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ENVIRONMENTAL CHANGES IN THE VICINITY OF BISKUPIN IN SELECTED PERIODS OF THE LAST SIX THOUSAND YEARS AND THEIR REFLECTION IN POLLEN DIAGRAMS

WŁADYSŁAW NIEWIAROWSKI and BOŻENA NORYŚKIEWICZ

Institute of Geography, Nicholas Copernicus University, Fredry 8, 87–100 Toruń, Poland; e-mail: norys@geo.uni.torun.pl

ABSTRACT. Potential forest communities, their range and size of used deforested areas have been approximately determined for selected periods in an area of 2664 ha near Biskupin. Changes in the vegetation cover have been identified with the use of pollen diagrams and transformed into palynological cyclograms. As a result, very complex relationships between environmental conditions, human activity and changes in vegetation cover have been recognized.

KEY WORDS: Biskupin, natural environment, pollen analysis, potential vegetation, deforestation, land use

INTRODUCTION

Biskupin is a world famous archaeological site in Poland (Fig. 1) with well-preserved remains of a fortified settlement of the Lusatian Culture from the Early Iron Age (Hallstatt C), about 750–670 BC (Zajączkowski 1995).

In the period 1986–1994 very precise, complex, geomorphological, geological, soil, hydrological, sedimentological and palynological investigations in the Biskupin region were carried out. More details of this and other research, including archaeological and radiocarbon datings (46), can be found in a joint publication edited by Niewiarowski (1995).

The existence of 5 main potential types of forest communiy were identified on the basis of a knowledge of the natural conditions (Table 1). Variations in their range were mainly caused by the changing size of lakes, the changing extent of deforestation, and subsequent land use.

Palaeographic maps (Fig. 3) reflect only a synthesis of the selected periods as follows: A. The end of the Mesolithic period (approximately 6.0 ka BP) when human interference with vegetation cover was very limited; B. The end of the Bronze Age and Early Iron Age, in particular the period when there was a fortified settlement in Biskupin, at the time of highest population density; C. The period of Roman influence when the lake had its largest extent in the Holocene; D. The period of recent land use which started between the 12th and 14th centuries.

The evaluation of the range of forest communities and land use in these periods is shown in Table 1. The history of the Holocene vegetation, based on pollen preserved in sediments, is presented in a pollen diagram (Fig. 4). The mean values of selected taxa that are typical of particular forest communities were calculated. The calculation included the NAP total (Fig. 5) that best characterizes the deforested areas in the periods shown in Fig. 3, based on profile 4 from the bay of the lake (water 4 m deep) and profile 5 from the central deep-water part (10.9 m). Synanthropic plants represent average and maximum values of the selected pollen taxa in profiles 4 and 5 (Fig. 6).

GENERAL CHARACTERISTICS OF THE AREA UNDER STUDY

The study area of 2664 hectares is located in the Gniezno Lakeland (Fig. 1), in a young glacial landscape, formed during the last glaciation in the Upper Plenivistulian, around 17–18 ka BP. It comprises two geomorphological units, i.e. a part of the Żnin subglacial channel with an area of 1600 hectares (60 % of the area) and part of the neighbouring moraine plateau of 1064 hectares (40% of the region).

The bottom of the channel contains numerous lakes totalling 354 hectares (13.3% of the area) of which Biskupińskie Lake (110 hectares, 13.22 m max. water depth) was investigated in detail.

Lessives and brown soils were formed on the tills both on the moraine plateau and in the Żnin subglacial channel with its ice-dammed lake sediments (sand, silt, clay); the shallow lying groundwater areas gave rise to black earths (Niewiarowski & Sienkiewicz 1995). According to Matuszkiewicz (1981), these soil varieties fa-

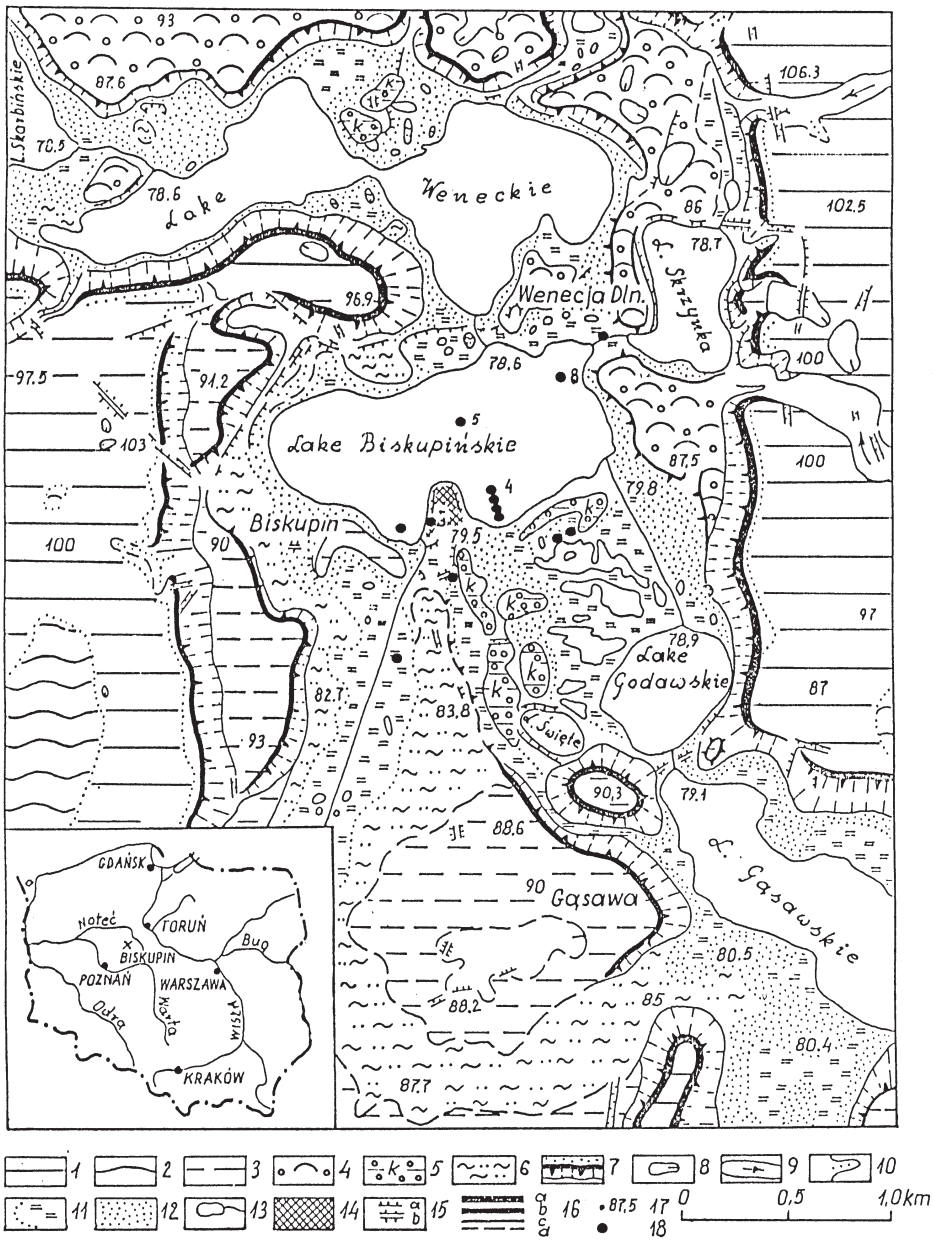

Fig. 1. Geomorphological map of the surround ings of Biskupin: 1 – flat moraine plateau, 2 – undulating mor aine plateau, 3 – plains and morainic undulations in the bot tom of the subglacial channel, 4 – morainic undulations wit h sandy and gravelly fluvio-glacial cover, 5 – kame hillocks, hills and ridges, 6 – plains composed of ice dammed lake sediments, 7 – slopes and degradation zone, 8 – kettles, 9 – melt-water valleys, 10 – periglacial denudation valleys, 11 – biogenic plains, mainly peat plains, 12 – inorganic lake terrace deposits, 13 – lakes, ponds, and streams, 14 – Early Iron Age fortified settlement at Biskupin, 15 – man-made structures (ditches, embankments etc.), 16 – height of escarpments: a – 10–20 m, b – 5–10 m, c – up to 5 m, d – indistinct, 17 – altitude points, 18 – location of palynological profiles

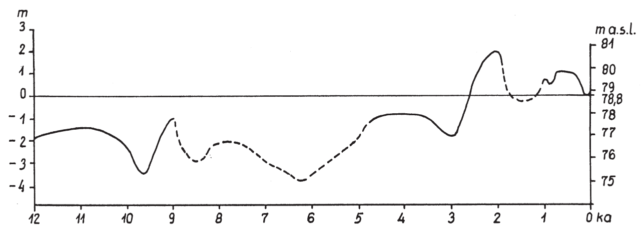

Fig. 2. Established (continuous line) and presumed (broken line) lake level fluctuations of Biskupińskie Lake during the last 12 000 years (78.8 m a.s.l. – present level), after Niewiarowski (1994, 1995)

cilitated the development of different plant communities of the *Querco-Carpinetum medioeuropaeum* type (*Quercus, Tilia, Ulmus, Carpinus, Acer* with an admixture of *Pinus*). Leached and acid brown soils that appeared on the Żnin channel bottom on sandy and silty kame deposits, and on fluvio-glacial covers, facilitated the growth of plant communities of the *Pino-Quercetum* type (mostly *Pinus* and *Quercus* with *Betula* and *Populus*). Alder-ash forest with genera such as *Alnus, Fraxinus* and locally *Ulmus* developed on degraded black earths and mucky soils in raised areas, with shallow lying ground water adjacent to former lakes. Muck and mucky, peaty and

Fig. 3. Potential vegetation, hydrography and land use in the Biskupin region. **A** – about 6.0 ka BP: 1 – lakes and streams, 2 – edge of the Żnin subglacial channel, 3 – alder forest and mire vegetation, 4 – alder-ash forest, 5 – oak-pine forest, 6 – oak-lime forest, 7 – Mesolithic sites, after Piotrowska (1995). **B** – about 3.0–2.5 ka BP: 1 – lakes and streams, 2 – edge of the Żnin subglacial channel, 3 – alder forest and mire vegetation, 4 – alder-ash forest, 5 – oak-hornbeam forest, 6 – mostly deforested areas used as arable land, pasture and woodland/ pasture, 7 – Biskupin fortified settlement, 8 – settlements, 9 – cemeteries, 10 – settlement traces. Lusati an Culture settlements of the Early Iron Age in the Biskupin region, after Zajączkowski (1995). **C** – about 2.0 ka BP: 1 – lakes and streams, 2 – edge of the Żnin subglacial channel, 3 – alder forest and mire vegetation, 4 – alder-ash forest, 5 – oak-hornbeam forest, 6 – mostly deforested areas used as arable land and pasture, 7 – settlements, 8 – cemeteries, 9 – traces of settlements and undetermined sites. Settlements in the Biskupin region during the younger pre-Roman period and period of Roman influence after Dąbrowska (1995). **D** – Recent land use and hydrography in the Biskupin region: 1 – lakes and streams, 2 – edge of the Żnin subglacial channel, 3 – forest, 4 – meadowland and pasture, 5 – arable land, 6 – fortified settlement of the Lusatian Culture, 6 – villages and farmsteads, 8 – main roads

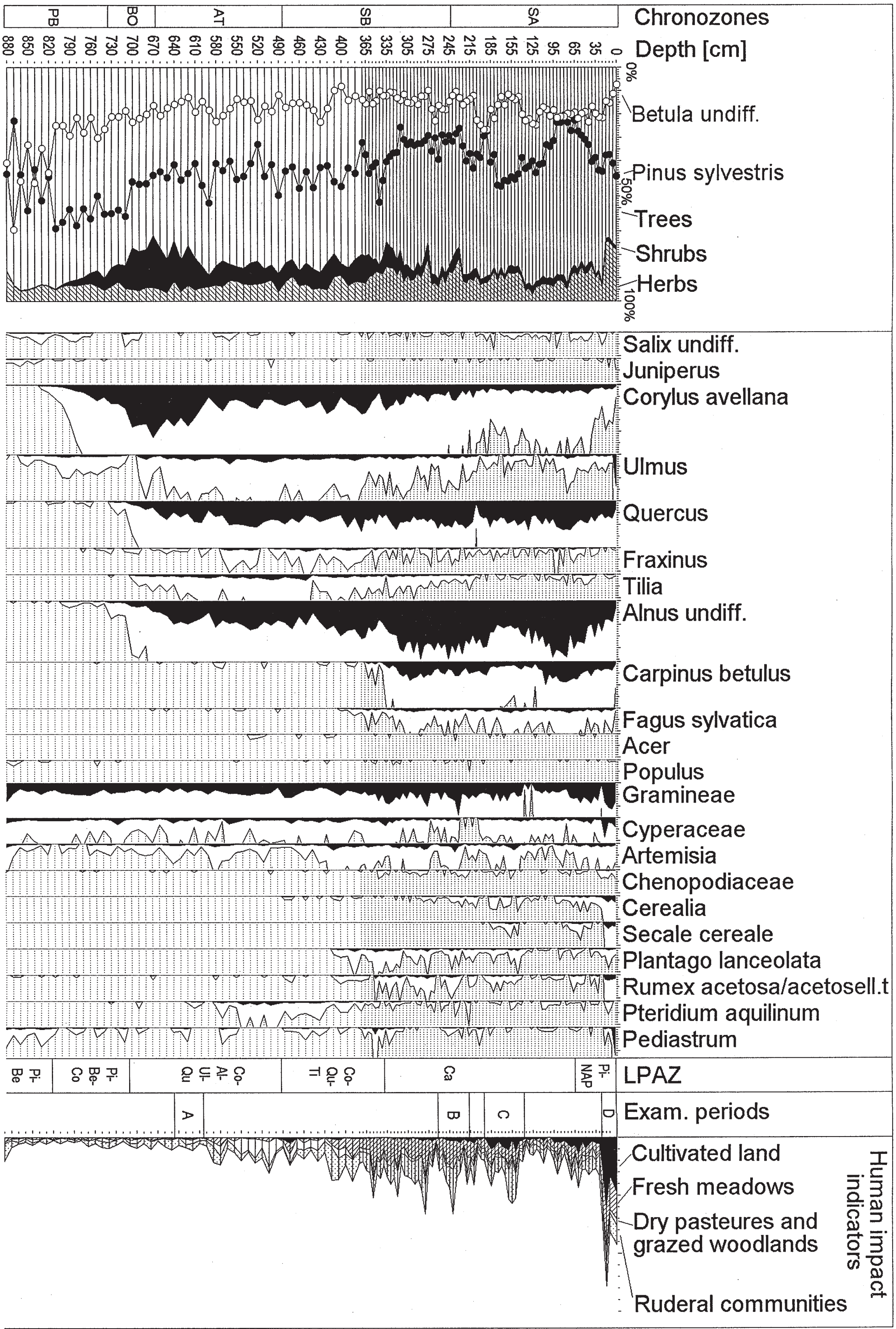

Fig. 4. Biskupińskie Lake. Pollen diagram (profile 4) with selected pollen types

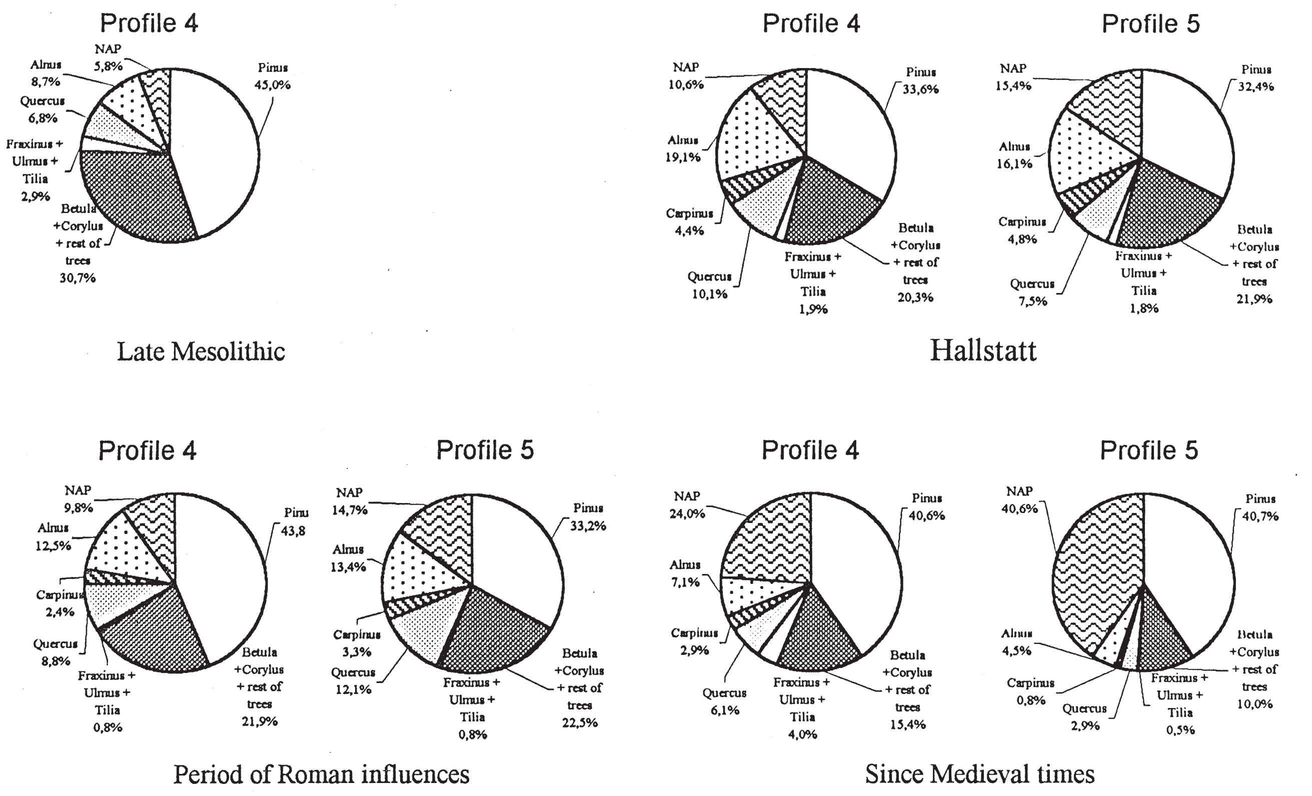

Fig. 5. Mean percentage values of selected pollen taxa

mud-peaty soils, covered with mire vegetation and alder forest developed on low level bogs.

POTENTIAL PLANT COMMUNITIES AROUND 6.0 KA BP AND THEIR REFLECTION IN POLLEN DIAGRAMS

During this period the level of lakes was 3–4 m below the present level and the lake extent was the smallest in the Holocene (354 ha, 13.2% of the area). The emerged sandy areas of the lake bottom were covered by mire vegetation, and alder forest started to appear on the waterlogged areas composed of gyttja-slime sediments. At that time alder forest occupied the maximum area (390 ha, 14.6% of the total area) as well as alder-ash forest (97 ha, 3.6%). Relatively small areas (166 ha, 6.2% of the area) were covered by oak-pine forest. The biggest areas, however, were occupied by broad-leaved deciduous forest (Fig. 3A, Table 1).

Table 1. Potential vegetation, hydrography and land use in the Biskupin Region during the selected periods, as percentages of the whole (2664 ha) area

	about 6.0 ka BP	about 3.0-2.5 ka BP	about 2.0 ka BP	13th C-14th C	Recent
Lakes	13.2	15.0	27.8	18.6	16.2
Alder forest	14.6	14.0	3.0	6.0	—
Ash-alder forest	3.6	0.7	1.6	—	—
Oak-lime forest	62.4	—	—	—	—
Oak-hornbeam forest	—	6.0	16.7	—	—
Oak-pine forest	6.2	—	—	—	—
Forest (indeterminate)	—	—	—	2.4	0.6
Deforested areas (arable, pasture and woodland/pastures)	—	64.3	50.9	—	—
Arable land	—	—	—	65.5	68.2
Meadowland and pasture	—	—	—	4.0	10.0
Settlements, roads and management areas	—	—	—	3.5	5.0

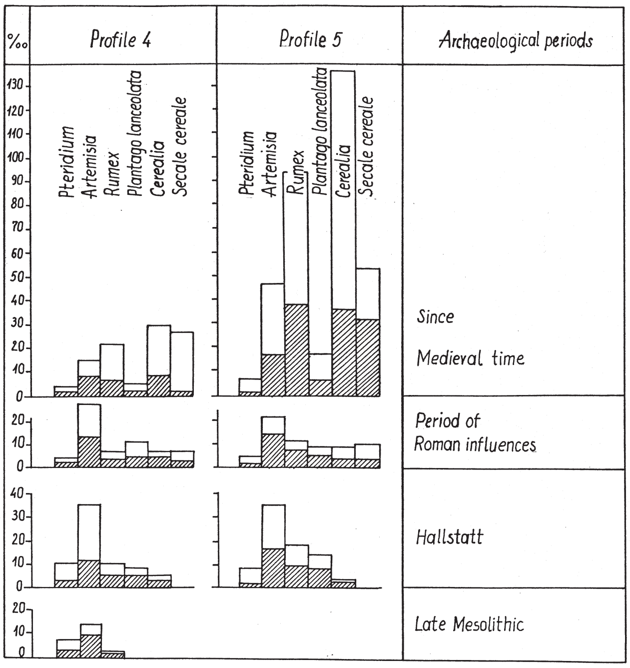

Fig. 6. Mean (hatched bars) and maximum (light bars) values of selected synanthropic pollen grains

At about 6.0 ka BP the pollen diagrams showed the lowest percentage of NAP (5.8%) and the maximum percentage of *Fraxinus, Ulmus* and *Tilia* (2.8%) (Noryśkiewicz 1995). The incidence of *Pinus* pollen (45%) is amazingly high, which may be attributed to the location of Profile 4 in the coastal bay part of the lake and the presence of oak-pine forest (Fig. 3A) in the immediate vicinity of the profile. A consequence is the overrepresentation of that pollen (Ammann 1989). The same factor may have influenced the relatively high percentage of *Betula* and *Corylus* (about 30%). There appears to be no correlation between the large area alder forest occupied (Table 1) and the relatively low values of alder pollen (8.7%) in profile 4. It may be assumed that the main areas of alder forest were located around Weneckie and Godawskie lakes and a smaller area of this forest occured in the vicinity of Biskupińskie Lake. The above mentioned argument would prove that *Alnus* pollen represents local vegetation.

PLANT COMMUNITIES AND LAND USE IN THE PERIOD 3.0 – 2.5 KA BP

At this time the plant communities, when compared with the nearly primeval vegetation cover of the climatic optimum, underwent considerable change for both natural and anthropogenic reasons. In the spatial arrangement plant communities that depended on shallow lying groundwater (alder and ash-alder forest) were subject to the biggest changes. This may well be connected with oscillations in lake levels attributable to climate. When the erection of the Biskupin fortified settlement was in progress (around 750 BC) the level of the lake reached 77.5 m above sea level (Niewiarowski 1994, 1995) i.e. it was 0.1–1.3 m lower than at present (Fig. 3B).

What may be concluded from the diagrams (Noryśkiewicz 1995) is that in the period 3.0–2.5 ka BP considerable changes in the quantity and quality of the plant communities took place. A noticeable deforestation, expressed in a rise in NAP of up to 15% (Fig. 5), occured. Among NAP, synanthropic plants, eg. Cerealia, *Plantago lanceolata, Rumex, Artemisia* (Fig. 6), were of major importance. The most precise data on population density come from this period. The Biskupin fortified settlement (750–670 BC), during its existence, was inhabited by 800–1000 people (Piotrowski & Zajączkowski 1991, Piotrowski 1995a). Once the number of inhabitants was known, it was possible to estimate the size of the cropped area necessary to feed the population. There are different opinions among archaeologists on this matter (Henneberg & Ostoja-Zagórski 1977, Kurnatowska & Kurnatowski 1991). The evaluation presented by Piotrowski & Zajączkowski (1991) appears reliable since it is based on experimental research and suggests that in order to feed 1000 persons an annual crop cultivation on an area of 250–310 ha at 0.9–1.0 t/ha efficiency was essential. If the requirements to be met when rearing and breeding animals are included, the utilized land had to total approx. 2000–2500 ha (Piotrowski & Zajączkowski 1991). The region that underwent intensive exploitation occupied around 64% of the area, similar to the area taken up in the Middle Ages.

The conclusion reached on the basis of pollen cyclogram analysis (Fig. 5) is that, compared with the end of the Mesolithic period, higher values of *Alnus* pollen appeared originating probably from the substantially overgrown areas of Godawskie Lake. The value of *Pinus* pollen decreased, however (32–33%), which may be attributed to the clearance of oak-pine forest. About 3200 BP oak-hornbeam forest was dominated by *Carpinus* (4.8–4.4%) and the percentage of *Fraxinus, Ulmus* and *Tilia* (1.8–1.9%) decreased. The disproportion between the size of the deforested area and the tree pollen quantity of *Querco-Carpinetum* forest may be explained by the fact that trees produce pollen more abundantly in thin forest (Ammann 1989) and that during the Lusatian Culture complete deforestation never took place as it did in the Middle Ages (Kurnatowska & Kurnatowski 1991). Cereal crop cultivation was conducted according to the fallow-forest system and scrub and woodland grew in the area between the parcels of used land. The markedly extensive exploitation of oak and pine (ca 8260 m^3) for building settlements was not or scarcely apparent in the pollen diagrams.

VEGETATION COVER, HYDROGRAPHIC CONDITIONS AND LAND USE IN THE PERIOD ABOUT 2.0 KA BP

In the Early Subatlantic period the level and extent of lakes increased in the Żnin channel. That rise was already noticeably marked when the Biskupin settlement was still inhabited and around 2.5 ka BP it reached 79.5 metres above sea level. The maximum lake water level in the channel in the Holocene occured in the period 2.1–1.9 ka BP when the level of Biskupińskie Lake was 1.7–2.2 m higher than at present (Fig. 3C). Then swampy areas and bogs were flooded, with 741 ha under water, ie 27.8% of the study area. The areas covered by alder forest (up to 3% of the area) and ash-alder forest (1.6%) considerably decreased.

The decline of the Lusatian Culture brought about a marked decrease in the population density in the Biskupin Region followed by an increase in population in the Younger pre-Roman period and during the time of Roman influence (Dąbrowska 1995).

It was a time of noticeable progress in the efficiency and management of agriculture. Comparison of Figs 3B and 3C shows distinctly a decrease in the number of settlements in the study area. Nevertheless, palynological diagrams and cyclograms register values of selected taxa and groups of taxa characteristic of deforestation (NAP) and human activity similar to those of previous period (Figs 5B, 5C, 6). In addition to Cerealia undiff., *Secale cereale* pollen had a considerable percentage (max. 2.7%) incidence. The percentage of *Alnus* pollen was lower than at the time when the Lusatian settlement was inhabited, a consequence of the flooding of habitats suitable for alder. With reference to Aaby (1994) and to the values of NAP and synanthropic plants, it may be estimated that the exploited area (crop cultivation and animal rearing) comprised around 50% of the total area, that is approximately 13% less than at Hallstatt. The incompatibility in the number of settlements and palynological data may be due to the badly preserved traces of settlement from that period or our still incomplete archaeological knowledge.

REMARKS ON VEGETATION COVER, HYDROGRAPHY AND LAND USE IN THE MIDDLE AGES AND AT PRESENT

In the Early Middle Ages the level of the lakes was slightly lower or similar to that observed at present. It started to rise in the 12th cent. and reached 79.5–80 m above sea level in Biskupin Lake in the 14th cent. Consequently, water covered 492 ha (18.6% of the whole area) and remained at that level until the end of the 18th cent. It fell by around 1.2 m in the 19th cent. due to regulation of the Gąsawka river and melioration that brought about a 16% lowering of the water table.

In the 5th and 6th centuries a noticeable depopulation occurred in the Biskupin Region and neighbouring areas, which facilitated forest regeneration. Later, a continously increasing population, dating back to the Early Middle Ages, caused first gradual and then complete deforestation. The deforested areas were used for cultivation and as meadowland and pasture. According to the research conducted by Hładyłowicz (1932) in Great Poland, the total area of forest in the 14th cent. approximated to that observed currently. In the Biskupin Region, forest was preserved only on waterlogged ground (alder forest) and in almost inaccessible areas (steep escarpments, gullies and other deep valleys that cut moraine plateau scarps) and covered in total around 8.4% of the area. Forest clearance in the waterlogged areas took place in the 19th and 20th centuries after the regulation of water conditions (meliorations). Nowadays, it is a practically deforested region since forest occupies only 0.6% of the area, meadow and pasture make up 10 %, and the arable land covers 68.2%.

These changes are best characterized by the diagrams and palynological cyclograms from profile 5 (Fig. 5). The conclusion is that the percentage of NAP increased up to 40% and the considerable content of pine pollen (40%) originated mainly from pine forest that grew about 5–6 km away and small pine plantations around Biskupińskie Lake. It concerns *Betula* pollen also. The total percentage incidence of *Fraxinus, Ulmus* and *Tilia* (0.5%) is also minimal. *Alnus* pollen (4.5%) came from alder scrub around the lake. The incidence of pollen from cultivated plants, weeds and ruderals was at a maximum, as is shown in Fig. 6.

CONCLUSIONS

The research carried out shows that:

– in the Biskupin Region there are correlations between the percentage incidence of NAP in sediments, including synanthropic plants, with major settlement phases and the assumed deforestation range, but there is no complete correlation in this aspect;

– in prehistoric times, with the fallow-forest system, the quantity of herb pollen does not fully reflect the range of deforestation since at that time the populated areas constituted enclaves (10–40% of the area) within dense forest which supplied pollen as well;

– complete deforestation dates back to the Middle Ages; therefore since that time, palynological diagrams and cyclograms are quite different;

– the quantities of pollen coming from particular plants during the same period are different in profiles taken from various parts of the lake;

– the correlations between the variations in the of local hydrological conditions and the variation of the alder pollen percentage are quite satisfactory;

– in the Biskupin Region under study the principal exploitation was of oak-pine, oak-hornbeam and alder-ash forest. Only finally, that is in modern times, was alder forest were cleared as well.

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