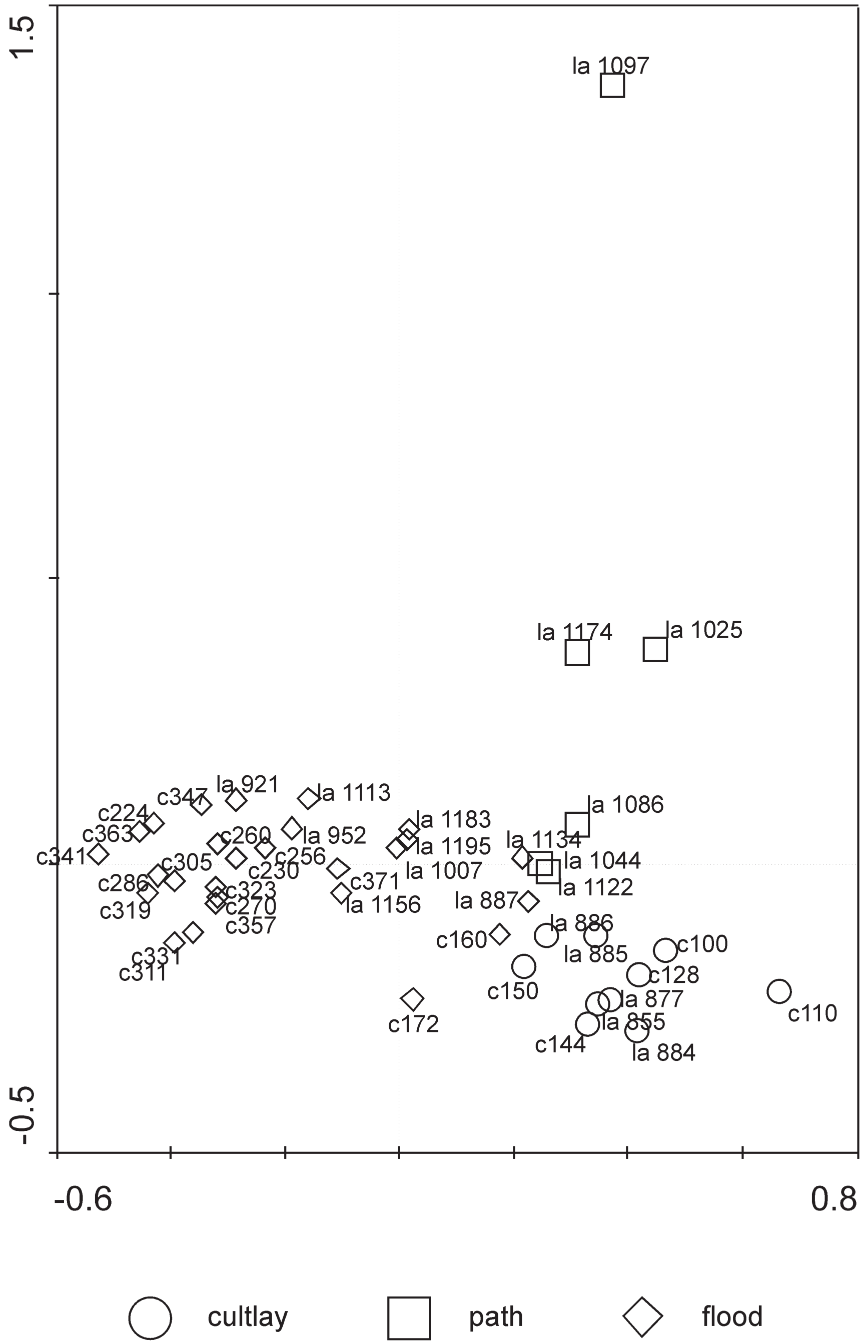

Fig 4. – PCA analysis showing the distribution of samples from c – core and la – archaeological layers. Unlike the samples from causeways, samples from flood loams and cultural layers form distinct groups.

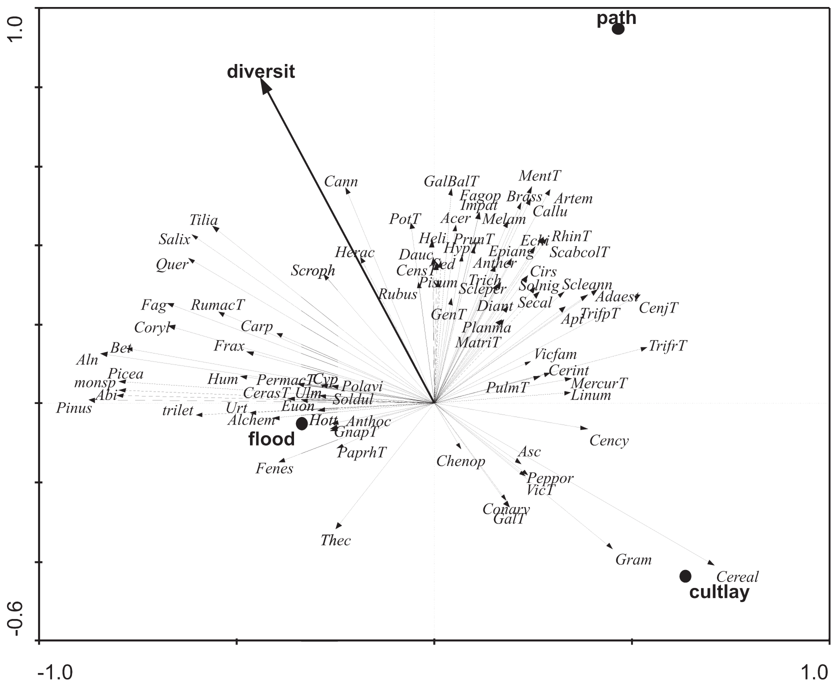

Fig 5. – RDA analysis testing the role of environmental parameters, diversity and type of sediment. Explained variability: (a) canonical axis: 8.3%, 4.9%, 2.6%; (b) noncanonical axis: 5.3%. Only species having a ratio over 5% are shown. A correlation of three groups of taxa defined in Fig. 6 with the three sediment types is evident: flood loams – group A, cultural layers – group B, causeways (paths) – group C. That high diversity of group C is correlated with paths indicate how diverse the medieval town was; of course pollen of many taxa does not belong to vegetation growing directly along a causeway. Paths are also exclusively Early Medieval, which poses a question, to what degree is this diversity associated with High Medieval town.

Abi – *Abies alba*, Acer – *Acer*, Adaest – *Adonis aestivalis/A. flammea*, Alchem – *Alchemilla*, Aln – *Alnus*, Anther – *Anthericum*, Anthoc – *Anthoceros punctatus*, Api – *Apiaceae*, Artem – *Artemisia*, AstT – *Aster* type, Bet – *Betula*, Brass – *Brassicaceae*, Bupl – *Bupleurum falcatum* type, Callu – *Calluna vulgaris*, Camp – *Campanula/Phyteuma*, Cann – *Cannabis*, Card – *Carduus*, Carp – *Carpinus*, Cency – *Centaurea cyanus*, Cenj – *Centaurea jacea/C. stoebe*, Cens – *Centaurea scabiosa*, Ceras – *Cerastium*, Cereal – *Cerealia*, Cerint – *Cerinthe minor*, Chenop – *Chenopodiaceae*, Cirs – *Cirsium*, Cons – *Consolida regalis*, Conarv – *Convolvulus arvensis*, Coryl – *Corylus avellana*, Cyp – *Cyperaceae*, Dauc – *Daucus carota*, Dian – *Dianthus*, DryoT – *Dryopteris filix-mas*, Echi – *Echium vulgare*, Epiang – *Epilobium angustifolium*, Euon – *Euonymus europaea*, Fag – *Fagus sylvatica*, Fallop – *Fallopia convolvulus/F. dumetorum*, Fenes – *Asteraceae-Fenestratae*, Fern – monolete fern spore, Filip – *Filipendula ulmaria/F. vulgaris*, Franal – *Frangula alnus*, Frax – *Fraxinus excelsior*, GalBal – *Galeopsis-Ballota* type, GenT – *Gentiana /Centaurium*, GnapT – *Gnaphalium* type, Gram – *Gramineae*, Hede – *Hedera helix*, Heli – *Helianthemum*, Herac – *Heracleum sphondylium*, Hott – *Hottonia palustris*, Hum – *Humulus lupulus*, Hyp – *Hypericum*, Impat – *Impatiens noli-tangere*, MatriT – *Matricaria* type, Linum – *Linum usitatissimum*, Melam – *Melampyrum*, MentT – *Mentha* type, Menya – *Menyanthes trifoliata*, Mercur – *Mercurialis*, Moss – trilete moss spore, Odont – *Odontites* type, PaprhT – *Papaver rhoeas* type, Peppor – *Peplis portula*, Picea – *Picea abies*, PersmT – *Persicaria maculosa* type, Pinus – *Pinus sylvestris*, Planlan – *Plantago lanceolata*, Planma – *Plantago major*, Polavi – *Polygonum aviculare*, Pot – *Potentilla/Fragaria*, PrunT – *Prunus* type, Anch – *Anchusa/Pulmonaria*, Quer – *Quercus*, Ranac – *Ranunculus acris* type, Ribes – *Ribes uva-crispa*, RhinT – *Rhinanthus* type, Rubi – *Rubiaceae*, Rubus – *Rubus*, Rumac – *Rumex acetosa* type, Salix – *Salix*, Scabcol – *Scabiosa columbaria* type, Scleran – *Scleranthus annuus*, Scleper – *Scleranthus perennis*, Scroph – *Scrophulariaceae*, Secale – *Secale cereale*, Sed – *Sedum*, Spergia – *Spergularia*, Sold – *Solanum dulcamara*, Soln – *Solanum nigrum*, Symph – *Symphytum*, Thali – *Thalictrum*, Thec – *Thecaphora*, Tilia – *Tilia*, Trich – *Trichuris trichiura*, Trifp – *Trifolium pratense* type, Trifr – *Trifolium repens* type, Ulm – *Ulmus*, Urt – *Urtica*, Valoff – *Valeriana officinalis*, VicT – *Vicia* type, Vicfam – *Viciaceae*, diversit – diversity, cultlay – cultural layer, path – path/causeway, flood – flood loam.

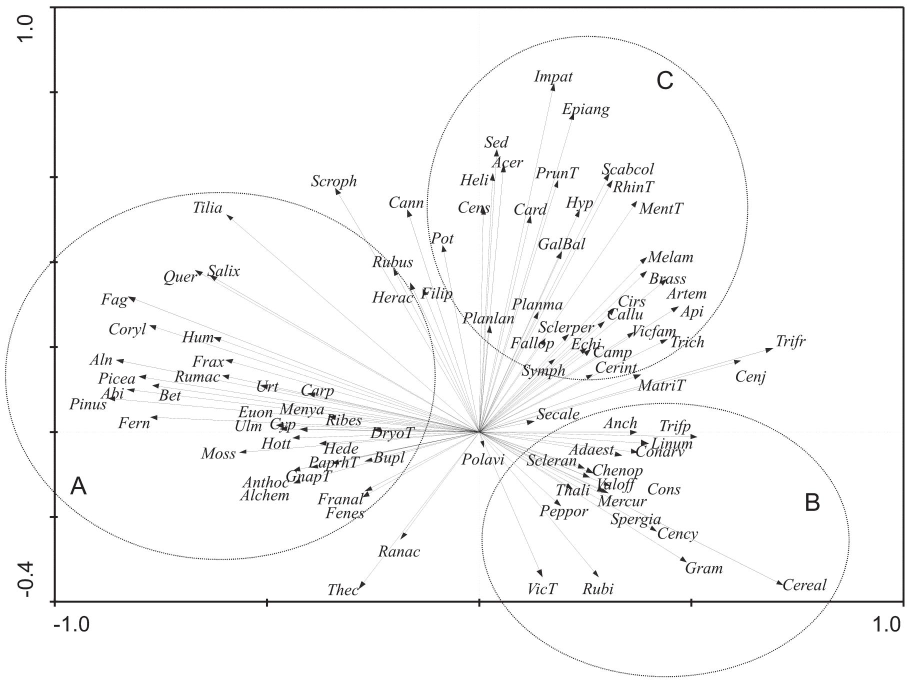

Fig 6. – PCA analysis showing distribution of species. Explained variability: 10.7%, 6.3% and 4.8% for the first three axis, respectively. Only species having a ratio of over 6% are shown. Three groups of pollen types are distinct. The largest contrast is between the two environments separated on the first axis – natural (A group) and cultural (B group). Group A includes trees, aquatic and wetland taxa and some weeds and ruderals. The whole group is connected with the alluvial environment where long distance transport and pollen rain from local vegetation is important. Group B includes above all cereals and weeds. This group represents the environment of cornfields. Group C includes many taxa of dry sunny biotopes, both ruderal and natural. It represents the diverse environment of a town where many taphonomical processes formed the pollen spectrum. See Fog. 5 for species codes.

aviculare or egg shells of *Trichuris trichiura*. Thus, indicators of the cultural environment (town) can be detected even in natural flood deposits (Fig. 2), which is expected since the old river channel formed part of the boundary of the rising medieval town.

A set of samples from Early Medieval sediments deposited in causeways (Table 1). This sediment type is characterized by a great diversity of species (Figs 5 and 6). Pollen types typical of this sediment belong to taxa of both ruderal and relatively natural biotopes associated with dry sunny sites. Typical ruderals are *Artemisia*, *Fallopia convolvulus/F. dumetorum*, *Epilobium angustifolium*, *Plantago major* and possibly even *Brassicaceae*, *Apiaceae* (Greig 1982), *Cerinthe minor*, *Trifolium repens* type, *Cirsium* (if we consider *Cirsium arvense*), *Matricaria* type and *Galeopsis-Ballota* type. Ecologically different are the taxa associated with steppe vegetation. These are above all *Helianthemum*, *Centaurea scabiosa*, *Hypericum*, *Sedum*, *Scabiosa columbaria* type and *Melampyrum.* The fact that the presence of *Melampyrum* is not correlated with that of deciduous trees (expecially *Quercus* and *Carpinus* as the dominant taxa of the *Melampyro-Carpinetum* association; Moravec & Neuhäusl et al. 1991) possibly indicates that the pollen grains were mainly of

Melampyrum arvense. Species such as *Centaurea jacea*, *Scleranthus perennis* and *Echium vulgare* originated from natural xerophilous communities, but can survive even after some degradation of the biotope. Pollen grains of *Acer* and *Prunus* type, unlike that of other tree taxa, probably did originate from local sources (Fig. 5). *Acer* belongs to a species the branches of which were used as a fodder for cattle (Greig 1982).

Causeways represent an environment that is in contact with many other environments. There must have been bushes of ruderals growing alongside the paths, along which the cattle were driven to market or pasture (possible source of pollen of pasture vegetation from dung), and goods and materials, including harvested crops and hay, were transported into town. A causeway is in general an environment by means of which a town communicates with the countryside. Figure 4 presents the distribution of particular samples (PCA analysis). Samples from flood loams and cultural layers formed distinct groups while the samples from causeways are less distinct. This can be accounted for in terms of how the sediment sampled from causeways originated; the initial layer of flood loam was stabilized by stones, and the sediment between the stones subsequently enriched with organic material in an accidental way. Moreover, in the case of causeways only seven samples were compared, which is statistically a very low number.

Development of the site in time

The pollen spectra span approximately five centuries. It is not possible to claim that vegetation over this period did not change. The results indicate three typical pollen spectra characterizing three sediment types. In terms of the taphonomical processes that formed these pollen spectra, it would be very difficult to interpret the results diachronically. On the other hand, all three sediment types were deposited quite independently at different times – first, the causeways, then flood loams and finally the cultural layers (Table 1). This means that the dissimilarities in the three pollen spectra are also related to time. Nevertheless, for the interpretation the environmental development at the site and its surroundings it is important to consider sedimentology.

There were three different phases in the sedimentology and archaeology of the study site. (1) In the Early Medieval period, the old river channel was part of an inhabited area. The Vltava river did not flow through the site any more (Hrdlička 2001). The evidence for this are the Early Medieval causeways crossing the old river channel. The not-very-thick flood loams separating them indicate that each causeway had to be rebuilt after each flood. (2) Construction of weirs on the Vltava river in the second half of the 13th century resulted in very destructive floods that filled the old river channel with thick layers of loams and sand. The previous flood plain was abandoned (Hrdlička 1972, 1984). (3) The site of the old river channel was levelled and on the top of the flood loams cultural sediments accumulated. As early as the 15th century, people probably contributed to levelling the ground in order to incorporate it into a built-up area (J. Čiháková, pers. comm.). This development of the locality will be better documented when the archaeological analysis is completed.

Vegetation of the old river channel could have differed during these three phases, even though there is no strong indication of this in the pollen spectra. It is wrong to focus on local vegetation, because pollen grains of weeds and ruderals in particular could have multiple origins as discussed above. Thus, one of the important conclusions of this study is that the information value of the pollen analysis is not sufficient to indicate accurately the character of the local vegetation. During the first phase, the role of annual weeds in the initial stage of succession was probably less important and nitrophilous perennials probably dominated. The same is true for the third phase, when the vegetation on the river banks, naturally developing into later successional stages (Ellenberg 1988), changed to ruderal vegetation as nutrients were added by man. Although the species spectra during this process may have remained very similar, some increase with eutrophication is evident from the growing abundance of weeds and ruderals (Figs. 2 and 3), *Trichuris trichiura* (Fig. 2) and the slightly lowered pollen diversity curve in the upper part of the profile (Fig. 3). Moreover, if the youngest pollen spectra from the cultural deposits are compared with the oldest pollen spectra from causeway sediments, that are also of cultural origin to a great extent, the decrease in species diversity is obvious and negatively correlated with cultural layers, i.e. the youngest strata (Fig. 5). To test this statistically a larger data set is needed, especially for the Early Medieval period.

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Souhrn

Záchranný archeologický výzkum ve Valdštejnské ulici v Praze odkryl povodňové sedimenty slepého ramene Vltavy, které byly naplaveny v průběhu středověku. Pro pylovou analýzu byl odebrán vrtaný profil povodňovými sedimenty a dále byly ovzorkovány jednotlivé odkryté archeologické vrstvy povodňových a kulturních horizontů. Celkové časové rozpětí zachycené pylovou analýzou odpovídá době od závěru 10. do 15. století. Unikátní soubor vzorků ze tří typů sedimentů (povodňové hlíny, kulturní uloženiny a sediment deponovaný na povrchu cest) byl vyhodnocen pomocí mnohorozměrných statistických metod. Strukturu dat do velké míry určuje charakter sedimentu, nejvíce kontrastní jsou dvě skupiny – druhy s vazbou na povodňové naplaveniny (převážně dřeviny, vodní a nitrofilní druhy) a druhy charakteristické pro kulturní vrstvy (obilniny a jiné plodiny, trávy a plevele). Prostředí vedlejšího říčního koryta bylo silně ovlivněno povodněmi zejména po stavbě pevných jezů na Vltavě v polovině 13. století. Vegetace měla charakter časných sukcesních stádií ruderálů a plevelů, které se uplatňovaly i v prostředí okolního města. Větší rozšíření mokřadních společenstev (rákosin či ostřicových porostů) pylová analýza vyvrátila, v prostoru bývalého říčního koryta však zůstávala fragmentovaná mokřadní vegetace s poměrně vzácnými druhy jako *Menyanthes trifoliata*, *Hottonia palustris* a *Thelypteris palustris*.

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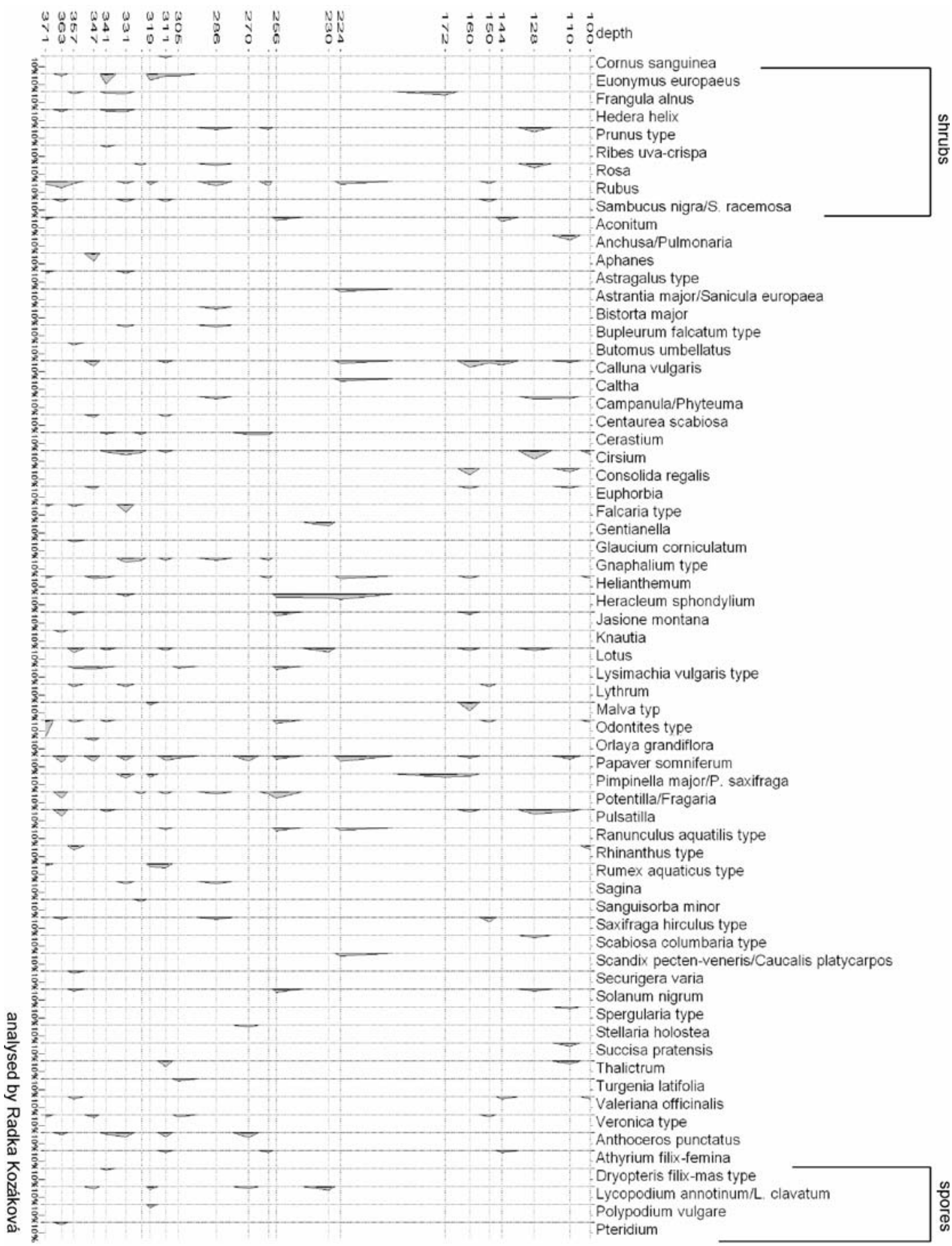
Appendix 1. – Percentage diagram of infrequent pollen types.



Appendix 2. – Percentage representation of pollen types identified in archaeological layers. ◇ causeway, □ cultural layer, ○ flood sediment. See Table 1 for details on layers. Percentages were counted from the sums of pollen given in the bottom row.

Pollen type	◇ 1174	◇ 1097	◇ 1086	◇ 1044	○ 1113	◇ 1025	◇ 1122	○ 1195	○ 1007	○ 952	○ 1183	○ 1156	□ 877	○ 1134	□ 855	○ 921	○ 887	□ 886	□ 885	□ 884
Trees																				
Abiea alba	0.6	0.3	0.7	1.7	4.3	0.2		0.5	1.0	6.5	3.9	2.0		0.9		9.5	2.1	2.2	0.2	
Acer		2.6	0.2			1.2					0.2						0.2	0.3	0.1	
Alnus	0.8	0.9	0.5	2.3	4.5	0.7	0.7	3.7	3.7	6.5	3.0	2.4		1.1		5.8	1.6	0.3	0.1	0.2
Betula	1.8	0.3	0.7	1.7	2.1	1.9	1.1	2.2	4.3	1.2	2.8	3.6	0.6	1.5		1.9	1.2	0.5	0.1	1.0
Carpinus betulus	0.6			0.6	0.5		0.2		0.8	0.3	1.2	0.8					0.2			
Corylus avellana	2.3	0.3	0.5		1.3	0.4	0.4	0.7	0.6	1.7	0.8	1.0		0.4	0.2	0.9	0.2			
Euonymus europaeus																0.7				
Fagus sylvatica	0.8	1.2	0.4	0.6	1.1	0.4		2.2	0.6	2.2	0.8	0.4				1.4				
Fraxinus excelsior		0.3				0.2				0.3		0.2					0.2			
Picea abies	0.6	0.6	0.5	1.2	5.6	0.4	0.4	0.7	2.2	3.9	4.3	3.8	0.1	1.1		5.1	1.1	0.8	0.1	
Pinus sylvestris	3.7	2.6	1.4	3.2	10.4	1.8	1.6	3.2	7.9	12.6	7.7	10.5	1.2	8.3		20.1	8.8	7.1	0.8	0.7
Prunus type		1.4	0.2		0.3		0.2				0.2						0.2			
Quercus	2.5	1.4	0.4	1.4	1.1	0.5	0.2	1.5	1.0	1.4	1.2	1.4	0.1	1.1	0.2	0.9	0.2	0.5	0.1	
Rubus		0.9	0.2				0.2			0.2								0.3	0.1	
Salix	2.1	1.7		7.0	2.7	0.4	0.5	1.7	1.8	1.4	1.8	1.2		0.9		1.4	0.5	0.5		0.2
Sambucus nigra/S. racemosa				0.3	0.3		0.2	0.5					0.3		0.2					
Tilia	0.4	2.3	0.2	0.6	0.3	0.2	0.2	0.2	0.4	0.2				0.4		0.5	0.5	0.5		
Ulmus	0.2											0.4				0.2		0.3		
Viburnum opulus																	0.2			
Herbs																				
Aconitum							0.5	0.2	0.2	0.2		0.2								
Adonis aestivalis/A. flammea	0.2			0.9		0.4	0.9								0.3					0.2
Agrostemma githago	0.4			0.3									0.3						0.1	
Alchemilla			0.2																	
Alisma																				
Anchusa/Pulmonaria						0.2														
Anemone type		0.6				0.2		0.2									0.2			
Anthericum				0.3																
Apiaceae	1.0	0.3	1.4	0.3	0.8	3.2	0.6	1.2	0.2	1.4	0.6	0.8	1.2	1.9	0.4	0.2	0.9	1.9	0.7	0.3
Artemisia	8.6	8.7	4.8	9.0	3.5	24.9	20.2	3.2	10.6	2.4	4.1	6.3	7.6	5.3	2.0	2.1	1.6	1.6	2.2	4.0
Aster type	0.4	0.6	0.5	0.3	1.1	0.2	0.9	0.2	0.4		0.4		0.4	0.8	0.5		0.2	0.3		0.3
Asteraceae-Fenestratae	1.2	0.9	0.9	0.6	2.1	1.9	1.6	2.2	2.0	2.2	1.6	2.0	0.4	2.3	0.8	3.2	2.3	3.0	0.3	1.4
Astrantia major/Sanicula europaea														0.2						
Brassicaceae	0.4	2.3	2.1	2.3	0.3	2.3	0.4	0.7		0.9	0.4	0.6		1.3	0.2	0.5	0.7	1.4	0.4	0.2
Calluna vulgaris	0.2	0.3	1.1	2.0	0.5	0.5	0.4		0.2	0.2		0.2		0.2	0.2	0.2				
Campanulla/Phyteuma	0.4	0.3		0.3	0.3									4.9			0.2	0.3		
Cannabis sativa	0.6	1.7		1.4		1.1	1.4	1.2	1.6	0.3	0.4	0.4	0.1	0.8		0.5		0.3	0.1	0.2
Carduus		0.6														0.2				
Centaurea cyanus	0.2	1.4	2.1	2.3	0.8	2.8	2.3	1.5	1.2	1.2	0.8	1.2	4.1	1.9	2.3	0.9	1.2	1.4	0.8	0.9
Centaurea jacea/C.stoebe	1.4	0.9	0.7	0.6		0.7	0.2	0.2	0.2	0.9	0.4		0.6	0.4	0.2		0.5	0.8	0.1	0.2
Centaurea scabiosa	0.4	0.3										0.2								
Cerastium	0.2				0.3				0.4	0.2	0.2			0.2			0.4			
Cerealia	27.5	13.9	15.4	10.7	3.5	8.2	9.8	13.6	11.4	11.8	17.1	14.9	55.6	22.7	58.3	12.7	30.6	43.3	35.1	29.0
Cerinthe minor						0.2													0.1	
Chenopodiaceae	1.0	1.4	1.8	2.0	1.3	3.9	1.6	22.6	5.5	1.7	1.4	3.6	2.6	3.2	0.8	3.2	2.5	3.3	1.0	4.4
Cirsium	0.2	0.6		0.3		0.7	0.2			0.5				0.4			0.5			0.3
Consolida regalis											0.4			0.2				0.3	0.1	
Convolvulus arvensis		0.3							0.4		0.2		0.9	0.2	0.2		0.2		0.1	

Pollen type	1174 ◇	1097 ◇	1086 ◇	1044 ◇	1113 ○	1025 ◇	1122 ◇	1195 ○	1007 ○	952 ○	1183 ○	1156 ○	877 □	1134 ○	855 □	921 ○	887 ○	886 □	885 □	884 □
Trees																				
Cuscuta	0.2																			
Cyperaceae	0.6	0.6	0.7	0.6	0.3		0.2	0.5	0.6	1.0		0.2		0.4	0.2	1.6	0.9	0.3		0.7
Dianthus			0.2																	
Echium vulgare			0.2			0.2														
Epilobium angustifolium		0.9																	0.1	
Euphorbia				0.3																
Falcaria type											0.2		0.1							
Fallopia convolvulus/F. dumetorum	0.2	0.3	0.2			0.5		0.2		0.2	0.2	0.2						0.5	0.1	
Filipendula ulmaria/F. vulgaris		3.5	0.7		4.0		0.2	0.2	0.2	0.3	0.2		0.3		0.2	0.7	0.4	0.3		0.5
Galeopsis-Ballota type	0.2	0.9	0.2	0.9		1.1	0.2	0.2	0.6	0.2				0.4		0.2				
Gentiana pneumonanthe type				0.3							0.2									
Gramineae	9.2	15.6	23.8	19.4	16.2	16.5	9.5	13.4	17.3	14.1	15.6	13.9	1.6	21.0	24.6	8.8	22.3	3.8	46.2	20.6
Helianthemum		0.9	0.2			0.4										0.2				
Heracleum sphondylium		0.3		0.3				0.2		0.2										
Humulus lupulus	0.4	0.9						0.5	0.2	0.9	0.6	0.8		0.2					0.1	
Hypericum	1.8	1.7	0.5		1.3	1.2	0.2	0.7	0.4		1.2		0.3	0.4		0.2	0.2		0.2	0.2
Impatiens noli-tangere		0.6																		
Iris sibirica																0.2				
Knautia														0.2						
Linum	0.2																			
Lotus		0.3			0.5		0.4	0.2				0.2		0.2	0.2		0.2			
Lysimachia vulgaris type							0.2												0.2	
Malva type	0.2																0.2			
Matricaria type	0.8	0.9	1.4	2.0	0.5	1.2	0.5	0.5	1.0	0.3	2.2	1.2	0.4	0.9	0.3	1.6	1.6	1.4	0.2	1.4
Melampyrum	0.8	0.6	0.2			0.5	0.2	0.7	0.2					0.2	0.2					
Mentha type	0.6	2.9	0.2	0.9		0.4	0.5		0.6		0.2	0.2			0.3		0.4	0.3		
Mercurialis				0.3																0.2
Odontites type		0.3	0.4		1.1	0.2	0.2						0.1		0.3					0.2
Orlaya grandiflora										0.2										
Papaver rhoeas type													0.1			0.9		0.3		
Peplis portula																				0.2
Persicaria maculosa type	0.2											0.2				0.7	0.2			
Pimpinela major/P. saxifraga							0.2						0.1							
Plantago lanceolata	2.7	1.2	0.2	0.9	0.8	2.1	0.4		1.8	1.5	0.8	1.0	1.2	0.6	0.3	1.6	0.4	1.1	0.7	0.7
Plantago major	0.4	0.6									0.4									0.3
Plantago media	0.2			0.6		0.5				0.2				0.2	0.2	0.2				
Polygonum aviculare	0.4	1.2	0.9	0.6	0.3	1.4	2.0	0.2	2.6	0.9	1.2	2.0	0.1	0.9	0.3	0.9	4.6	3.5	0.4	1.9
Potamogeton						0.4								0.2						
Potentilla/Fragaria	0.2	0.3	0.4		0.3	0.4	0.2				0.6					0.2		0.3		
Pulsatilla	0.2		0.2				0.2	0.2	0.2	0.2							0.5	0.3		
Ranunculus acris type			0.7	0.3	0.3	0.2	0.7	0.5	0.2	0.2	0.6	0.4		0.2	0.7	0.2		0.8	0.4	0.7
Ranunculus aquatilis type					0.8															0.2
Rhinanthus type	0.2	1.4				0.2	0.4		0.6										0.3	
Rubiaceae					0.5	0.7	0.4		0.2	0.2		0.2		0.2	0.3	0.2	0.4	1.1		0.5
Rumex acetosa type	1.0		0.9	0.9	1.6	1.4	1.1	1.5	0.6	2.4	1.8	2.0		0.4	0.2	0.7			0.2	0.2
Rumex aquaticus type	0.2							0.2						0.9				0.5		
Sagina				0.3					0.2											
Sanguisorba minor																	0.2			
Saxifraga hirculus type										0.2										
Scabiosa columbaria type	0.2	0.3																		
Scleranthus annuus				0.3			0.2													0.2
Scleranthus perennis						0.2														
Scrophulariaceae	0.2	2.3			0.3	0.5		0.2		1.2	0.2				0.2	0.5				

Pollen type	◇ 1174	◇ 1097	◇ 1086	◇ 1044	○ 1113	◇ 1025	◇ 1122	○ 1195	○ 1007	○ 952	○ 1183	○ 1156	□ 877	○ 1134	□ 855	○ 921	○ 887	□ 886	□ 885	□ 884
Trees																				
Secale cereale	7.2	3.5	26.8	9.3	4.5	5.4	30.8	6.5	6.3	6.3	8.7	9.1	11.8	3.2	2.6	0.5	1.2	4.6	5.7	20.2
Sedum		0.6														0.5				
Silene	0.2		0.7	0.3		0.4			0.4	0.2	0.6		0.7		0.3					0.2
Solanum dulcamara								0.2									0.2			
Solanum nigrum	0.4		0.2				0.2						0.1							
Sparganium/Typha angustifolia									0.2						0.2					
Succisa pratensis			0.2													0.2				
Symphytum	0.2													0.2						
Thalictrum				0.3						0.2	0.4			0.6			0.2	0.5		0.2
Trifolium pratense type	5.3		0.5	1.7	0.5	0.5	0.5	1.2	0.6		0.2	0.2	0.4	0.9				0.5	0.1	1.6
Trifolium repens type	2.9	2.0		1.2	0.3	1.1	0.4	0.7	0.2	0.3	0.8	1.0	1.8	0.6	0.3		0.9	2.2	0.7	3.7
Urtica		1.4	0.5	0.9	9.8	0.4	0.7	0.7	1.2	1.2	1.4	1.0	1.0	0.8	0.3	0.7		0.3	0.8	0.2
Valeriana officinalis	0.2										0.2						0.2			0.2
Valerianella	0.2				0.3															
Veronica type			0.2	0.6			0.2	0.2				0.2			0.2	0.5		0.5		
Vicia type				0.6			0.2													0.9
Viciaceae		0.9	0.4			0.2		0.2		0.2			0.6		0.8		2.5	1.1		
Viola arvensis/V. tricolor																		0.3		
Xanthium													0.1	0.2		0.5				
Non pollen objects																				
Lycopodium annotinum	0.2					0.2		0.2												
Lycopodium clavatum								0.2		0.3						0.5				
Lycopodium annotinum/L. clavatum											0.2									
Monolete fern spore	0.6	0.3	0.7	1.7	5.1	1.2	1.3	2.7	4.5	3.9	4.9	5.9	0.4	2.1	0.2	4.2	2.8	2.7		
Trilete moss spore			0.2	0.3	0.5			0.5	0.4	0.5	0.2	0.8		0.2		0.2				
Thecaphora							0.5	0.7		0.3		0.4	1.0	0.2		0.2	0.4	1.1		0.9
Trichuris trichiura	1.0	0.9	0.9	0.3	1.6	1.4	0.9	0.2	0.6	0.3	0.8	0.4	1.0	0.9			0.7	0.5	0.3	
Sum	512	346	564	345	376	570	559	403	509	587	508	495	680	528	605	432	569	367	889	573