Acta Palaeobotanica 50(2): 133–148, 2010

The last two millennia of vegetation development and human activity in the Orawa-Nowy Targ Basin (south-eastern Poland)

PIOTR KOŁACZEK[1, 3], BARBARA FIAŁKIEWICZ-KOZIEŁ[2, 3], MONIKA KARPIŃSKA-KOŁACZEK[1], and MARIUSZ GAŁKA[3]

[1]Department of Palaeobotany, Faculty of Biology and Earth Sciences, Jagiellonian University, Lubicz 46, 31-512 Kraków, Poland; e-mail: piotrkolaczek@op.pl

[2]Department of Ecology, Faculty of Biology and Environmental Protection, Silesian University, Bankowa 9, 40-007 Katowice, Poland

[3]Department of Biogeography and Palaeoecology, Faculty of Geographical and Geological Science, Adam Mickiewicz University, Dzięgielowa 27, 61-680 Poznań, Poland

Received 2 June 2010; accepted for publication 2 November 2010

ABSTRACT. The aim of this paper was to reconstruct environmental changes during the last 2 kyr in the Orawa-Nowy Targ Basin based on palynological anlaysis and the radiocarbon dating of two peat bog profiles from Puścizna Mała and Puścizna Krauszowska. So far, pollen profiles from this area have failed to include any radiocarbon dates from this period. The first human activity was recorded between the 1st and the 6th centuries AD when the sporadic presence of Cerealia pollen may point to agricultural activity by the Przeworsk Culture tribes. The reversal of the chronological order of layers between the 7th and the 17th century in Puścizna Krauszowska is also the result of human activity on the peat bog dome. This has led to the exclusion of this part from consideration. Busier economic activity in the 9th–11th centuries in Puścizna Mała is apparent from more frequent occurrences of Cerealia type and *Secale cereale* pollen, as well as from the rise in the proportions of open ground herbs. However, historical sources do not confirm constant settlement in this area at that time. The beginning of medieval colonization caused strong deforestation in the Orawa-Nowy Targ Basin, when mainly beech-fir forests and on a smaller scale spruce were destroyed. The domes of reclaimed peat bogs were colonized by *Calluna vulgaris* and *Pinus sylvestris*. An increase in the percentage of coprophilous fungi in the profiles indicates development of pastures. Between medieval and present times the sharp rise in the frequency of charred particles may be explained by peat bog fires and/or the foundation of factories in the 20th century.

KEYWORDS: pollen analysis, vegetation history, human impact, Orawa-Nowy Targ Basin

INTRODUCTION

The area of the Orawa-Nowy Targ Basin has been the object of palynological study since the 1920s (Peterschilka 1927, Dyakowska 1928). The first palynological studies after the World War II were conducted by Koperowa (1962) on the Puścizna Rękowiańska and Grel peat bogs. Further detailed research included such peat bogs as Przymiarki, Bór na Czerwonem and Puścizna Rękowiańska, and for the latter radiocarbon datings were made (Obidowicz 1990, 1996). Hence, this profile was selected as representative of this geographical unit when the monograph "Late Glacial and Holocene history of vegetation in Poland based on isopollen maps" was published (Ralska-Jasiewiczowa et al. eds 2004). However, due to the fact that the youngest radiocarbon date in the profile from Puścizna Rękowiańska is

3030 ± 60 ^{14}C BP, the profiles from Puścizna Mała and Puścizna Krauszowska will supplement knowledge about the last 2 millennia in the Orawa-Nowy Targ Basin. Palynological analyses of the profiles were part of the research undertaken during the preparations of the PhD thesis (Fiałkiewicz-Kozieł 2010).

CHARACTERISTICS OF THE AREA

GEOLOGY, GEOMORPHOLOGY AND SOILS

The Orawa-Nowy Targ Basin is an area bounded by the Western Beskids Mountains (Babia Góra and Gorce ranges) in the north and the Tatra Mountains in the south. The Polish part covers 369 km² and has a flat floor. The European Watershed runs through the Basin and divides it into two hydrographical parts. One of them is in the west of the Orawa-Nowy Targ Basin and is drained by the Orawa to the Váh and the Danube, while the other is in the east of the Orawa-Nowy Targ Basin and is drained by the Dunajec to the Vistula. The basin evolved during the younger part of the Tertiary as a result of the deformation of an area between the mountain ridges and the foothills. A lake developed in the Basin with sediments consisting of gravels and loam, and it reached a depth of 300 m in the west. Additionally, in the Quaternary, during three subsequent glacials, fluvioglacial sediments were deposited on the outwash fan (Kondracki 2002). A wide belt of alluvium and gravels runs along the Dunajec in the form of terraces (Dobrowolski 1970).

The poor permeability to ground waters of the loam layer, along with the area's geomorphology and hydrography results in constant moisture in the surface layers. This contributed to the development of peat bogs in this area (Obidowicz 1990, Łajczak 2007). The floors of valleys are occupied by rich alluvial soils, next to which occur areas with turfy podsols and cambisols (Dobrowolski 1970).

CLIMATE

The Orawa-Nowy Targ Basin is located in a moderately warm climatic zone with local variations. Temperatures in winter are significantly lower with a tendency towards fog, while summers are warmer and more arid than in other areas (Kondracki 2002). The annual precipitation ranges from 900–1100 mm (1971–2000 yrs) and is highest in July. The mean annual temperature varies from 5 to 6°C (1971–2000). The coldest month is January, in which mean temperatures are between –3.5 and –4.0°C (Lorenc ed. 2005) and the warmest is July, in which mean temperatures reach 15.6°C (Kowanetz 1998). Generally the mean temperatures of the coldest months are lower than in the eastern part of this region which can be attributed to cold air stagnation in the lowest parts of the basin (Milata 1955). An important factor contributing to the development of peat bogs in the Orawa-Nowy Targ Basin is the predominance of precipitation over evaporation in the period between May and October (Kowanetz 1998).

RECENT VEGETATION

About 420 species of vascular plants have been found, on peat bogs and adjacent environs according to studies of flora in the Orawa-Nowy Targ Basin (A. Koczur, unpublished data). However, only 57 species of them were found growing on typical domes of raised peat bogs (Koczur 2006).

Eight species can be found occurring exclusively on the undisturbed, best-preserved portions of the domes of raised peat bogs. These are *Carex limosa*, *C. pauciflora*, *Empetrum nigrum*, *Oxycoccus microcarpus*, *Pinus mugo*, *Pinus ×rhaetica*, *Rubus chamaemorus*, and *Scheuchzeria palustris*. There are slightly more widespread stations for *Andromeda polifolia*, *Drosera anglica*, *D. rotundifolia*, and *Rhynchospora alba*. Further outside the peat bog domes there are species such as *Eriophorum vaginatum*, *Ledum palustre*, *Oxycoccus palustris*, and *Vaccinium uliginosum*, which occur frequently in the surrounding coniferous bog forests, and *Eriophorum angustifolium* which grows on oligotrophic fens.

More diversified yet is the group of plant species on the lagg communities and in some post-exploitation areas. Some of these also occur on domes, although they are less numerous and more scattered. In marginal communities, there are species typical of intermediate peat bogs and acidic fens, such as *Agrostis canina*, *Carex canescens*, *C. echinata*, *C. lasiocarpa*, *C. nigra*, *Comarum palustre*, *Eriophorum gracile*, *Juncus filiformis*, *Menyanthes trifoliata*, *Ranunculus flammula*, *Stellaria palustris*, *Veronica scutellata*, and *Viola palustris*.

There are also reed community species *Alisma plantago-aquatica*, *Carex disticha*, *C. gracilis*, *C. hudsonii*, *C. rostrata*, *C. vesicaria*, *Eleocharis palustris*, *Phragmites australis*, *Sparganium emersum*, *S. erectum*, *Typha latifolia*, and even some plant species typical of low-growing mires and eutrophic mountain fens, such as *Carex dioica*, *C. flava*, *C. lepidocarpa*, *C. pulicaris*, *Eleocharis pauciflora*, *Epipactis palustris*, *Eriophorum latifolium*, *Parnassia palustris*, *Pinguicula vulgaris*, and *Valeriana simplicifolia*. In small natural ponds and in numerous peat pits there are communities of aquatic plants where *Nymphaea alba*, *Potamogeton alpinus*, *P. natans*, *P. pusillus*, *Sparganium minimum*, *Utricularia minor*, and *U. vulgaris* can be found among other species (Koczur 2006). Adjacent to the peat bogs are vast areas occupied by bog coniferous forests.

SETTLEMENT HISTORY

There was constant settlement in the Orawa area until the 4th century and then, during the Migration period and in early Medieval times all traces of human presence disappeared to surface again in the late Middle Ages (Ładygin 1984).

At the turn of the 12th and the 13th centuries the Podhale region was under the reign of the Gryfita family. One of them, Teodor, the voivod of Kraków, gained from Henry I the Bearded a privilege to settle villages based on German law. At that time the village of Rogoźnik was settled, as is mentioned in historical documents from 1237 (Dobrowolski 1970). In 1238 Teodor also brought the first monks to the church and monastery founded by him in Ludźmierz, but in 1341 they moved to Szczyrzyc, which is located 40 km to the north-east of Ludźmierz. However, there are historians who claim that the removal took place in 1245 (Czachura 2003). The Cistercians, after leaving Ludźmierz, kept their lands in the Podhale region and their habit of founding settlements contributed to the establishment of Nowy Targ in 1287, Długopole in 1327 and Krauszów in 1333 (Dobrowolski 1970). In 1368, in the area of modern Jabłonka, a customs office was set up which controlled the sale of salt to Poland's southern neighbours (Semkowicz 1932). Jabłonka was founded later in the years 1558–1561 (Trajdos 1993).

Villages were usually located in river and stream valleys which were clear of woods. Another important event was the founding of Czarny Dunajec in 1552 which developed quite fast at that time because of its good geographical position on the trade route from Kraków to Orawa and, further on, to Hungary. Historical data shows that during the Partition of Poland Czarny Dunajec became more important because it had the right to organize markets once a week. In addition to this in 1880 the village became a town, although in 1934 it lost its municipal rights (Kiryk ed. 1997).

Nowadays, about 47% of peat bog areas lie fallow, while domes are usually covered with woods (Łajczak 2007).

MATERIAL AND METHODS

SITE DESCRIPTION

The Puścizna Mała peat bog developed on the course of the old outlet of the Czarny Dunajec. It is additionally supplied with ground waters, which seep through gravel sediments from the side of the Czarny Dunajec river bed in a north-westerly direction. It is in the Czarna Orawa river basin and encircled by the Ogrójcowy Potok (Czarna Woda) from the east and by the Grudnik stream from the west (Łajczak 2006). The Puścizna Mała peat bog extends over 125 ha and its dome over 51 ha. This peat bog was exploited as early as medieval times, however, not until the 20th century was peat extraction significant. Then former peat bog areas which were devoid of peat were turned into grasslands or fields. Puścizna Mała was drained from the north and the west by numerous ditches and from the east by the Ogrójcowy Potok. Nowadays, these ditches have gradually become overgrown (Łajczak 2006).

Puścizna Krauszowska, also known as Puścizna Franków, covers an area of 79 ha and its fragmentary dome covers 29 ha. This peat bog, which is supplied mainly by precipitative waters, developed on a local natural elevation between the Czarny Potok and Czerwony Potok and has the character of a watershed peat bog. The peat bog has been exploited since the 14th century and peat is still extracted using simple methods, which is obvious from the drying stacks of peat in the area. Almost the whole vicinity of the dome is drained by numerous ditches (Łajczak 2006).

METHODS

Material for analyses was collected in the early summer of 2006 (Puścizna Mała) and 2008 (Puścizna Krauszowska) as peat monoliths from the surface of peat bog dome. A 1.35 m long core from the former peat bog was taken with a wooden box (Tobolski 2000),

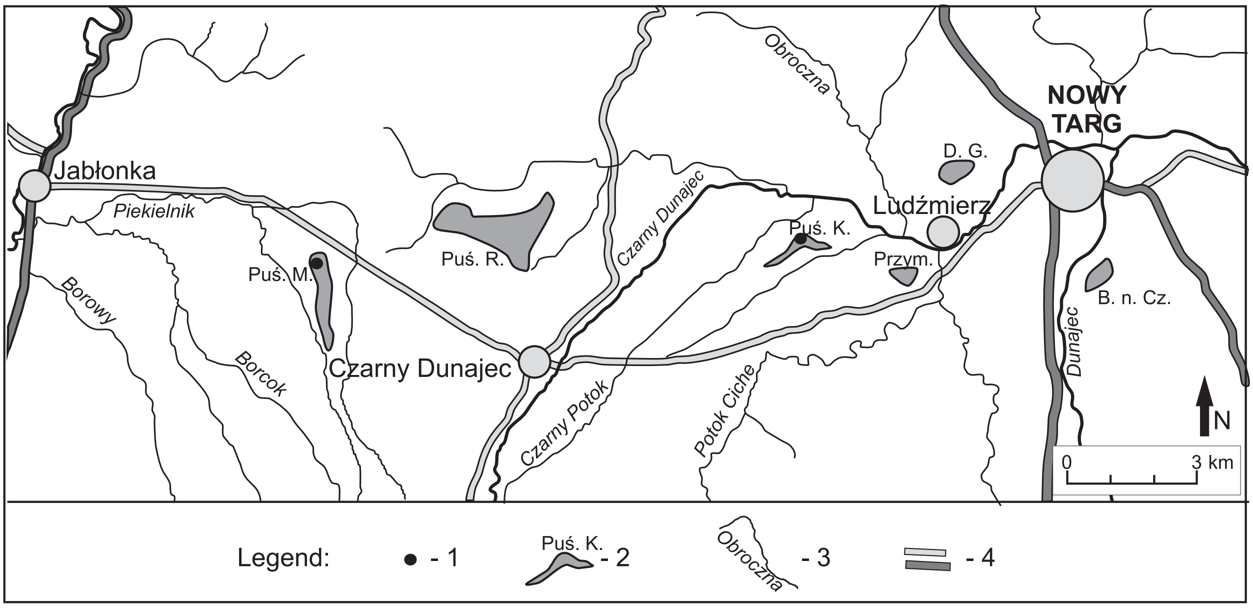

Fig. 1. Map of the Puścizna Mała, Puścizna Krauszowska location together with the other peat bogs mention in the text. **1** – place of the profile collection, **2** – peat bogs (area of domes); **Puś. M**. – Puścizna Mała, **Puś. R**. Puścizna Rękowiańska, **Puś. K**. – Puścizna Krauszowska, **Przym**. – Przymiarki, **D. G**. – Do Grela, **B. n. Cz.** – Bór na Czerwonem; **3** – rivers and streams, **4** – roads

while a 1 m long core from the latter was collected using a Wardenaar corer (Wardenaar 1986).

For palynological analysis 45 samples of 1 cm^3 were chosen, of which 28 were from the Puścizna Mała profile and 17 from Puścizna Krauszowska. Every sample was acetolyzed by Erdtman's method (Faegri & Iversen 1989) and a *Lycopodium* tablet was added as a concentration indicator (Stockmarr 1971).

Pollen taxa and selected non-pollen palynomorphs (NPPs) were observed using a Zeiss AMPLIVAL light microscope under 400× and 1000× magnification. Pollen identification was conducted with the help of specialist keys and atlases (Moore et al. 1991, Beug 2004, Punt & Hoen 2009), as well as using the reference slide collection of W. Szafer Institute of Botany, Polish Academy of Sciences. The identification of NPPs was done by comparison with photographs and descriptions available in the literature on NPPs (e.g. van Geel et al. 1981, 2003, 2007). Samples were counted until a minimum sum of 500 tree and herb pollen grains were reached and, if the pollen concentration was low, the minimum was 200 pollen grains. The results of palynological analysis were presented as pollen percentage diagrams, drawn using the POLPAL program (Nalepka & Walanus 2003). Percentage values in individual spectra were calculated on the basis of particular taxa values in ratio to the total pollen sum (AP+NAP), from which were excluded local taxa (cryptogams, limnophytes, telamtophytes, and Cyperaceae). The percentage values of local pollen taxa, cryptogams and NPPs were calculated in ratio to the total pollen sum adding in term each taxon to this sum. In each diagram an analysis of the Rarefacted Number of Taxa was performed, for which a minimum value of 500 pollen grains in the total pollen sum is needed. This method allows for an independent comparison of samples with a different number of pollen grains.

DESCRIPTION OF THE PROFILES

The profile from the Puścizna Mała peat bog was collected from its dome (655 m a.s.l., 49°27′36″N, 19°47′12″E). This site is located within the Krauszów area.

1–17 cm	Tb4, Th+ , not decomposed *Sphagnum* peat
17–23 cm	Tb4, Th+, Sh+, very weakly decomposed *Sphagnum* peat
23–32 cm	Tb2, Th+, Sh2, moderately decomposed *Sphagnum* peat
32–46 cm	Tb1, Th+, Sh3, highly decomposed *Sphagnum* peat
46–50 cm	Tb2, Sh2, moderately decomposed *Sphagnum* peat
50–80 cm	Tb3, Th+, Sh1, weakly decomposed *Sphagnum* peat
80–91 cm	Tb4, Th+, Sh+, very weakly decomposed *Sphagnum* peat
91–99 cm	Tb3, Th+, Sh2, moderately decomposed *Sphagnum* peat
99–114 cm	Tb4, Th+, Sh+, very weakly decomposed *Sphagnum* peat
114–130 cm	Tb2, Th+,Sh2, moderately decomposed *Sphagnum* peat
130–138 cm	Tb1, Th1, Sh2, moderately decomposed *Sphagnum* peat with *Eriophorum* macroremains

The profile from the Puścizna Krauszowska peat bog was collected from its dome (613 m a.s.l., 49°28′06″N, 19°56′18″E). This site is located within the Krauszów area, close to Ludźmierz.

1–13.5 cm	Tb4, not decomposed *Sphagnum* peat
13.5–15 cm	Tb2, Th1, Sh1, weakly decomposed *Sphagnum* peat with plant macroremains
15–24 cm	Tb4, not decomposed *Sphagnum* peat
24–30 cm	Tb1, Th1, Sh2, moderately decomposed *Sphagnum* peat with plant macroremains
30–42 cm	Tb2, Th1, Sh1, weakly decomposed *Sphagnum* peat with plant macroremains
42–45 cm	Tb3, Th1, Sh+, very weakly decomposed *Sphagnum* peat with plant macroremains
45–48 cm	Tb2, Th1, Sh1, weakly decomposed *Sphagnum* peat with plant macroremains
48–54 cm	Tb1, Th1, Sh2, moderately decomposed *Sphagnum* peat with plant macroremains
54–63 cm	Tb2, Th1, Sh1, weakly decomposed *Sphagnum* peat with plant macroremains
63–72 cm	Tb4, Th+, very weakly decomposed *Sphagnum* peat
72–78 cm	Tb1, Th1, Sh2, moderately decomposed *Sphagnum* peat with plant macroremains
78–87 cm	Tb3, Th1, Sh+, very weakly decomposed *Sphagnum* peat with plant macroremains
87–90 cm	Tb4, Sh+, very weakly decomposed *Sphagnum* peat
90–93 cm	Tb4, not decomposed *Sphagnum* peat
93–98 cm	Tb4, Sh+, very weakly decomposed *Sphagnum* peat

RADIOCARBON DATINGS

The radiocarbon dating of samples from the profiles from Puścizna Mała (6 dates) and Puścizna Krauszowska (5 dates) was performed in the Institute of Physics of the Silesian Technical University in Gliwice. Each of them was calibrated using the OxCal v 4.10 program (Bronk Ramsey 2009), according to the calibration curve IntCal 04 (Reimer et al. 2004). The results are presented in Table 1.

DESCRIPTION OF POLLEN ZONES

Pollen diagrams were divided into local pollen asssemblage zones (L PAZ) on palynological principles (Figs 2,3) and on the basis of a spectra similarity dendrogram generated by the

Table 1. Radiocarbon dates from the Puścizna Mała and Puścizna Krauszowska profiles.

Laboratory code	Depth (cm)	Material	^{14}C dates BP conv. uncal.	Callibrated age range 95.4%
		Puścizna Mała		
Gd-19011	15–16	peat	1.0302 ± 0.008 pMC	4 BP (95.4%) –7 BP
GdS-443	27–28	peat	519 ± 45	641BP (25.3%) 589BP 564BP (70.1%) 500BP
Gd-12925	48–49	peat	650 ± 45	673BP (95.4%) 551BP
GdS-466	75–76	peat	1059 ± 52	1120BP (0.3%) 1113BP 1081BP (91.3%) 902BP 864BP (2.9%) 827BP 812BP (0.9%) 800BP
GdS-470	99–100	peat	1471 ± 56	1516BP (11.3%) 1458BP 1443BP (1.8%) 1430BP 1422BP (82.3%) 1291BP
Gd-19024	123–124	peat	1680 ± 80	1812BP (1.7%) 1789BP 1786BP (2.4%) 1754BP 1742BP (91.3%) 1405BP
		Puścizna Krauszowska		
GdS-897	24–25	peat	1360 ± 40	604AD (86.5%) 719AD 742AD (8.9%) 769AD
GdS-941	36–37	peat	430 ± 60	1406AD (95.4%) 1635AD
GdS-942	42–43	peat	465 ± 60	1316AD (6.7%) 1354AD 1388AD (77.3%) 1524AD 1558AD (11.4%) 1632AD
GdS-935	54–55	peat	1440 ± 55	440AD (3.6%) 484AD 532AD (91.8%) 675AD
GdS-945	90–91	peat	2000 ± 80	203BC (93.9%) 181AD 186AD (1.5%) 214AD

Table 2. Puścizna Mała. Description of the local pollen assemblage zones (L PAZ).

L PAZ. Depth (cm)	Description	Top boundary description
PM-1 *Alnus-Pinus*. 135–107.5	The highest percentage values of *Alnus* undiff. (9.0–16.5%), *Pinus sylvestris* type (11–42%),and *Carpinus betulus* (2.0–8.5%); high percentages of *Betula* undiff., *Picea abies*, *Abies alba*, *Fagus sylvatica*, *Quercus*, and *Corylus avellana*. Presence of continuous low value curves of *Ulmus* and *Fraxinus excelsior*. The lowest frequency of herbs and dwarf shrubs in the diagram, only single grains of Cerealia type, *Triticum* type, and *Avena* type. Pollen of Cyperaceae present at low percentages. Cryptogams are represented by *Sphagnum* (high values that fluctuate), Filicales monolete, and *Pteridium aquilinum*. At the bottom *Tilletia sphagni* spores are abundant, whereas in the upper part of this zone the *Amphitrema flavum* and *Assulina* tests number rises. A maximum of occurrence of Microthyriales fruit bodies (max. 2.7%) is detected. The zone shows the lowest taxonomic variety in the whole diagram (Rarefracted number of taxa analysis). However, there is the highest pollen concentration. Regular occurrence of charcoal (20–100 µm). ConSLink analysis failed to confirm that all spectra belong to this zone.	A fall in *Pinus sylvestris* type curve and a rise in *Picea abies* values.
PM-2 *Picea-Fagus*. 107.5–42.5	*Picea abies* (9.5–21.0%), *Fagus sylvatica* (12.0–24.5%, decreasing tendency in the curve), *Abies alba* (7–25%, increasing tendency in the curve), *Betula* undiff. (7–20%),and *Quercus* (2.5–9.5%) reach the highest percentage values in the diagram. A decrease in *Pinus sylvestris* type and *Alnus* undiff. values. Low, continuous curves of *Ulmus* and *Corylus avellana*. There is a gradual rise in herbs and dwarf shrub taxa represented by *Artemisia*, *Rumex acetosa* type, Chenopodiaceae, *Plantago lanceolata*, *Calluna vulgaris*, and *Vaccinum* type. More abundant is Cerealia type pollen; *Secale cereale* appears. Cyperaceae presents low percentage values. The highest percentages in the profile of *Sphagnum* spores (49%, a fluctuating curve), a continuous curve of Filicales monolete, irregular presence of *Pteridium aquilinum* spores. High amounts of amoebae tests of *Amphitrema flavum* (max. 31%) and *Assulina*. *Tilletia sphagni* and *Ustulina* cf. *deusta* spores are present in almost every spectrum. Charcoal particles occur in all samples, except for the sample at depth 90 cm. Taxonomic variety increases slightly. Pollen concentration decreases. ConSLink analysis confirmed that all spectra belong to this zone.	Noticeable falls in *Picea abies*, *Fagus sylvatica* and *Abies alba* curves and a rise in herbs and dwarf shrub values.
PM-3 NAP. 42.5–0.00	Percentage values of NAP sum and *Pinus sylvestris* type rise. High values of charcoal are characteristic of this zone. There is also a decrease in *Picea abies*, *Abies alba*, and *Fagus sylvatica* values. ConsLink analysis confirmed that all spectra belong to this zone, except the spectrum from the subzone PM-3c.	
PM-3a NAP (*Calluna*). 42.5–17.5	Herbs and dwarf shrubs dominate in this subzone. There is a noticeable fall in *Picea abies*, *Abies alba*, and *Fagus sylvatica* frequency. Gradual increase in percentage values of *Pinus sylvestris* type; *Betula* undiff. decrease and increase in the younger part of the zone. Regular occurrence of *Salix* undiff. and *Juniperus* pollen. A sharp rise and then a fall in *Calluna vulgaris* values (max. 24%); frequency of Poaceae undiff. increases (max. 18.5%). Regular presence of *Vaccinium* type, *Humulus*/*Cannabis* (max. 2%), *Plantago lanceolata* (max. 2.5%), *Rumex acetosa* type (max. 4%), Chenopodiaceae, Brassicaceae, Rubiaceae, *Anthemis* type, *Plantago major*, as well as Cerealia type, *Secale cereale* (max. 2.5%), and *Triticum* type. Pollen of *Ambrosia artemisifolia* type appears in the younger part of the zone. There is a rise in *Phragmites australis* type values and a slight decrease in Cyperaceae curve. Percentage values of *Sphagnum* fluctuate. Regular presence of Filicales monolete; single spores of *Pteridium aquilinum* in the lower part of the subzone. A sharp decrease in *Assulina*, the lack of *Amphitrema flavum*. Constant presence of *Sordaria* type spores. The zone shows the highest taxonomic variety in the whole diagram (rarefacted number of taxa analysis). A sharp rise in the concentration of 20–100 µm charcoal particles (reaches about 58×10^3particles/cm^3).	A fall in NAP values and a rise in *Pinus sylvestris* type percentage values.

Table 2. Continued

L PAZ. Depth (cm)	Description	Top boundary description
PM-3b NAP (*Pinus*). 17.5–2.5	A rise in AP sum values, of which main components are *Pinus sylvestris* type, *Betula* undiff., and *Picea abies*; high percentage values are still characteristic for Poaceae undiff. There is a noticeable fall in *Calluna vulgaris* curve; percentages of *Vaccinium* type reached their maximum. Frequency of *Secale cereale* and *Ambrosia artemisifolia* type is rising. The continuous curve of *Humulus*/*Cannabis* disappears. *Assulina* tests are the most abundant in the whole diagram (max. 20.5%). Decreasing trend in the concentration of 20–100 µm charcoal particles. A fall in pollen concentration values.	A fall in *Pinus sylvestris* type and a rise in *Betula* undiff. and *Picea abies*.
PM-3c. NAP (*Hypericum*) 2.5–0.00	Only one spectrum represents this zone. The frequency of *Pinus sylvestris* type is falling. An increase in *Betula* undiff., *Picea abies*, and *Quercus* percentage values. High values of NAP sum, of which the most abundant are Poaceae undiff., *Hypericum perforatum* type (max. 10%), *Calluna vulgaris*, and *Trifolium repens* type (max. 2.5%). A sharp increase in *Sphagnum* spore abundance (max. 49.5%). *Assulina* represents non-pollen microfossils. A fall in the concentration of charcoal particles (20–100 µm).	

ConSLink method (Constrained Single Link of samples; Birks 1986, Janczyk-Kopikowa 1987). A shortened description of L PAZ from both profiles is presented in Tables 2, 3.

REGIONAL AND LOCAL VEGETATION CHANGES

PM-1 *Alnus-Pinus* L PAZ, PKra-1 *Picea-Fagus-Abies-Alnus* L PAZ (ca 100 BC–500 AD)

High percentage values of trees and shrubs in the profile confirm that the area was heavily forested with alder woods being most common. *Pinus sylvestris*, *Betula alba*, and *B. pubescens* might have grown on the laggs and surroundings of peat bogs. The surroundings were covered with mezophilous woods with *Picea abies*, *Abies alba*, and *Fagus sylvatica* where *Quercus* and *Carpinus betulus* were an admixture. The higher percentage values of hornbeam in both layers dated back to the period between the 3rd and the 6th century AD. There were sporadic findings of cereal pollen along with an irregular presence of coprophilous fungi spores, which may indicate minor agricultural and pastural activity in the region. In the 6th –7th century AD visible deforestation took place on the Puścizna Krauszowska peat bog, which is demonstrated by the abundance of Poaceae undiff, *Rumex acetosa* type, and *Plantago lanceolata*. The high percentage values of *Tilletia sphagni*, connected with an increase of *Sphagnum* spores, in the Puścizna Mała profile may indicate a more abundant presence of *Sphagnum cuspidatum* on the peat bog. This species is more prone to infection caused by this fungus than other taxa within the *Sphagnum* genera (van Geel 1978). Between the 2nd century BC and the 6th century AD there is a significant rise in the number of the testate amoebae *Amphitrema flavum* and *Assulina* sp. in both profiles. *Amphitrema flavum*, in particular, which is a hygrophilous species with an optimum water depth of 5.8 cm and pH 4.05, may suggest that the water depth was relatively rather stable (Tolonen 1986, Lamentowicz & Mitchell 2004). Between the 3rd and the 7th century AD there was a sudden reduction in water depth on the peat bog, which is demonstrated by a sharp decrease in amoeba tests and an increase in pine values, probably as this tree colonized the dome of the Puścizna Mała peat bog. The next high frequency rise in *Amphitrema flavum* and *Assulina* sp. values in the profile from Puścizna Mała is correlated with the retreat of *Pinus sylvestris* from the peat bog surface and dates back to the 6th–7th century AD. It may be attributed to an increase in precipitation and a rise in the water table on the peat bog.

The order of layers in the profile from Puścizna Krauszowska was reversed (probably as a result of human peat extraction) at depths of 43–24 cm, so this section was not interpretable. For this reason it was not included in the data set.

PM-2 *Picea-Fagus* L PAZ (ca 500–1400 AD)

The area covered by alder woods was reduced in this zone. The region came to be

Table 3. Puścizna Krauszowska. Description of the local pollen assemblage zones (L PAZ).

L PAZ. Depth (cm)	Description	Top boundary description
PKra-1 *Picea-Fagus-Abies*. 97.5–21	The highest values are reached by *Picea abies* (9.5–26.0%), *Fagus sylvatica* (9.0–17.5%), *Abies alba* (7–20%), *Alnus* undiff. (4.0–12.5%), *Quercus* (3.5–9.0%), *Carpinus betulus* (2.5–9.0%), *Ulmus* (0.5–3.0%), *Corylus avellana* (1.5–3.5%), and *Fraxinus excelsior*. High percentage values are characteristic of *Pinus sylvestris* type, and *Betula* undiff. Increase in frequency NAP components, of which Poaceae undiff., *Artemisia* and *Calluna vulgaris* are characteristic from constant occurrence in the middle of the zone; *Plantago lanceolata*, *Rumex acetosa* type, and *Vaccinium* type are present in most of samples. The continuous curves of Cerealia type, *Secale cereale* and *Triticum* type appear in the upper part. Pollen of Cyperaceae is present in low values; single grains of *Phragmites australis* type occur. Among cryptogams the most common are spores of *Sphagnum*; Filicales monolete have a low percentage value curve, *Pteridium aquilinum* spores are present almost in every spectrum. Continuous curves of testate amoebae *Assulina* and *Amphitrema flavum* (max. 22%) disappear in the upper part of the zone. Abundant spores of *Tilletia sphagni, Ustulina* cf. *deusta*, and *Sporormiella* type are present in most of the samples. In the upper part of this zone more spores of *Gelasinospora* type (max. 1.3%) were found. The number of 20–100 µm charcoal particles µm increases in the upper part and >100 µm charcoal particles reach their maximum (about 1.2×10^3/cm^3). There is a gradual increase in taxonomic variety. ConSLink analysis confirmed that all spectra belong to this zone.	Decrease in *Picea abies*, *Abies alba*, *Fagus sylvatica*, increase in NAP.
PKra-2 NAP. 21–0.75	Sharp decrease in curves of *Picea abies* (it increases again in the upper part), *Abies alba* and *Fagus sylvatica*. A sudden rise and then a fall is characteristic of NAP values. *Ambrosia artemisifolia* type pollen is present in all samples. Firstly, concentration of charcoal particles (20–100 µm) sharply raise and then they fall. Taxonomic variety is still on the constant high level. ConSLink analysis confirmed that all spectra belong to this zone.	
PKra-2a NAP (*Calluna*). 21–10.25	Percentage values of *Picea abies*, *Abies alba*, *Fagus sylvatica*, and *Ulmus* sharply decrease. A gradual rise of the *Pinus sylvestris* type curve. The frequency of *Salix* undiff. and *Sambucus nigra* type slightly increase. A sudden rise and then a fall is characteristic of NAP values. There is a noticeable increase in the frequency of *Calluna vulgaris* (max. 29%) and Poaceae undiff. (max. 20%). Cerealia type (max. 3.5%), *Secale cereale* (max. 3%), *Triticum* type (max. 1.5%), *Avena* type (max. 1%), *Plantago lanceolata* (max. 3%), *Rumex acetosa* type (max. 4.5%), Brassicaceae, Chenopodiaceae, and *Phragmites australis* type (max. 2.5%) reach the highest percentage values in the diagram. There is a maximum of concentration of charcoal with a 20–100 µm (about 115.8×10^3/cm^3) and presence of the continuous curve of >100 µm charcoal particles. Continuous curves are characteristic of *Gelasinospora* type, *Sporormiella* type, and *Sordaria* type as well. ConSLink analysis confirmed that all spectra belong to this subzone.	Fall in *Calluna vulgaris* curve.
PKra-2b NAP (*Pinus*). 10.25–0.75	NAP values decrease noticeably. Rise and then a fall in the *Pinus sylvestris* type frequency (max. 36%). Gradually increase in abundance of *Betula* undiff. (max. 20%). The *Vaccinium* type curve (max. 5%) is rising, but frequency of *Calluna vulgaris* is falling sharply. There is an increase and then a decrease in the *Urtica* curve (max. 5%) and regular occurrence of *Ambrosia artemisifolia* type (max. 1.5%). At the depth of 10 cm Cyperaceae pollen values reach their maximum (31.5%). Decrease in values of charcoal particles. A noticeable rise in *Assulina* values (max. 14.5%). ConsLink analysis confirmed that all spectra belong to this subzone.	

dominated by mesophilous forests with *Picea abies*, *Fagus sylvatica* and *Abies alba*. During the first phase the water level probably rose. This caused a retreat of pine, and species of birch entered some of its abandoned habitats. A similar exchange was observed in the case of spruce and fir. At first spruce outnumbered fir, but then the latter became the dominant component of forests in the younger phase. There was also a slight reduction in the area covered by woodlands (most significantly in the 9th–11th century), which was connected with the presence of *Secale cereale* and a rise in the frequency of taxa representing ruderal and meadow communities, of which the most abundant were *Artemisia*, *Rumex acetosa* type, and *Plantago lanceolata*. In the younger part of this zone, which dates back to the 13th–14th century, another decrease in forest size then took place, which is correlated with the spread

Fig. 2. Percentage pollen diagram from the Puścizna Mała site. 1 – Tb, *turfa bryophytica*; 2 – Th, *turfa herbacea*; 3 – Sh, *substantia humosa*; 4 – Tb1-3, Th, Sh; 5 – Tb4; 6 – Tb4, Th; 7 – Tb4, Sh; 8 – Tb4, Th, Sh.

of members of the Ericaceae particularly *Vaccinium* spp. or *Oxycoccus*, and a gradual increase in crop production areas, meadows and pastures. In this zone, similar to the Subatlantic period in the profile from Puścizna Rękowiańska analysed by Obidowicz (1996), there were the most numerous occurrences of *Betula nana* type pollen, which may simply represent the existence of relict populations of this taxon on the Puścizna Mała peat bog. Specimens of *Betula nana* were still present in the 19th century on peat bogs in the Nowotarska Basin (Lubicz-Niezabitowski 1922). There was a high water table in this zone, which promoted the presence of hygrophilous amoebae like *Amphitrema* (particularly at the bottom of PM-2) and *Assulina* as well as *Drosera*. Peat bogs became more eutrophic in the upper parts of this zone and this reduced the number of testate amoebae. Moreover, in most of the samples there were ascospores of *Ustulina* cf. *deusta*, which is parasite of trees and occur on the lower parts of deciduous trees. They also need high temperatures (optimum at 25–30°C) during the sporulation period (van Geel & Andersen 1988). The more frequent occurrence of this taxon may be a result of climate warming in medieval times, as well as suggesting the presence of trees on the peat bog dome.

Subzones PM-3a and PKra-2a NAP (*Calluna*) (ca 1400–1900 AD)

In these subzones the forested areas were strongly affected by intense arable and pastural farming, hence their shrinkage. Fir-beech forests were mostly destroyed along with spruce. Areas of cereal cultivation expanded, most commonly rye, and to a lesser extent barley and oats. The highest percentage values of *Humulus/Cannabis* pollen in the older part of subzone PM-3a may be connected with hemp cultivation or the existence of hop thickets. There were expanding areas covered by ruderal communities (an increase in the Chenopodiaceae and Brassicaceae curves), pastures and mown meadows (a rise in Poaceae undiff., *Plantago lanceolata*, *Rumex acetosa* type, and *Ranunculus acris* type). The most intense pastural activity in the whole diagram is confirmed by the regular presence of coprophilous fungi like *Sporormiella* type (PKra-2a) and *Sordaria* type (PM-3a and PKra-2a). A fall in water level probably caused by drainage and/or eutrophication seems to be the reason for the disappearance of the hygrophilous testate amoebae. This contributed to the expansion of *Calluna vulgaris* on the peat bog domes in both subzones and a rise in *Juniperus* values in PM-3a. The increasing size of the area covered by nitrophilous communities on the edges of peat bogs is demonstrated by an increase in the *Urtica* and *Sambucus nigra* curves (on the edge of the Puścizna Krauszowska peat bog). The highest *Tilletia sphagni* values at a depth of 25 cm in PM-3a and a sharp rise in the number of *Sphagnum* spores, similar to subzone PM-1, may indicate the abundant presence of *Sphagnum cuspidatum* on the peat bog. However, the lack of *Amphitrema* tests suggests that water the level fell, making the presence of this highly hygrophilous species of *Sphagnum* impossible.

The continuous curve of *Ambrosia artemisifolia* type that appears at depths of 27.5 cm in PM-3a and 21 cm in PKra-2a probably records the rapid expansion of North American species of the genus *Ambrosia* in the south of Europe (Hungary?), which have been recorded since the 19th century and spread particularly in the 1920s after World War I (Makra et al. 2005). The first records of the presence of *Ambrosia* in western, south-western and northern parts of Poland come from the second half of the 20th century (Chłopek & Tokarska-Guzik 2006). The date obtained from a depth of 27.5 cm indicated the14th–15th century, apparently very early, as discussed later, and another from a depth of 15.5 cm indicates the 1950s.

Subzones PM-3b and PKra-2b NAP (*Pinus*) (ca 1900–2000 AD)

In those subzones *Pinus sylvestris* covered wide areas and might have occurred on the peat bog surface after drainage. Birch was also more common. Open area vegetation was reduced, which is confirmed by a fall in the sum of NAP values, of which the decrease in *Calluna vulgaris* is most significant. This change is mostly visible in PKra-2b. In the profile from Puścizna Mała a reduction in the occurrence of heather is correlated with a decrease in *Juniperus* pollen values. In this site a probable fall in pastural activity is demonstrated by a decrease in the number of coprophilous fungi spores. A reduction in hemp cultivation and/or in the area of hop thickets also took place then. At the beginning of the PKra-2b subzone, the role of nettle became more significant in ruderal areas rich in nitrogen. However, its values fell in the younger part of the zone. The reappearance of *Assulina* tests without the presence of *Amphitrema flavum* in sediments might have been a result of the occurrence of the xerophylous taxa *Assulina muscorum*. A single finding of *Utricularia* pollen at a depth of 9.75 cm in subzone PKra-2b may suggest the presence of small water bodies or holes after peat exploatation. In both subzones *Ambrosia artemisifolia* type reached the highest percentage values, which can be attributed to the spread of this taxon in southern, central and eastern Europe after World War II (Dahl et al. 1999). At present *A. artemisifolia* is thought to be a non-native invasive plant in Poland (http://www.iop.krakow.pl/ias/Gatunek.aspx?spID=34).

PM-3c NAP (*Hypericum*) L PAZ

This subzone is represented by a surface sample, which presents the most recent history of the peat bog. In its vicinity birch and spruce became more abundant. The very low pollen concentration is the result of the loose peat structure. The presence of plentiful *Hypericum* pollen is probably caused by the local occurrence of *Hypericum maculatum* and indicates a local expansion of this taxon. In contrast with PKra-2b, there was an increase in *Urtica* values, which indicates a rise in nitrogen levels in soil in the surroundings of the Puścizna Mała peat bog.

AN ANALYSIS OF THE HUMAN IMPACT RECORDED IN THE PUŚCIZNA MAŁA AND PUŚCIZNA KRAUSZOWSKA POLLEN PROFILES

The cereal pollen that was found at depths of 135.0–102.5 cm in the profile from Puścizna Mała (Fig. 4) and its single occurrences at depths of 91–69 cm in the profile from Puścizna Krauszowska (Fig. 5) may indicate the activity of peoples from the Przeworsk Culture. The maximum hornbeam occurrence in the former profile, which dates back to the 3rd–6th century may be attributed to the expansion of this taxon in the areas abandoned by people in the migration period. *Carpinus betulus* is considered to be a taxon whose spread is favored by deforestation caused by people (Ralska-Jasiewiczowa & van Geel 1998). In the light of the historical data it is difficult to explain a slight decrease in the sum of trees and shrubs, which is correlated with an increase in *Secale cereale*, *Plantago lanceolata*, and *Rumex acetosa* type at depths of 82.5–67.5 cm, of which the most visible manifestation dates back to 849–1048 AD in the profile from Puścizna Mała. These are probably signs of Slavic activity from the tribal period or from the embryonic nation, which are not recorded in the historical records. Dobrowolski (1970) points to the fact that the rich alluvial soils near modern Ludźmierz were places where local people could have made attempts at cereal cultivation at the turn of the 12th and the 13th century. This might later favour the location of the city. Different alluvial areas were probably exploited by Slavs in the same way. It must be added that the sparse occurrences of cereal pollen in zones PM-1, PM-2 and PKra-1 may indicate long distance transport.

Heavy deforestation of the Puścizna Mała site, attributed to medieval settlement, becomes visible from a depth of 52.5 cm and the date from this point indicates the13th–14th century. These changes may correspond to the beginning of medieval settlement in the Orawa and Podhale areas.

Zones PM-3a and PKra-2 which span the period from medieval times to the beginning of the 20th century represent the highest human activity which can be seen in the highest proportions of open area communities in the Orawa-Nowy Targ Basin. The drainage of peat bogs allowed the expansion of *Calluna vulgaris* on their domes and the rise in coprophilous fungi spores suggests the presence of pastures on them. Cereal fields expanded to their largest extent recorded during the last 2000 years. They are characterized by the domination of *Secale* and *Triticum*, together with *Hordeum* and *Avena*. At a depth of 40 cm in PM-3a maze pollen (*Zea mays*) was found which began to be cultivated in Poland at the end of the 16th century or at the beginning of the 17th century, after its cultivation in Romania or Hungary (http://www.e-kukurydza.pl/historia-uprawy.php). However, the occurrence of a single grain is of doubtful value and contamination cannot be excluded. An increase in Brassicaceae values may point to the first rapeseed cultivation as well as to the presence of a larger number of ruderal and crop weeds which belong to this family. A growing population and intense pastural activities led to a higher nitrification of habitats and thus the expansion of nitrophilous communities.

A sharp rise in the frequency of charcoal fragments (20–100 µm) correlated with sporadically occurring fragments of more than 100 µm in size, which are considered to be indicators of local fires (Toney & Anderson 2006), suggest fires on the small areas of the peat bogs or some extraneous origin. In both zones the most numerous occurrences of *Gelasinospora* (Type 1) spores were recorded, and this too is thought to be an indicator of fires (van Geel 1978, Feeser & O'Connel 2009). Fires on the peat bogs in the Orawa-Nowy Targ Basin were at first started accidentally on pasture land, and especially in dry periods large areas burned. Such areas were firstly used for pasture and then for cultivation (Łajczak 2007).

The large falls in tree and shrub taxa values at depths of 32.5–22.5 cm in the diagram from Puścizna Mała probably took place in the 19th century and might be a result of the economic development of Czarny Dunajec. Above a depth of 27.5 cm there is a continuous curve of *Ambrosia artemisifolia* type, which may confirm the above date of change. A radiocarbon date from a depth of 27.5 cm (the part where the strongest deforestation is visible) indicated the 1386–1450 AD period. However, because this would be before the foundation of Czarny Dunajec, in the light of palynological evidence this date must be too old, as also surely indicated by the presence of *Ambrosia*.

In the profile from Puścizna Krauszowska the curve of *Ambrosia artemisifolia* type begins with a large decrease in AP, which indicates a discontinuity between the presence of medieval sediments and those from the 19th century. This could be the result of the intense peat exploitation which took place in the 19th–20th century (comp. Łajczak 2007). The reversal of dates in the profile from Puścizna Krauszowska, at least in the section between depths of 43 cm and 24 cm, probably indicates exploitation on the peat bog dome itself and not only on its edges. Several ways of exploiting peat bogs in the Orawa-Nowy Targ Basin have been described. The first historically documented was sheep and cattle grazing (Łajczak 2007). Lubicz-Niezabitowski (1922) pointed to the gathering of peat surface layers from the tops of the peat bog domes and using them as bedding. When this practice was abandoned then *Sphagnum* mosses were gathered from purpose-made holes in the summit of peat domes for export and use in the production of shoe liners. However, peat bogs were mostly exploited for fuel in this area, especially from the period of 1850–1880 it became popular and the rate of its exploitation escalated up until the 1980s (Łajczak 2007). Jostowa (1963) writes that it was the main fuel in the local villages of Podhale and Orawa until the 1960s.

An increase in tree and shrub pollen values in subzones PKra-2b and PM3-b is probably a result of the spread of pine and birch on the dome surfaces of drained peat bogs. However, when taxa potentially present on a peat bog, such as *Pinus*, *Betula* and *Alnus*, are not taken into account a slight increase in trees and shrub values is still visible. This suggests an expansion of forests in the region.

A fall in pine values in the upper samples may be caused by the withdrawal of this taxa from the peat bog surface due to a recent rise in the level of water available.

Interesting occurrence of *Comandra elegans* pollen was recorded in the PKra-1 (twice) and PKra-2b (once) zones. This plant is not indigenous to Poland (Mirek et al. 1995). It occurs as part of the native flora in Bulgaria and northern Greece (Jallas & Suominen eds 1988), and its closest isolated populations can be found in northern Romania. Hence, there is no possibility of any historical presence in Poland, and these findings may be the result of long distance transport. This fact shows the wide area from which vegetation changes are recorded by peat bogs within the Orawa-Nowy Targ Basin and needs to be taken into consideration when the presence of people in premedieval times is being considered.

PALYNOLOGICAL DATA FROM PUŚCIZNA MAŁA AND PUŚCIZNA KRAUSZOWSKA PEAT BOGS IN A REGIONAL CONTEXT

So far, in all those profiles from within the Orawa-Nowy Targ Basin which have been analysed, only one from Puścizna Rękowiańska has any dating evidence for those upper parts, which span the last 200 years. These dates were obtained using a ^{210}Pb method at intervals of 2 cm. A noticeable decrease in the proportion of trees and shrubs in the upper part of this

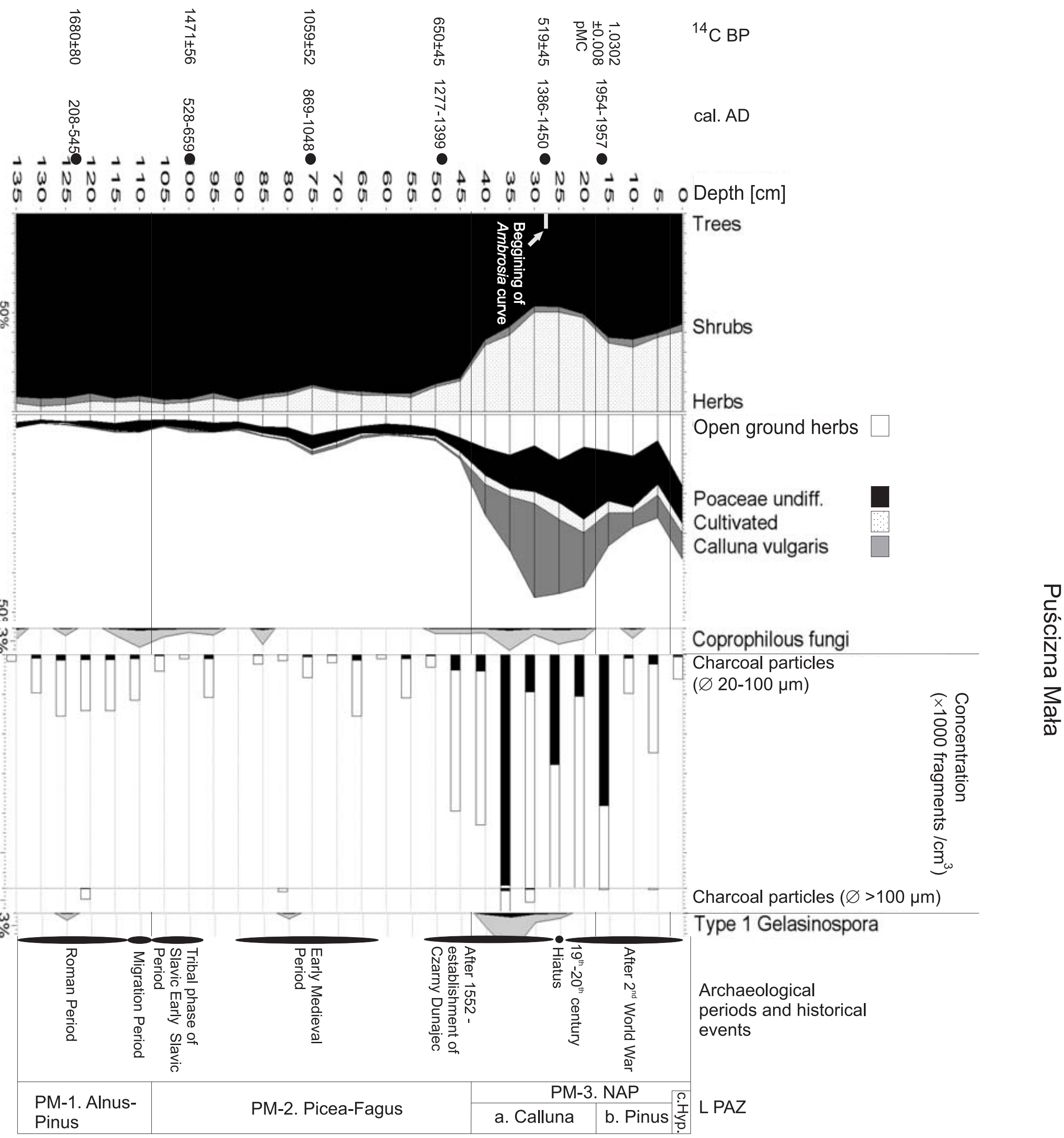

Fig. 4. Summary diagram of human impact from the Puścizna Mała

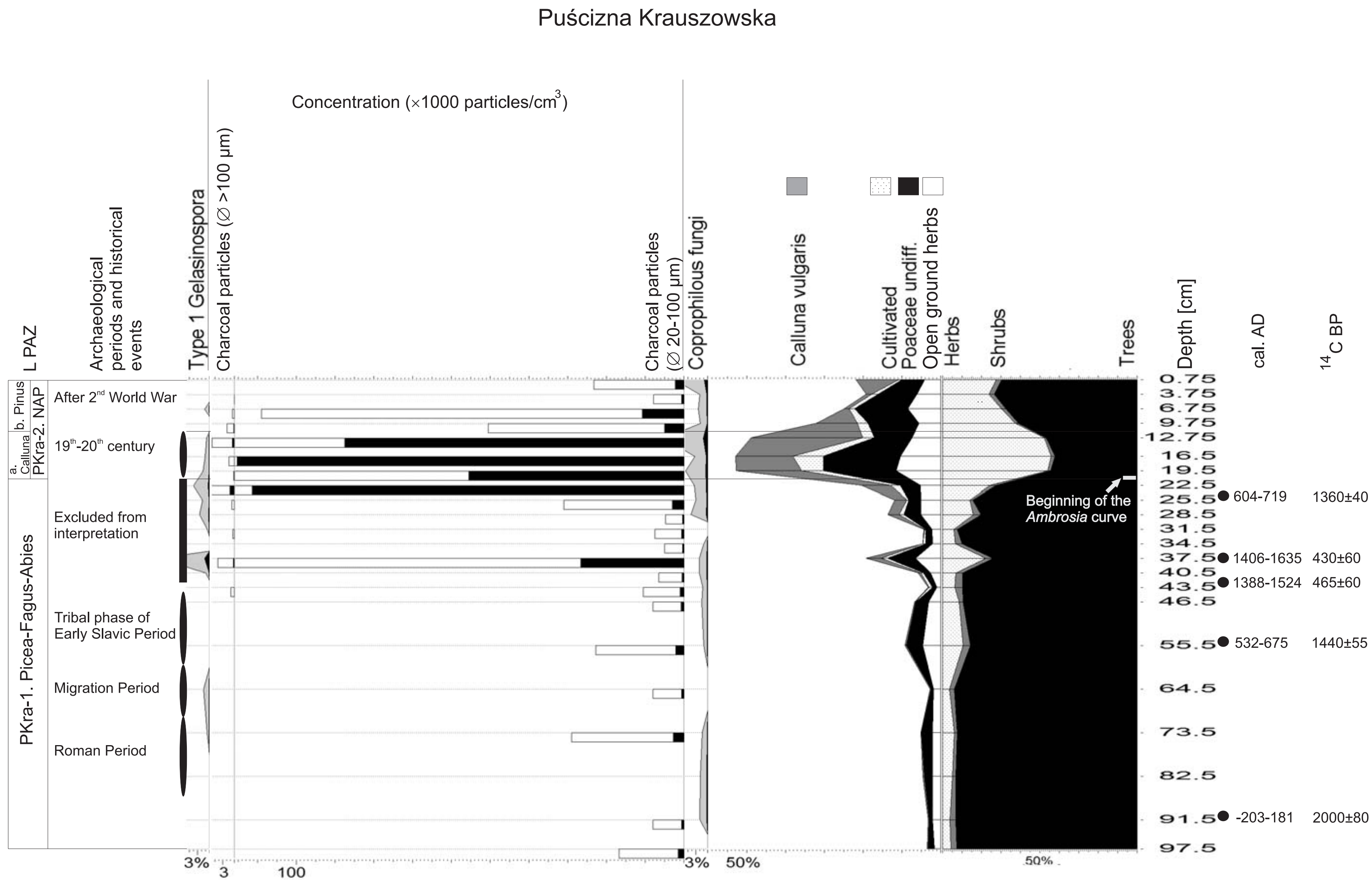

Fig. 5. Summary diagram of human impact from the Puścizna Krauszowska sites

profile took place in the 17th century. However, the results are of uncertain value due to the method used (Hołyńska et al. 1998). Additionally, at depths of 34–36 cm, as in the bottom parts of the PM-3 and PKra-2 zones, a sharp decrease in *Fagus sylvatica* and *Abies alba* was recorded. Similar considerable decreases in AP were also present in the upper parts of other profiles within the Nowy Targ Basin such as Puścizna Rękowiańska (subzones PR-10b, PR-10c and the part of the subatlantic chronozone associated with the 16th century according to Koperowa), Bór na Czerwonem (zone BC-6), Przymiarki (zone PZ-6) and Grel (Koperowa 1962, Obidowicz 1990, 1996). In most of the sites such a decrease is correlated with a strong increase in Ericaceae pollen values, what can be attributed to the expansion of *Calluna vulgaris* on drained peat bogs, and is also recorded in the PM-3a and PKra-2a subzones.

A particular phenomenon, which was recorded in the Puścizna Krauszowska profile, is a reversal, in other words an overturning of sediments, at least in the part between depths of 43–24 cm, which has been confirmed by radiocarbon datings. It is worth noticing a single spectrum from a depth of 37.5 cm, which represents a considerable decrease in AP values simultaneous with an increase in the values of cultivated and open area plants. A similar decline in the AP curve correlated with a rise in synanthropic plants was recorded in the profile from Puścizna Rękowiańska at a depth of 50 cm (subzone PR-10a) and allocated to the beginnings of medieval settlement, which started in 1234 (Obidowicz 1990). Because the profile from Puścizna Mała consists of sediments in chronological order and such a decrease in AP was not recorded, this suggests that the Puścizna Rękowiańska profile also probably shows a time reversal of younger sediments. Moreover, the trend of pollen taxa curves, as well as the *Amphitrema flavum* curve in the bottom parts of the PKra-1 and PM-1, 2 zones is very similar to that of the PR-9 zone in the profile from Puścizna Rękowiańska.

CONCLUSIONS

Firstly, the Puścizna Mała (1.35 m) and Puścizna Krauszowska (1.0 m) profiles record the succession of vegetation during the last 2000 years. In both profiles probable traces of human activity associated with people of the Przeworska Culture and then of tribal period Slavs were discovered. The subsequent layers in Puścizna Mała represent the strongest human impact from the development of settlement in medieval times and after the 13th century. Reversal of radiocarbon dates between 7th and 17th century in the Puścizna Krauszowska profile caused exclusion of this part from interpretation. The layer above this part represents period of the strongest deforestation, similar to that found in the Puścizna Mała profile.

Secondly, the high percentage values of charcoal particles in the upper parts of the profiles is probably caused by peat bog fires and/or an increase in the number of homesteads heated with wood, as well as emissions from the nearby steelworks in Kościelisko, and from large industrial plants established in the 20th century.

Furthermore, single findings of *Comandra elegans* pollen and the constant occurrence of *Ambrosia artemisifolia* type pollen, normally associated with the 19th and the 20th century, in the upper parts of the profiles are the results of long distance transport. The question of such transport is very important when interpreting the traces of human activity during the Slavic and early medieval period, because we lack information from historical and archaeological sources.

Finally, analysis of selected non-pollen palynomorphs showed significant interdependences between human activity, climate changes and the water level on the peat bogs.

ACKNOWLEDGEMENTS

We wish to express our gratitude to the anonymous reviewers for useful comments, which helped us to improve the manuscript. This research was financially supported by the Ministry of Science and Higher Education (Ministerstwo Nauki i Szkolnictwa Wyższego) – grant No N N304 275134, as well as by the Society of PhD Students of the Jagiellonian University (Towarzystwo Doktorantów UJ) which supported language revision.

REFERENCES

BEUG H.-J. 2004. Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende Gebiete. Verlag Dr. Friedrich Pfeil, München.

BIRKS H.J.B. 1986. Numerical zonation, comparison and correlation of Quaternary pollen-stratigraphical data: 743–774. In: Berglund B.E. (eds), Handbook of Holocene Palaeoecology and Palaeohydrology. J. Wiley & Sons, Chichester.

BRONK RAMSEY C. 2009. Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1): 337–360.

DAHL A., STRANDHEDE S.-O. & WIHL J.-A. 1999, Ragweed – an allergy risk in Sweden. Aerobiologia, 15: 293–297.

CHŁOPEK K. & TOKARSKA-GUZIK B. 2006. Pyłek ambrozji (*Ambrosia*) w aeroplanktonie Górnego Śląska. Acta Agrobot., 59(1): 335–345.

CZACHURA S. 2003. Browar klasztorny w Szczyrzycu. Almanach Ziemi Limanowskiej, 12: 17–18.

DOBROWOLSKI K. 1970. Najstarsze osadnictwo Podhala: 23–88. In: Antoniewicz W., Dobrowolski K. & Paryski W.H. (eds), Studia Podhalańskie i bibliografia pasterstwa Tatr i Podhala. Ossolineum, Wrocław-Warszawa-Kraków.

DYAKOWSKA J. 1928. Historia torfowiska na Czerwonem pod Nowym Targiem w świetle analizy pyłkowej. Spraw. Kom. Fizjogr. PAU, 63: 128–150.

FAEGRI K. & IVERSEN J. 1989. Textbook of Pollen Analysis. 4th edition. John Wiley & Sons, Chichester.

FEESER I. & O'CONNEL M. 2009. Fresh insight into long-term changes in flora, vegetation, land use and soil erosion in the karstic environment of the Burren, western Ireland. Journal of Ecology, 97: 1083–1100.

FIAŁKIEWICZ-KOZIEŁ B. 2010. Dynamika zmian zanieczyszczenia metalami ciężkimi na przykładzie wybranych torfowisk Kotliny Orawsko-Nowotarska (Dynamic in heavy metal concentrations using ombrotrophic peat bogs from Orawa-Nowy Targ Basin). PhD thesis, Silesian University.

van GEEL B. 1978. A palaeoecological study of Holocene peat bog section in Germany and The Netherlands, based on the analysis of pollen, spores and macro- and microscopic remains of fungi, algae, coprophytes and animals. Rev. Palaeob. Palynol., 31: 367–448.

van GEEL B. & ANDERSEN S.T. 1988. Fossil ascospores of the parasitic fungus *Ustulina deusta* in Eemian deposits in Denmark. Rev. Palaeobot. Palynol., 56: 89–93.

van GEEL B., BOHNECKE S.J.P & DEE H. 1981. A palaeoecological study of an upper Late Glacial and Holocene sequence from “De Borchert”, The Netherlands. Rev. Palaeobot. Palynol., 31: 367–448.

van GEEL B., ZAZULA G.D. & SCHWEGER CH.E. 2007. Spores of coprophilous fungi from under the Dawson tephra (25 300 ^{14}C years BP), Yukon Territory, northwestern Canada. Palaeogeogr., Palaeoclimat, Palaeoecol., 252: 481–485.

van GEEL B., BUURMAN J., BRINKKEMPER O., SCHELVIS J., APTROOT A., van REENEN G. & HAKBIJL T. 2003: Environmental reconstruction of a Roman Period settlement site in Uitgeest (The Netherlands), with special reference to coprophilous fungi. J. Archaeol. Sc., 30: 873–883.

HOŁYŃSKA B., OSTACHOWICZ B., OSTACHOWICZ J., SAMEK L., WACHNIEW P., OBIDOWICZ A., WOBRAUSCHEK P., STRELI C. & HALMETSCHLAGER G. 1998. Characterisation of ^{210}Pb dated peat core by various X-ray fluorescence techniques. The Science of the Total Environ., 21: 239–248.

JALLAS J. & SUOMINEN J. (eds),1988. Atlas florae Europaeae, distribution of vascular plants in Europe II. Cambridge University Press: 99.

JANCZYK-KOPIKOWA Z. 1987. Uwagi na temat palinostrtygrafii czwartorzędu (summary: Remarks on Palynostratigraphy of the Quaternary). Kwart. Geol., 31(1): 155–162.

JOSTOWA W. 1963. Materiały do zagadnień gospodarki chłopskiej w „Borach” Orawskich (summary: Materials concerning the problem of peasant economy in in the region Bory Orawskie). Lud, 2: 503–554.

KIRYK F. (ed.) 1997. Czarny Dunajec i okolice. Zarys dziejów do roku 1945. Wydawnictwo i Drukarnia “Secesja”, Kraków.

KOCZUR A. 2006. Importance of vegetation in the Orawsko-Nowotarskie peat bogs to biological diversity in the Polish Carpathians. Acta Agrophysica, 7(2): 383–393.

KONDRACKI J. 2002. Geografia regionalna Polski. Wydawnictwo Naukowe PWN, Warszawa.

KOWANETZ L. 1998. On the method of determining the climatic water balance in mountainous areas with an example from the Polish Carpathians. Pr. Geogr. IG UJ, 105: 137–164.

LAMENTOWICZ M. & MITCHELL E. A. D. 2005. The ecology of testae amoebae (Protists) in *Sphagnum* in north-western Poland in relation to peatland ecology. Microbial Ecol., 50(1): 48–63.

LORENC H. (ed.) 2005. Atlas Klimatu Polski. IMGW. Warszawa.

LUBICZ-NIEZABITOWSKI E. 1922. Wysokie torfowiska Podhala i konieczność ich ochrony. Ochr. Przyr., 3: 26–34.

ŁADYGIN Z. 1984. 7 dni na Orawie Polskiej. Przewodnik turystyczny. PTTK Kraj, Warszawa-Kraków.

ŁAJCZAK A. 2006. Torfowiska Kotliny Orawsko-Nowotarskiej. Rozwój, antropogeniczna degradacja, renaturyzacja i wybrane problemy ochrony. W. Szafer Institute of Botany Polish Academy of Sciences, Kraków.

ŁAJCZAK A. 2007. Natura 2000 in Poland, Area PLH120016 the Orawsko-Podhalańskie peatlands. W. Szafer Institute of Botany Polish Academy of Sciences, Kraków.

MAKRA L., JUHÁSZ M., BÉCZI R. & BORSOS E. 2005. The history and impacts of airborne *Ambrosia* (Asteraceae) pollen in Hungary. Grana, 44: 57–64.

MILATA W. 1955. Klimat Kotliny Nowotarskiej i jego zmiany spowodowane budową zbiornika wodnego w dolinie Dunajca. Wszechświat, 2: 58–63.

MIREK Z., PIĘKOŚ-MIRKOWA H., ZAJĄC A. & ZAJĄC M. 1995. Vascular plants of Poland: a checklist. *Pol. Bot. Stud., Guidebook Series*, 15: 1–303.

MOORE P.D., WEEB J.A. & COLLINSON M.E. 1991. Pollen analysis. Blackwell Scientific Publications, Oxford.

NALEPKA D. & WALANUS A. 2003. Data processing in pollen analysis. Acta Palaeobot., 43(1): 125–134.

OBIDOWICZ A. 1990. Eine Pollenanalytische und Moorkundliche Studie zur Vegetationsgeschichte des Podhale-Gebietes (West-Karpaten). Acta Palaeobot., 30(1,2): 147–219.

OBIDOWICZ A. 1996. A Late Glacial-Holocene history of the formation of vegetation belts in the Tatra Mts. Acta Palaeobot., 36(2): 159–206.

PETERSCHILKA F. 1927. Pollenanalytische Untersuchungen der "Borysümpfe" in Polen. Ber. Deutsch. Bot. Ges., 45: 368–373.

PUNT W. & HOEN P. P. 2009. The Northwest European Pollen Flora, 70, Asteraceae – Asteroideae. Rev. Palaeobot. Palynol., 157: 22–183.

RALSKA-JASIEWICZOWA M. & van GEEL B. 1998. Human impact on the vegetation of the Lake Gościąż surroundings in prehistoric and early-historic times: 267–294. In: Ralska-Jasiewiczowa M., Goslar T., Madeyska T. & Starkel L. (eds), Lake Gościąż, Central Poland a monographic study, part 1. W. Szafer Institute of Botany Polish Academy of Sciences, Kraków.

RALSKA-JASIEWICZOWA M., LATAŁOWA M., WASYLIKOWA K., TOBOLSKI K., MADEYSKA E., WRIGHT H.E.Jr. & TURNER C. (eds), 2004. Late Glacial and Holocene history of vegetation in Poland based on isopollen maps. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

REIMER P.J., BAILLIE M.G.L. BARD E., BAYLISS A., BECK J.W., BERTRAND C.J.H., BLACKWELL P.G., BUCK C.E., BURR G.S., CUTLER K.B., DAMON P.E., EDWARDS R.L., FAIRBANKS R.G., FRIEDRICH M., GUILDERSON T.P., HOGG A.G., HUGHEN K.A., KROMER B., MCCORMAC G., MANNING S., BRONK RAMSEY C., REIMER R.W., REMMELE S., SOUTHON J.R., STUIVER M., TALAMO S., TAYLOR F.W., van der PLICHT J. & WEYHENMEYER C.E. 2004. IntCal04 terrestrial radiocarbon age calibration, 0–26 cal. kyr. BP. Radiocarbon, 46: 1029–1058.

SEMKOWICZ W. 1932. Materiały źródłowe do dziejów osadnictwa Górnej Orawy, vol. 1: Dokumenty. Zakopane.

STOCKMARR J. 1971. Tabletes with spores used in absolute pollen analysis. Pollen et Spores, 13(4): 615–621.

TOBOLSKI K. 2000. Przewodnik do oznaczania torfów i osadów jeziornych. Wydawnictwo Naukowe PWN, Warszawa.

TOLONEN K. 1986. Rhizopods analysis: 645–666. In: Berglund B. E. (ed.), Handbook of Holocene Palaeoecology and Palaeohydrology. John Wiley & Sons Ltd, Chichester–New York–Brisbane–Toronto–Singapore.

TONEY J.L. & ANDERSON R.S. 2006. A postglacial palaeoecological record from the San Juan Mountains of Colorado USA: fire, climate and vegetation history. The Holocene, 16: 505–517.

TRAJDOS T.M. 1993. Dzieje i kultura Orawy. Wydawnictwo „Secesja", Kraków.

WARDENAAR E.P.C. 1986. A new hand tool for cutting peat profiles. Canad. Jour. Bot. 65: 1772–1773.

http://www.e-kukurydza.pl/historia-uprawy.php

http://www.iop.krakow.pl/ias/Gatunek.aspx?spID=34