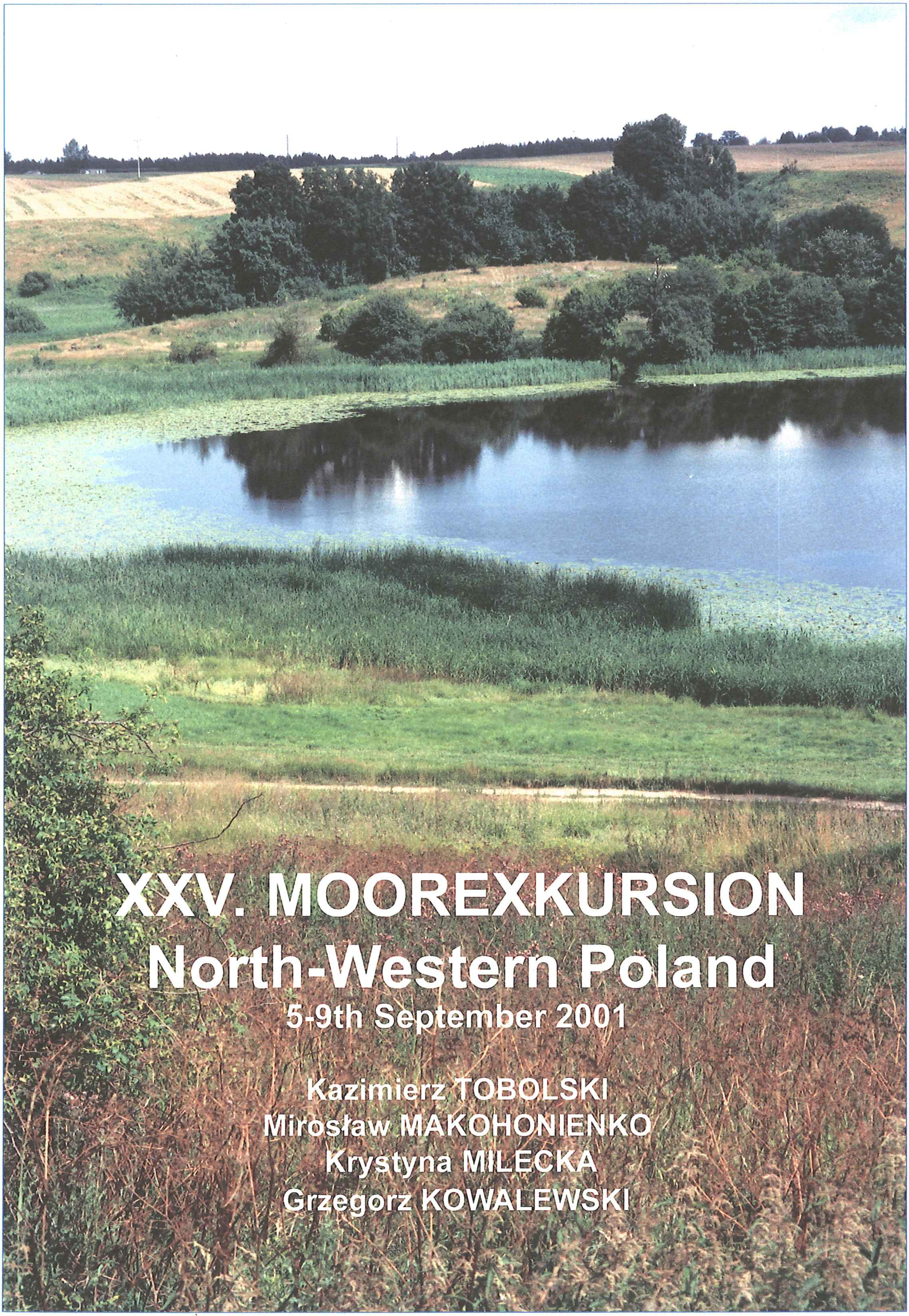


XXV. MOOREXKURSION
North-Western Poland

5-9th September 2001

Kazimierz TOBOLSKI
Mirosław MAKOHONIENKO
Krystyna MILECKA
Grzegorz KOWALEWSKI

XXV. MOOREXKURSION
North-Western Poland

25th University of Bern
International Vegetation-Historical
Bog and Mire Excursion

GUIDE TO THE TUCHOLA PINEWOODS (BORY TUCHOLSKIE) AND GREAT POLAND – KUJAWY LOWLAND EXCURSION

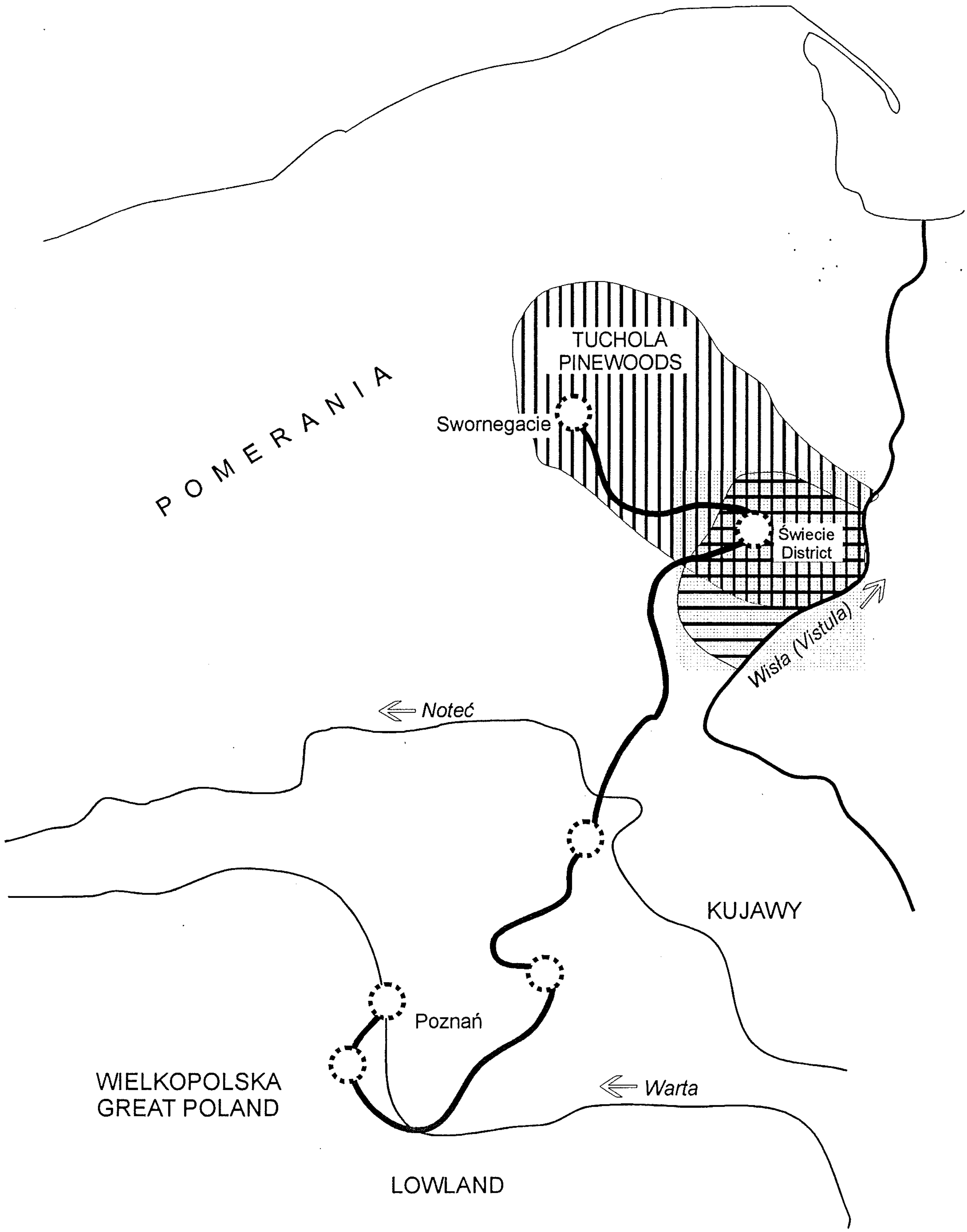
5- 9TH SEPTEMBER 2001

Kazimierz TOBOLSKI
Mirosław MAKOHONIENKO, Krystyna MILECKA, Grzegorz KOWALEWSKI

Department of Biogeography and Palaeoecology
Adam Mickiewicz University
Poznań

UAM

Poznań 2001



POMERANIA
TUCHOLA PINEWOODS
Swornegacie
Świecie District
Wisła (Vistula)
Noteć
KUJAWY
Poznań
WIELKOPOLSKA
GREAT POLAND
Warta
LOWLAND

Programme of the second part of the excursion

1st DAY – 5 SEPTEMBER

***Swornegacie** – Breakfast 8.00*

Departure 9.00

Lobelian Lakes – K. Milecka pp. 26-33

Ostrowite Lake – K. Milecka & K. Szeroczyńska pp. 34-39

Ostrowite Lake – Lunch

Dury – G. Kowalewski & K. Milecka pp. 49-56

***Tleń** – Dinner 19.30*

2nd DAY – 6 SEPTEMBER

***Tleń** – Breakfast 7.30*

Departure 8.30

Wierzchlas – A. Noryśkiewicz pp. 57-64

Koronowski Reservoir – G. Kowalewski pp. 65-69

Koronowski Reservoir – Lunch

Toruń-Eberswalde ice-marginal valley – K. Tobolski pp. 70-74

Biskupin – A. Noryśkiewicz & B. Noryśkiewicz pp. 77-84

Żnin – Dinner 19.00

3rd DAY – 7 SEPTEMBER

Żnin – Breakfast 7.30

Departure 8.30

Głęboczek – M. Makohonienko pp. 85-93

Lednica – K. Tobolski & M. Makohonienko & K. Szeroczyńska & M. Polcyn pp. 94-126

Lednica – Lunch

Gniezno – M. Makohonienko pp. 127-137

Gniezno - Dinner 19.00

4th DAY – 8 SEPTEMBER

Gniezno – Breakfast 8.00

Departure 9.00

Giecz – K. Milecka & J. Strzelczyk pp. 138-153

Rogalin – Lunch

Rogalin – K. Tobolski pp. 154-157

Wielkopolski National Park – K. Tobolski & M. Makohonienko pp. 158-165

Będlewo – Dinner 19.00

5th DAY – 9 SEPTEMBER

Będlewo – Breakfest 7.15

Departure 8.00

Location of hotels

4/5.09: Swornegacie

Ośrodek Wypoczynkowy Psia Góra – Zofia i Jerzy Zych s.c.
89-608 Swornegacie
ul. Podgórna 12
tel/fax: (0-52) 398 11 60
tel. kom. 0 604 274 614

5/6.09: Tleń

Ośrodek Rypoczynkowo-Sportowy GEOVITA
ul. Czerska 11
86-156 Tleń
tel/fax: (0-52) 333-398-04, 33-39-974

6/7.09: Żnin

Hotel MARTINA - Mirosław Walczak
ul. Mickiewicza 32
88-400 Żnin
tel: (0-52) 30-28-731

7/8.09: Gniezno

Hotel MIESZKO
ul. Strumykowa 2
tel: (0-61) 426-46-25, fax: 426-46-28

8/9.09: Będlewo

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General review
Nature in Poland

Poland is located in Central Europe and covers an area of 312383 km^2. To the north of the country lies the Baltic Sea and to the south lie the Carpathians and Sudety Mountains. Poland is a typical lowland country, 54% of land is below 150 m, 37% is below 300 m and only 3% of the country is mountainous. Although the countryside is predominantly lowland, there is a variation in the landscape as a result of the changes in altitude from the sea to the mountains. There are also regional variations caused by the differential spread of glacial zones during the Pleistocene, influences of continental and oceanic conditions and history of land use.

Due to the geographical location of Poland in the temperate latitudes, arctic air masses dominate. The share of maritime air is greater than of continental air (46% to 38%), because of the more common, western (oceanic) circulation of air (75% of atmospheric fronts come from the West). The transitional, maritime-continental nature of the climate of Poland causes large day-to-day and year-to-year variability in the weather patterns. The features of the continental climate are more prevalent in the southeast, which is reflected in the increase of the amplitude of average annual air temperature, as well as in the change of distribution of precipitation during the year.

The development of the soil dates back to the retreat of the last ice-sheet. Podsolic and brown soils are spread out over the whole territory of Poland taking up more than 77% of the total surface of soils.

The transitional nature of Poland's natural environment is distinct as it is shown in the plant cover. Over 50% of species are so-called trasistory species. That is, species whose full range does not occur on Polish territory. They are usually common species, representing the Holarctic geographical element and the Euro-Siberian and Mid-European sub-elements. Arctic and Mediterranean sub-elements are relatively rare, although Atlantic and Mediterranean-Atlantic sub-elements are well represented in western and northwestern regions. In the southeast Poland, there is increased evidence of the Pontic-Panon elements. Northeast Poland is characterized by numerous Boreal and Boreal-Continental elements (Fig. 1). The geographic range of selected trees and shrubs is shown in Fig. 2. The distribution of some forest plant communities are presented in Fig. 3 and chosen types of geographical ranges of the forest communities are in Fig. 4.

Woodlands have survived in the agricultural landscape of Poland and are in fact expanding in area. At the end of 1990, forests covered 86.900m^2, which comprises nearly 27.8% of the total area in Poland. There are 21 species of tree growing natural sites in Poland. This is out of a total of 45 species in Europe. The state owns 82.5% of the total forest area and non-state bodies own 17.5%, that of which 15.9% is in private ownership. Nearly 48% of forested areas are covered with young trees, less than 40 years old. Distribution of woodlands in Poland is shown in Fig. 5, and in Fig. 6, the percentage of forest cover in Poland can be viewed.

The total area of peatbogs amounts to 13200 km^2 or 4.2% of the total country. The Polish peatbogs show wide variation with all the characteristic form, that are found in Central Europe: fens (98%), raised bogs (6.5%) and transitional bogs (4.5%) of all peatlands. Most peatlands are located in northern Poland (Fig.7), especially in northeastern part of the country (Fig. 8). Most peatlands are small, no more than 10 ha, and they account for almost 60% of all peatlands. Peatlands covering 10 to 100 ha account for 32%. Those ranging from 100 to 1000 ha amount to 7.5% and any larger peatlands to only about 1%. The largest area is covered by very large peatlands – more than 47% of the total peatland area. Peatlands of 100 to 1000 ha account for 32%, those ranging between 10 to 100 ha account for 17% and small peatlands of less than 10 ha occupy only 3.3% of the total peatland area. The flora of Polish peatlands consist of about 900 species, including about 200 species of *Bryophyta.*

About 1% of the total area (7081 lakes larger than 1 ha) in Poland is covered by lakes. Its distribution is very uneven (Fig. 9). The largest aggregations of lakes occur in the northern part of the country (Masuria and Pomerania) and in the central western regions (Wielkopolska, Kujawy). Most lakes in Poland are of postglacial origin, meaning that they very young on the geological scale – no more than 8000 to 13000 years old. Their classification is mostly based on their trophy, but it also refers to the configuration of the lake basin and to the bedrock.

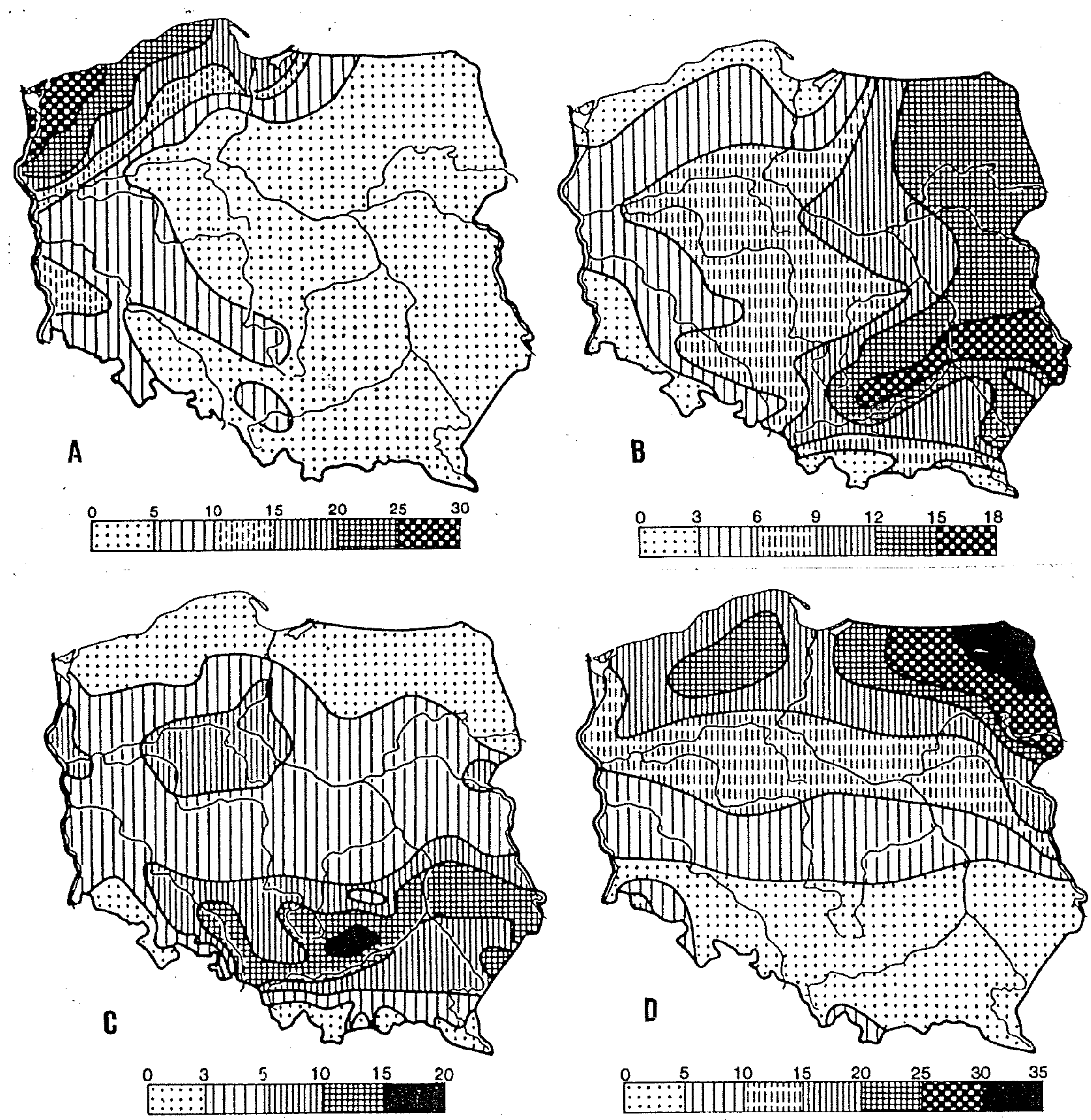


Fig. 1. Concentration of Subatlantic (A), Continental (B), Submediterranian (C) and Boreal (D) plant communities in Poland (Matuszkiewicz 1991).

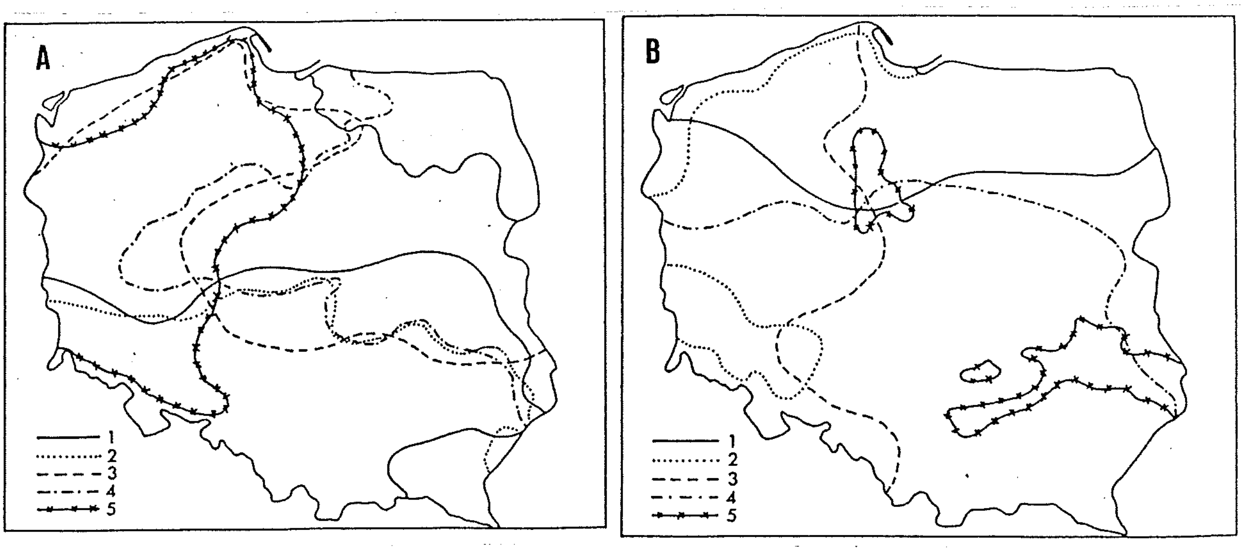


Fig. 2. Geographical range of selected trees (A) and shrubs (B) in Poland.

A: 1- *Picea abies*, 2- *Abies alba*, 3- *Acer pseudoplatanus*, 4- *Fagus sylvatica*, 5- *Sorbus torminalis*;

B: 1- *Linnaea borealis*, 2- *Lonicera peryclimenum*, 3- *Euonymus verrucosus*, 4- *Betula humilis*, 5- *Cerasus fruticosa*.

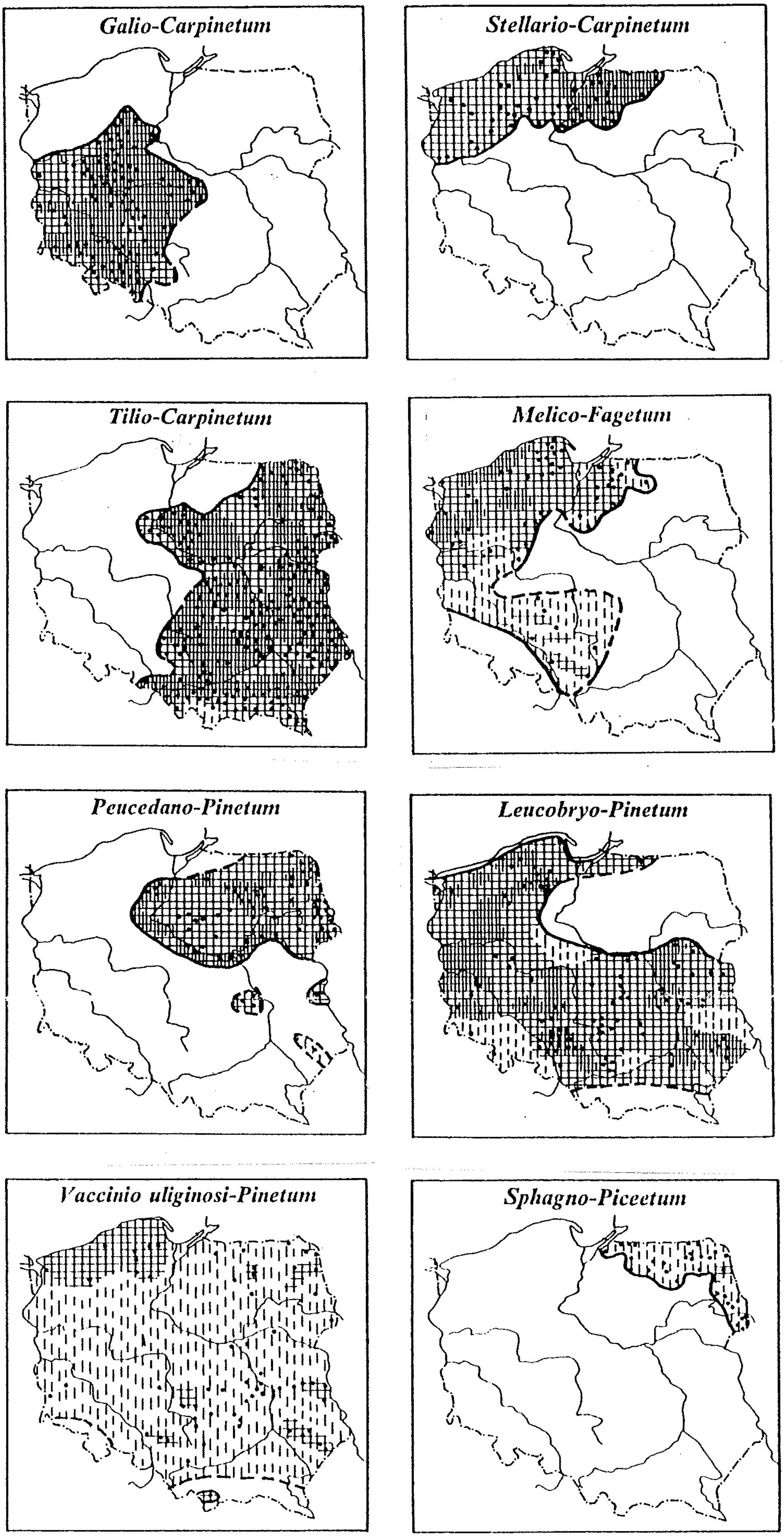


Fig. 3. Distribution of the forest communities in Poland (Matuszkiewicz & Matuszkiewicz 1996).

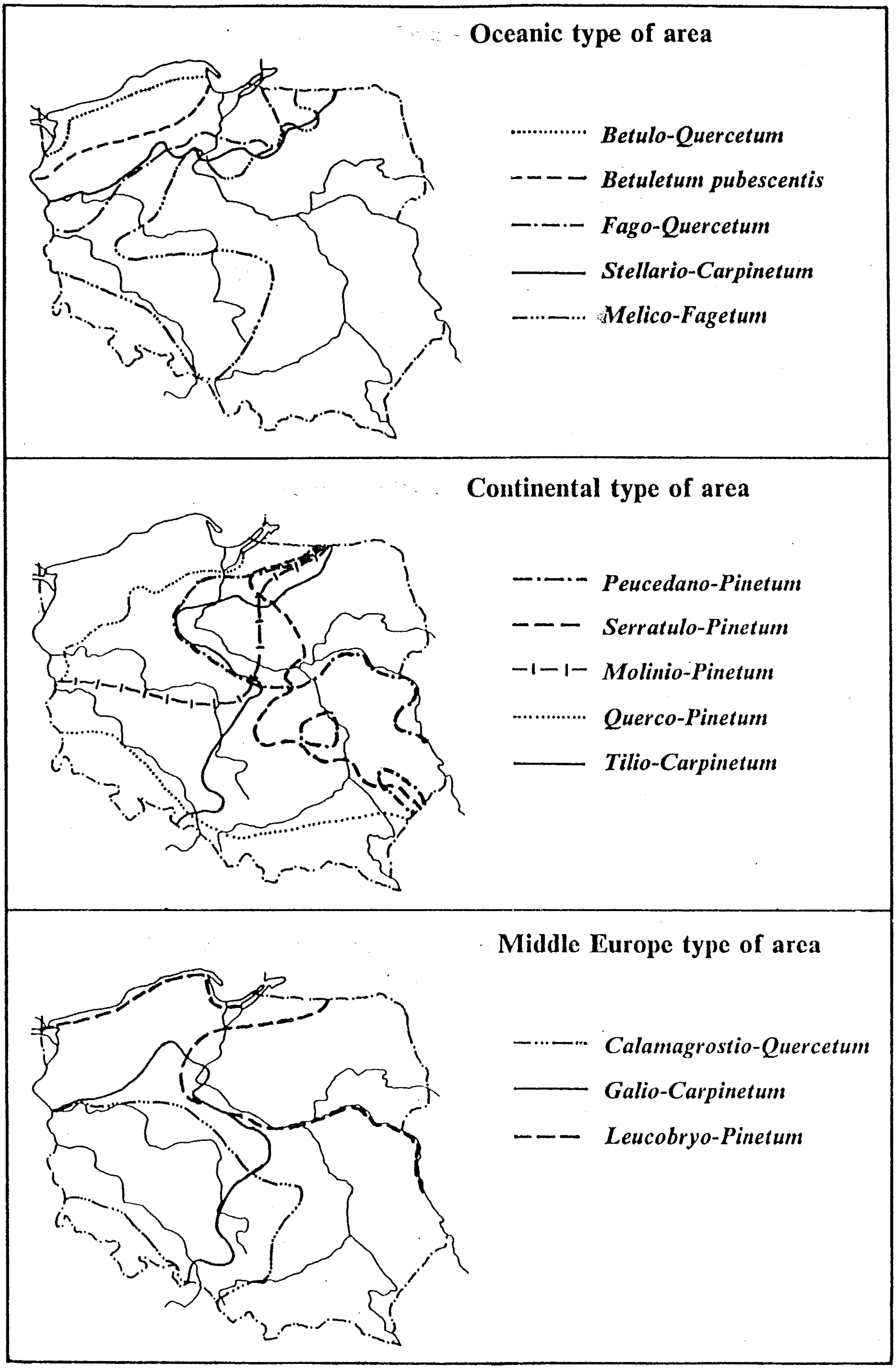


Fig. 4. Chosen types of geographical ranges of the forest communities in Poland (Matuszkiewicz & Matuszkiewicz 1996).

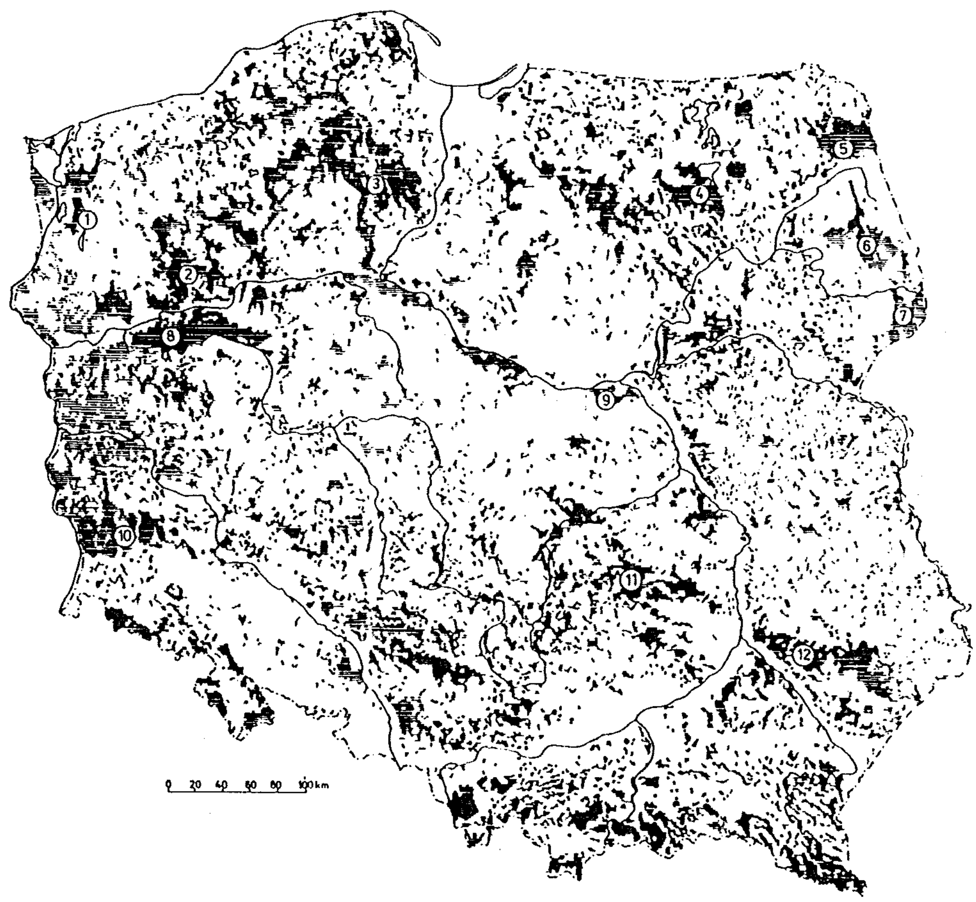


Fig. 5. Distribution of woodland in Poland. 3- Tuchola Pinewoods (Denisiuk et al. 1991).

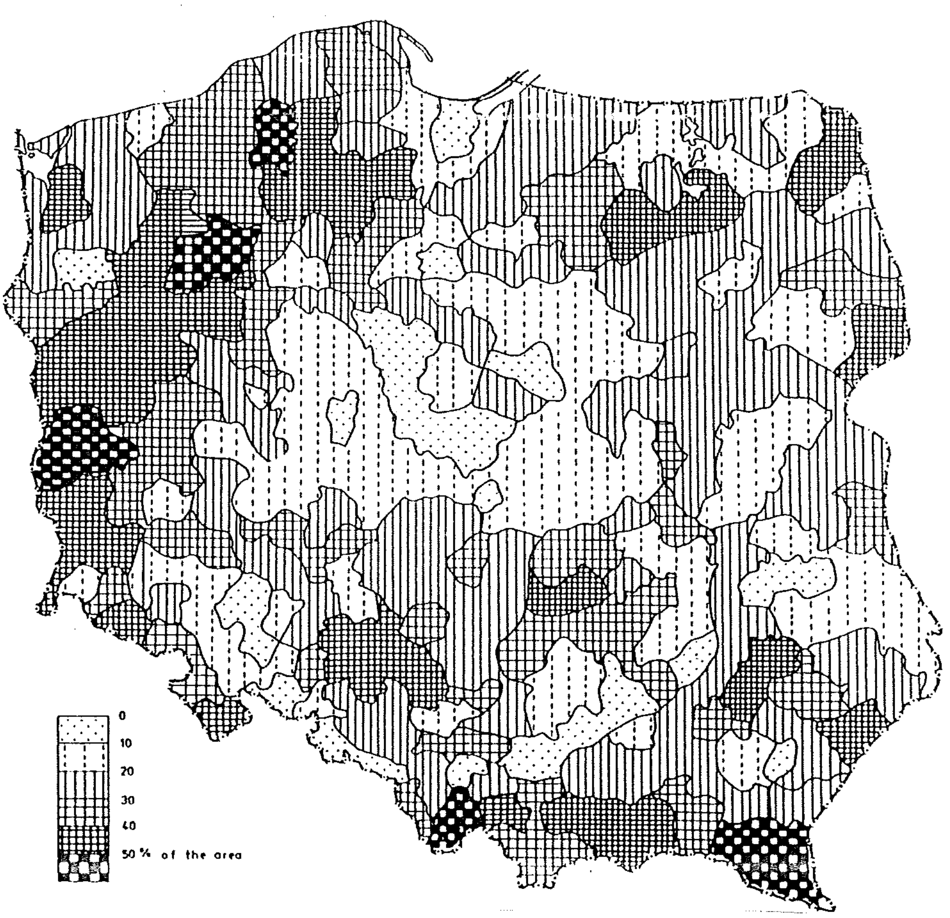


Fig. 6. Percentages of forest cover in Poland (Denisiuk et al. 1991).

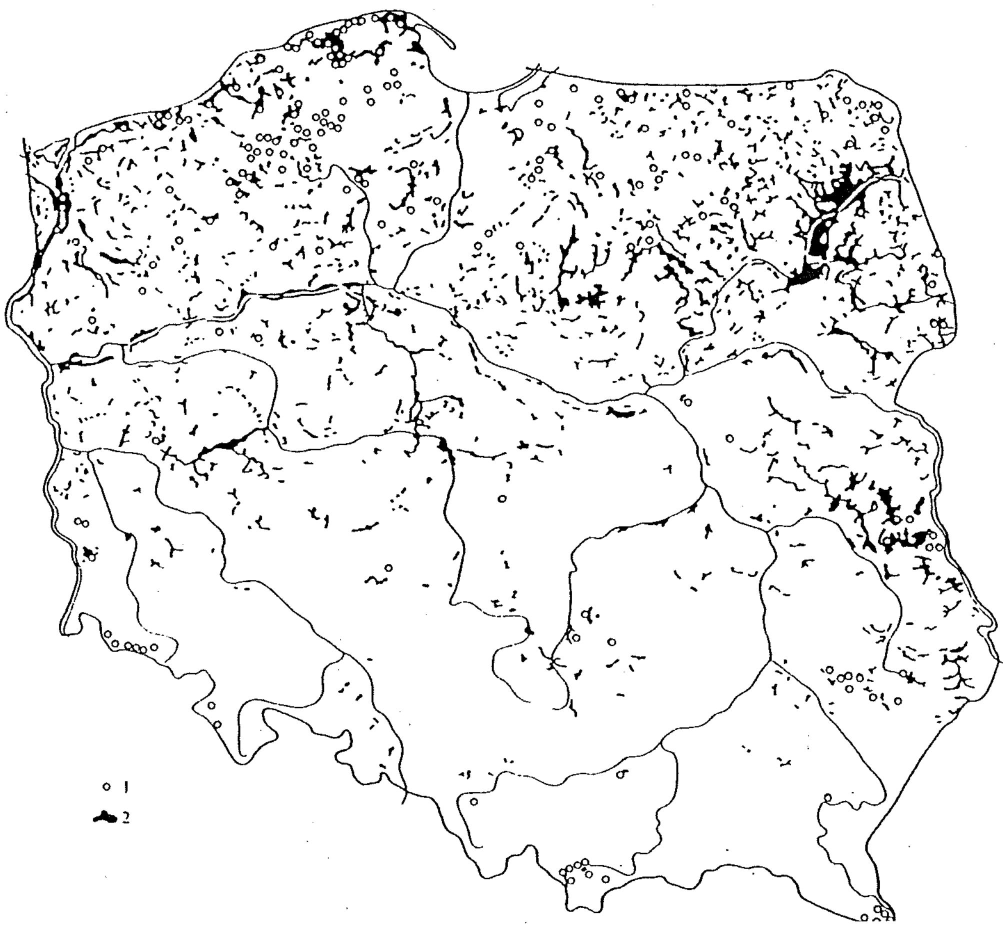


Fig. 7. The distribution of larger peatlands in Poland (Dobrowolski et al. 1998). 1- raised bogs of more than 100 ha, - fens of more than 200 ha.

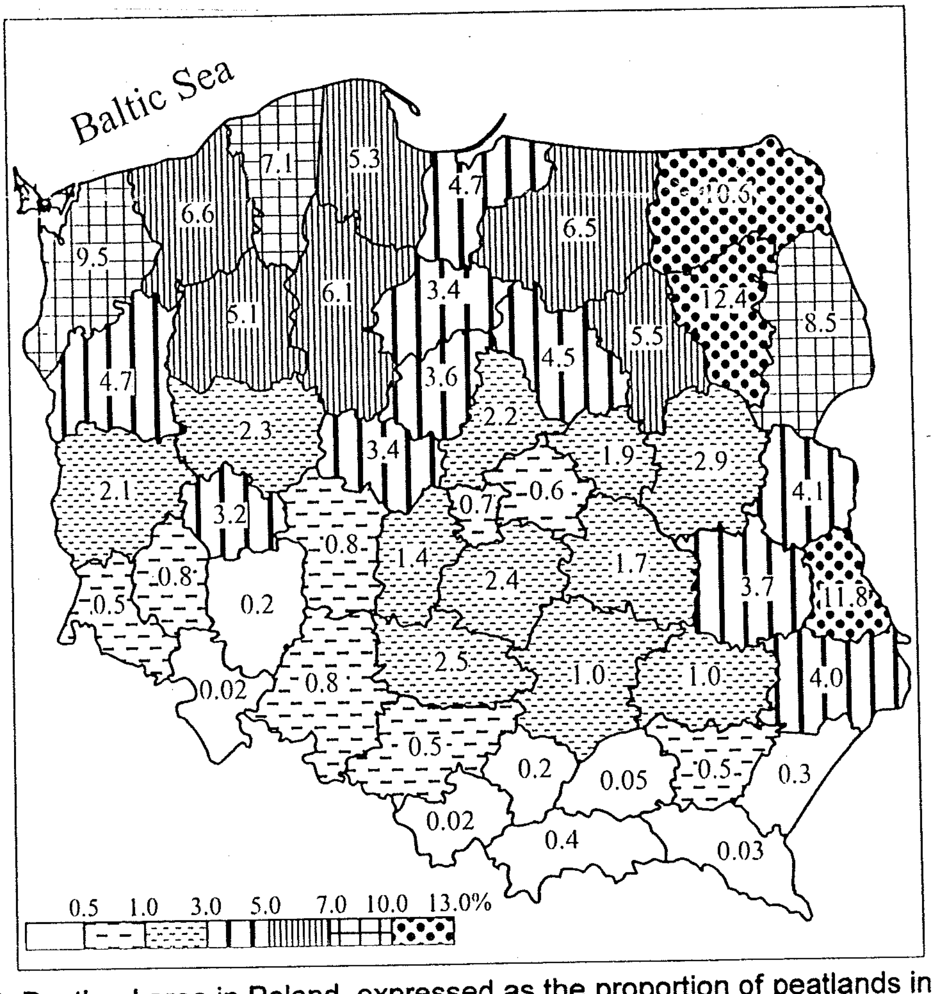


Fig. 8. Peatland area in Poland, expressed as the proportion of peatlands in the total province area. (Dobrowolski et al. 1998).

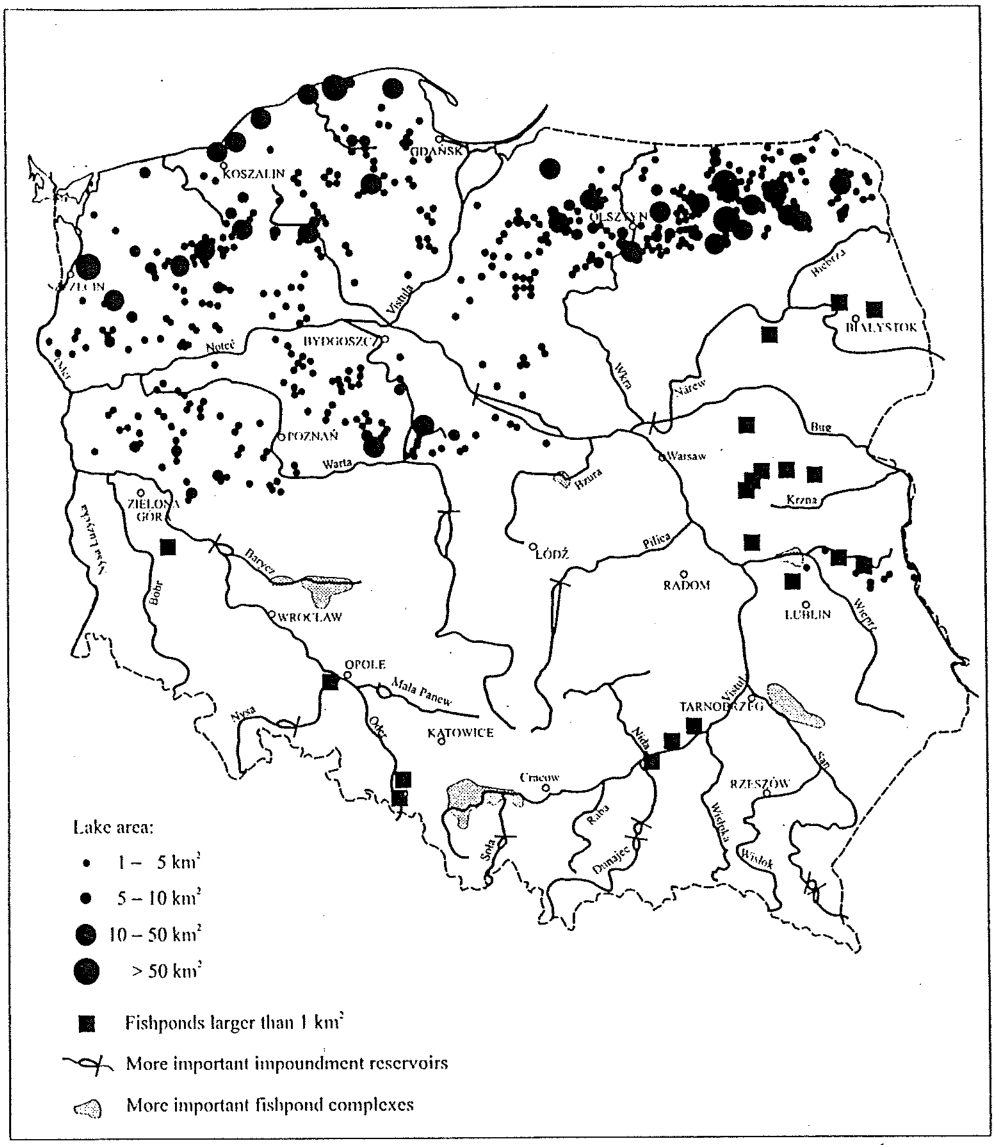


Fig. 9. The distribution of lakes and ponds in Poland (Dobrowolski et al. 1998).

In Poland, there exists over 2300 species of vascular plants. They coexist with other species (46900) of living organisms in Poland, which shows a fairly high biological diversity. The number of vascular plant species that prevail in Poland are constantly changing. In the last 200-300 years, about 300 species of vascular plants have been brought to our country. As a result, as many species have recently become or are threatened by extinction. The number of threatened plant species in Poland is shown in Table 1.

Table1.

Taxonomic group	Edition year	The Red Data Book Categories					Total threatened	% of Polish flora
		Ex	E	V	R	I		
Liverworts	1986 1992	– –	26 26	5 5	14 14	5 5	50 50	ca 20 ca 20
Mosses	1986 1992	4 4	14 17	43 45	29 29	31 41	121 136	ca 18 ca 20
Vascular plants	1986 1992	31 40	32 54	90 142	130 146	56 36	339 418	ca 15 ca 19

Categories:

Ex – Extinct or propably extinct.

E – Endangered. Taxa in danger of extinction.

V – Vulnerable. Taxa believed likely to move into Endangered category in the near future.

R – Rare.

I – Indeterminate.

The number of endemic vascular plants in the Polish Lowland (Fig. 10A) is very poor. The endemic plant associations are distributed in SE part of Poland (Fig. 10B).

An interesting group of mountain plants is growing in the Polish Lowland. To the important biogeographical vascular plants belongs 118 species (Zając 1996). In its distribution, many taxons represent a type with distinct Central Poland disjunction (Fig. 11).

About 200 vascular plants are under legal species protection, among them several growing in the wetlands: *Betula nana*, *B. humilis*, *Myrica gale*, *Salix myrtilloides*, *Isoëtes laustris*, *I. setacea*, *Trapa natans*, *Nuphar lutea*, *N. pumila*, *Nymphaea alba*, *N. candida* and some others.

Geo-botanical characteristics of North-Western Poland

The Northwestern part of Poland is situated within range of the Pomeranian and Poznań stages of the Vistulian glaciation (Fig. 12, 13). On our route we will cross two major areas: **The Lakeland** in the north and **The Belt of the Great Valleys** in the south of the visited area.

The Lakeland Belt (Pas Pojezierzy) ranges in altitude from 100 to 300 m above sea level. The main landforms include ground moraines with gentle and undulating elevations, frontal moraines forming the several hills, large outwash surfaces, different depressions filled with lakes and peat- and marshlands. The considerable elevation, the differentiation of the relief and the abundance of water reservoirs have resulted in the region being floristically (acc. to Czubiński 1950) the richest of all Polish lowlands.

During the two first days we will travel along the outwash-plain situated in the southeastern part of West-Pomeranian Lakeland Belt, It is a sandy area, mostly covered by pine forests (Tuchola Forest, Tuchola Pinewoods – Bory Tucholskie). An important borderline between Pomerania and Great Poland (Wielkopolska)- Kujawy Lowland runs along the Toruń-Eberswalde (pradolina) ice-marginal valley.

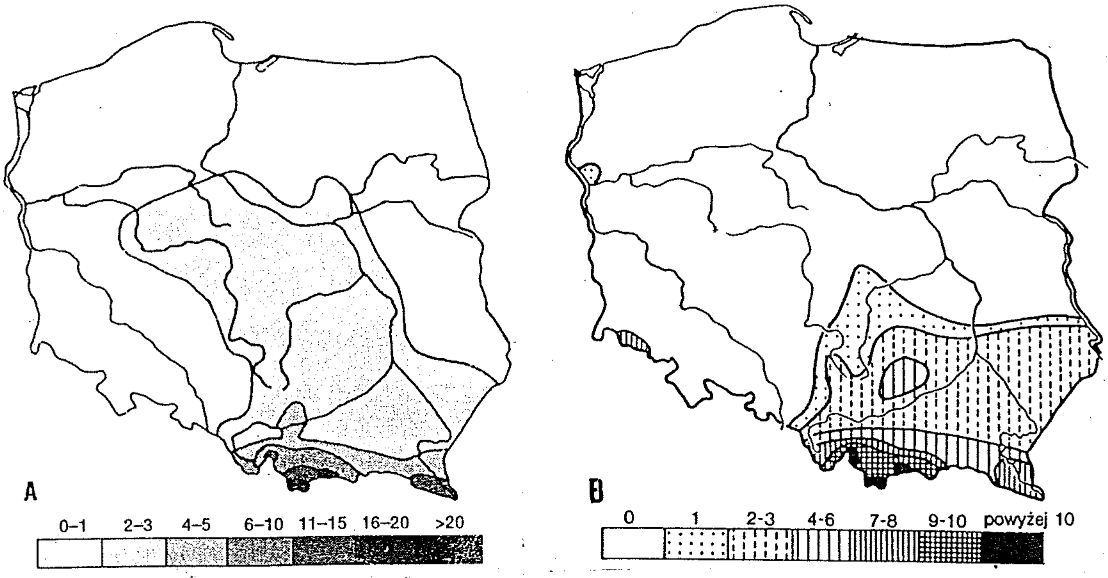


Fig 10. Number of the endemic species in Poland (A) and the concentration of Polish endemic plant associations (B). (A- after Piękoś-Mirkowa, Mirek, Miechówka 1996; B- after Matuszkiwicz 1991).

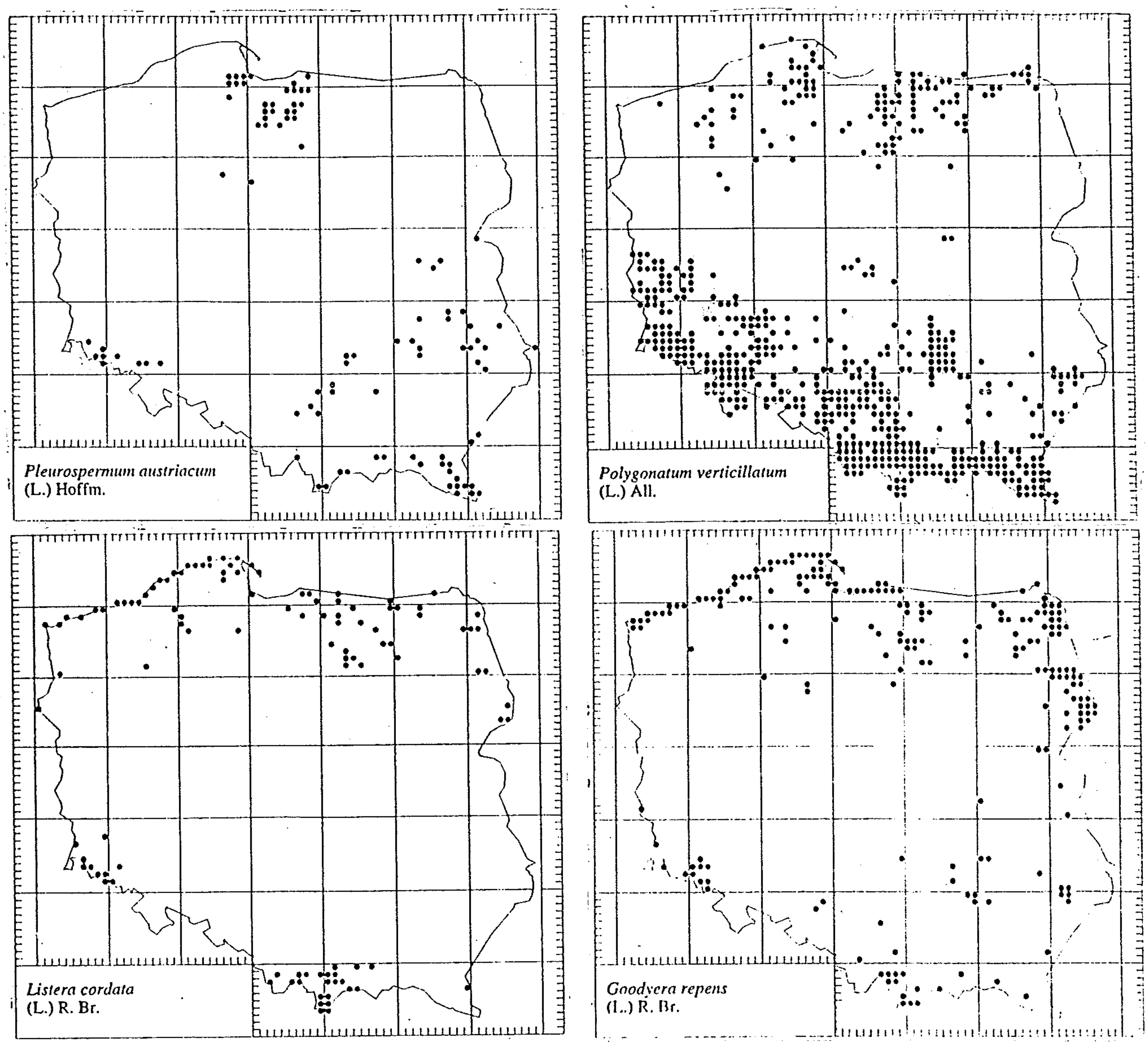


Fig. 11. Mountainous vascular plants distributed in the Polish Lowland (Zając 1996).

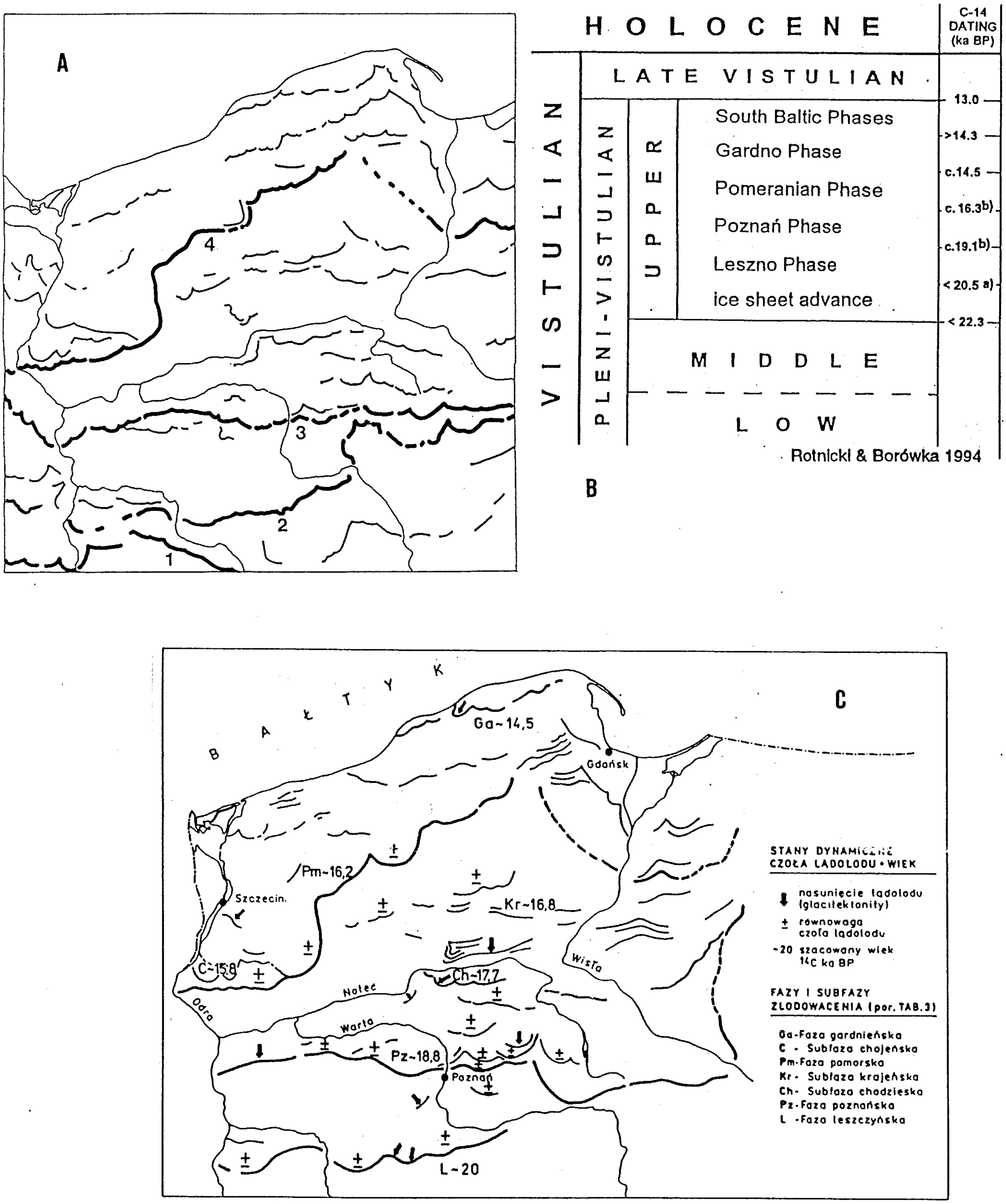
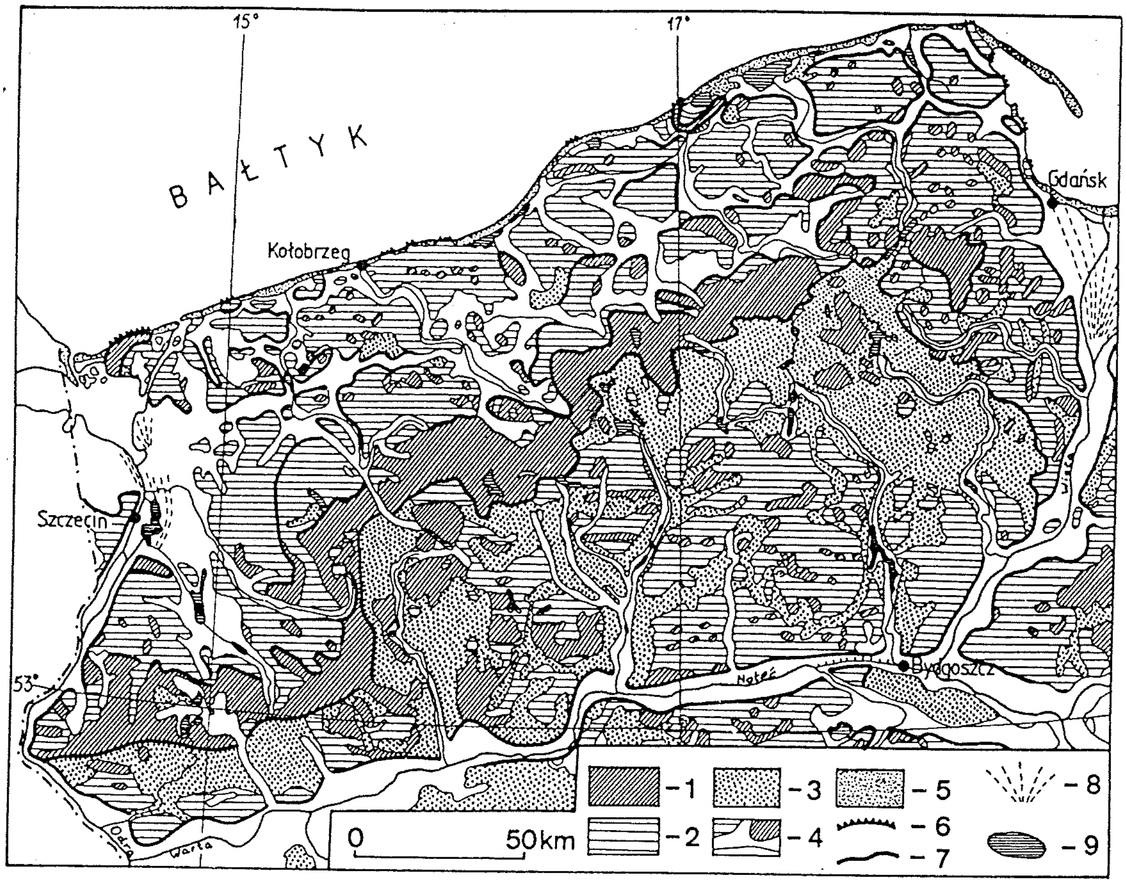


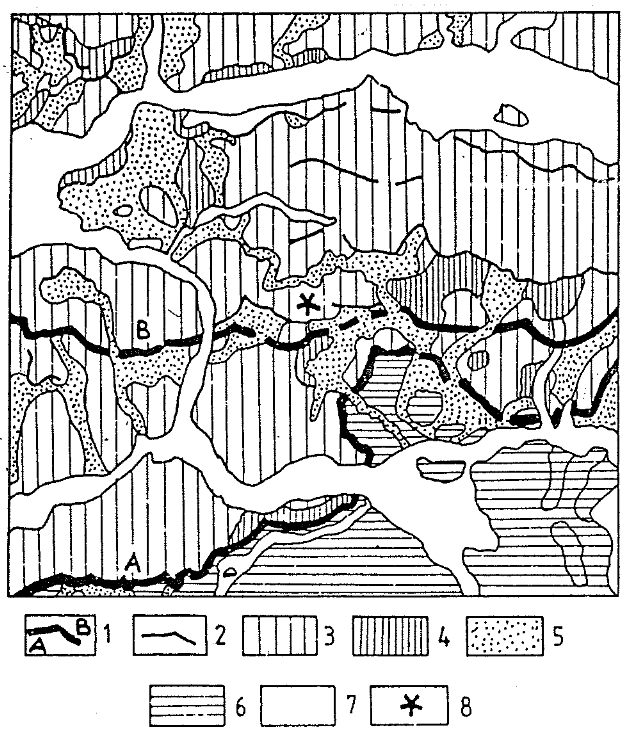
Fig. 12. Last ice-sheet and its deglatiation.

A. Location of the Scandinavian continental ice sheets in northwest Poland: 1- Drenthe Glaciation; Vistulian Glaciation: 2- Leszno Phase, 3- Poznań Phase, 4- Pomerania Phase (simplified from Liedke 1969); B. The age of the Upper Pleni-Vistulian phases (acc. To Rotnicki & Borowka 1994); C. Dynamic states of the last ice-sheet margins along major extension lines during deglaciation of northwestern Poland (Kozarski 1995).



Geomorphological map of the Western Pomerania (after Augustowski 1977). 1 – terminal moraines, kames and oses; 2 – ground moraines; 3 – outwash plains; 4 – ice-marginal valleys and valleys; 5 – spits and dunes; 6 – cliffs; 7 – the high ledges of the morainic uplands, valleys and terraces; 8 – alluvial fans; 9 – lakes.

Fig. 13. Geomorfology of Western Pomerania and Central Great Poland



Geomorphologische Skizze der Umgebung des Lednicer Landschaftsparks (vereinfachter Ausschnitt aus Liedtke, 1969). Weichsel–Eiszeit: 1 – Hauptendmoränenzüge: *A* – Leszno-Phase (Brandenburger Stadium), *B* – Poznań-Phase (Frankfurter Stadium), 2 – kleinere Endomoränenzüge, 3 – flache oder wellige Moränenlandschaft, 4 – kuppige Moränenlandschaft, 5 – Sander, 6 – flache, wellige oder kuppige Moränenlandschaft der mittelpolnischen Vereisung (Saale–Eiszeit), 7 – Urstromtäler, Terrassen und breite Täler, 8 – Lednicer Landschaftspark

The Belt of the Great Valleys - with an altitude above sea level amounts to 50-150 m. A typical feature of this belt is the occurrence of great, latitudinal extension of ice-marginal valleys (pradolina, Urstromtal), partly utilized by present-day rivers such as the Vistula (Wisła), Noteć, Warta, Odra. The landscape has a low relief diversified in many places by humps of sand dunes, undulating ground moraines, and small hills marking the end moraine of the main glacial oscillation. The slopes of the ice-marginal valleys were the routes of migration for xerothermic plants, a number of which have survived to the present day (e.g. along the Toruń-Eberswalde ice-marginal valley).

The major features of the climate may be traced to subatlantic and subcontinental influences. The average July temperature reaches +19°C, minimum temperatures in the coldest month, January, are between –1° and –2°C, and the annual average temperature is 7.6-8.1°C. Annual rainfall is about 500-600 mm, but in many parts of the region it remains below 500 mm. Selected features illustrating the climate are presented in Fig. 14.

Geobotanically, Tuchola Pinewoods (Bory Tucholskie) is a separate geobotanic district which lies within the subdivision of the "Belt of the Maritime Plain and Pomeranian Uplands" in a section of the "West-Pomeranian Transition Belt (6c on Fig. 15A). On sandy soils of outwash surfaces grow large forests and mainly cultivated pine stands, with many remnants of natural plant cover (e.g. *Taxus* forests, peatlands, understurbet lakes).

In the seven-degree scale of anthropogenic changes in the vegetation of Poland (Faliński 1975), Tuchola Pinewoods area belongs to the zone III and IV. The distribution of areas in the northwestern part of Poland between categories II to VII on the scale is shown in Fig. 16.

The Central Great Poland belongs to the western subdivision of the "Belt of the Great Valleys" in section "Great Poland-Kujawy" (the Poznan-Gniezno district 7c on Fig. 15A). This geobotanical unit is characterized by a lack of beech, fir, spruce and larch trees (Szafer 1972). The contrasts in terms of climate and soil are particularly emphasized by the complete deforestation of vast areas and a lowering of the groundwater table caused by unsustainable drainage practices. The forests are dominated by pine, (*Pinus sylvestris*), which as a result of human activity, has replaced some elements of the original deciduous forests. The deciduous forests which do occur in this area differ from others growing on dry ground as they frequently contain *Acer campestre* and *Sorbus torminalis*. One peculiar feature of this unit is that it lacks any raised bogs, and even transition bogs are rare. The valleys are covered by remnants of flood-plain forests with marshy meadows, fens and other wetlands, which are usually transformed considerably by human activity.

Falinski (1975) places Central Great Poland in the sixth, 'deeply transformed' zone (Fig. 16). This zone comprises land with a synanthropic vegetation which has itself undergone degeneration as a result of human activity.

As far as palaeoecological units are concerned, the discussed area belongs to the "Pomeranian Lake District" (Ps) and to the "Poznan-Gniezno-Kujawy Lake District" (Pr) (Fig. 15B), created for the International Geological Correlation Programme 158B: Palaeohydrological changes in the temperate zone in the last 15.000 years, Lake and mire environments (Ralska-Jasiewiczowa 1986).

In Pomerania, there exist a numerous group of geographic relicts plants. To the glacial relicts after Czubiński (1950) belongs:

Equisetum variegatum	*Stellaria crassifolia*	*Empetrum nigrum*
Saxifraga hirculus	*Polemonium coeruleum*	*Oxycoccus microcarpus*
Rubus chamaemorus	*Viola epipsila*	*Carex heleonastres*
Betula nana	*Nuphar pumila*	*Carex pauciflora*
Betula humilis	*Pedicularis sceptrum-Carolinum*	*Carex chordorrhiza*
Salix myrtilloides	*Linnaea borealis*	*Trichophorum alpinum*
Salix livida	*Ledum palustre*	*Calamagrostis neglecta*

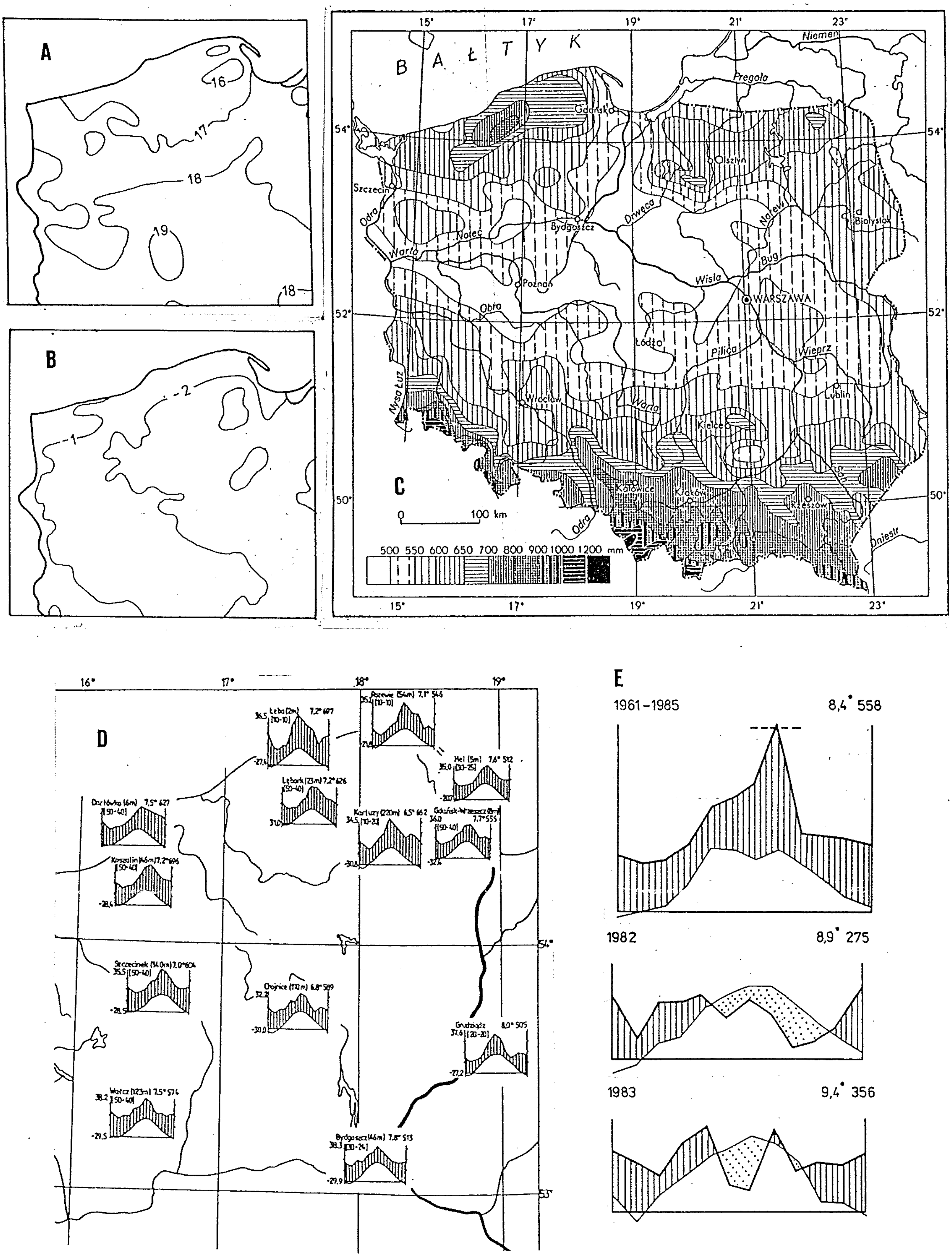
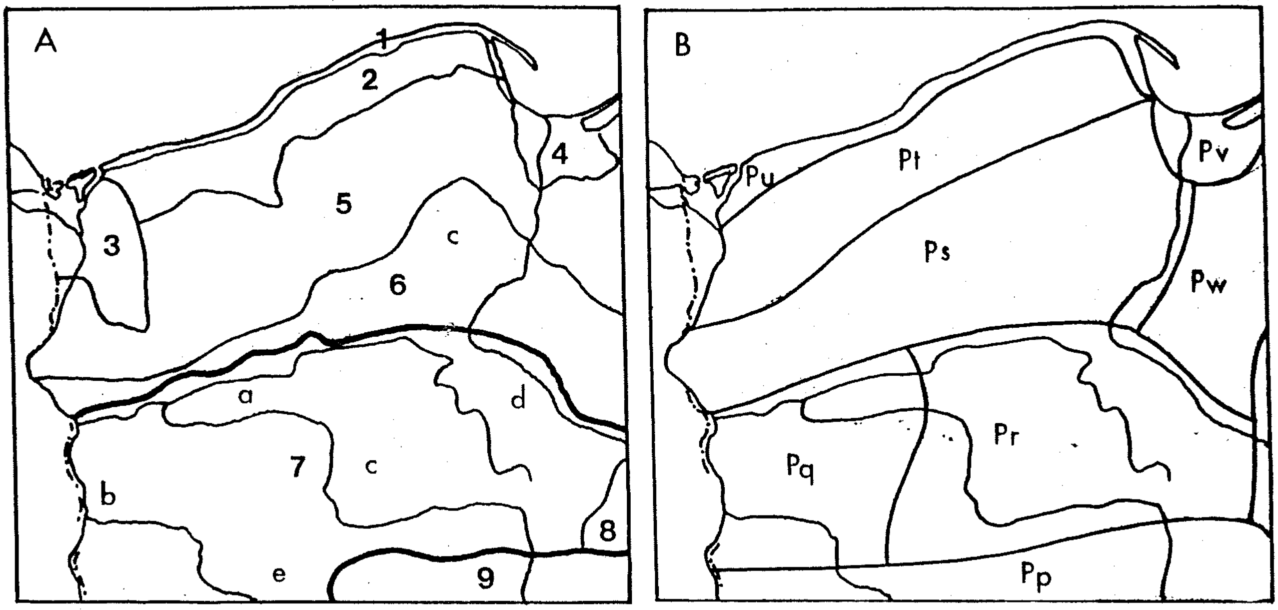


Fig. 14. Selected elements of climate

Isotherm of mean temperatures in July (A) and January (B) in NW Poland; average annual precipitation in Poland (C), climatic diagrams for E-part of Western Pomerania (D) and for Poznań (E).



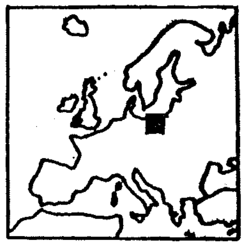


Fig. 15. Geobotanical (A) and palaeoecological divisions of NW Poland (simplified after Szafer 1972 – A, and Ralska-Jasiewiczowa 1986 - B).

Geobotanical division (A):

Kingdom: Holarctis

Region: Euro-Siberian

Province: Central European

Subprovince: Lowland-Highland

Division: Baltic

Subdivision: Belt of the Maritime Plain and Pomerania Uplands

a- Section: Baltic Shore

b- Section: Baltic Coast

c- Section: Szczecin Lowland

d- Section: Delta of the Vistula

e- Section: Pomeranian Lakeland

f- Section: West-Pomeranian Transtion Belt

c/ District: Tuchola Pinewoods

Subdivision: Belt of the Great Valleys

g- Section : Great Poland-Kujawy

c/ District: Poznań-Gniezno

h- Section: Mazovian

Subdivision: Belt of the Central Highlands

i- Section: Northern Marginal Uplands

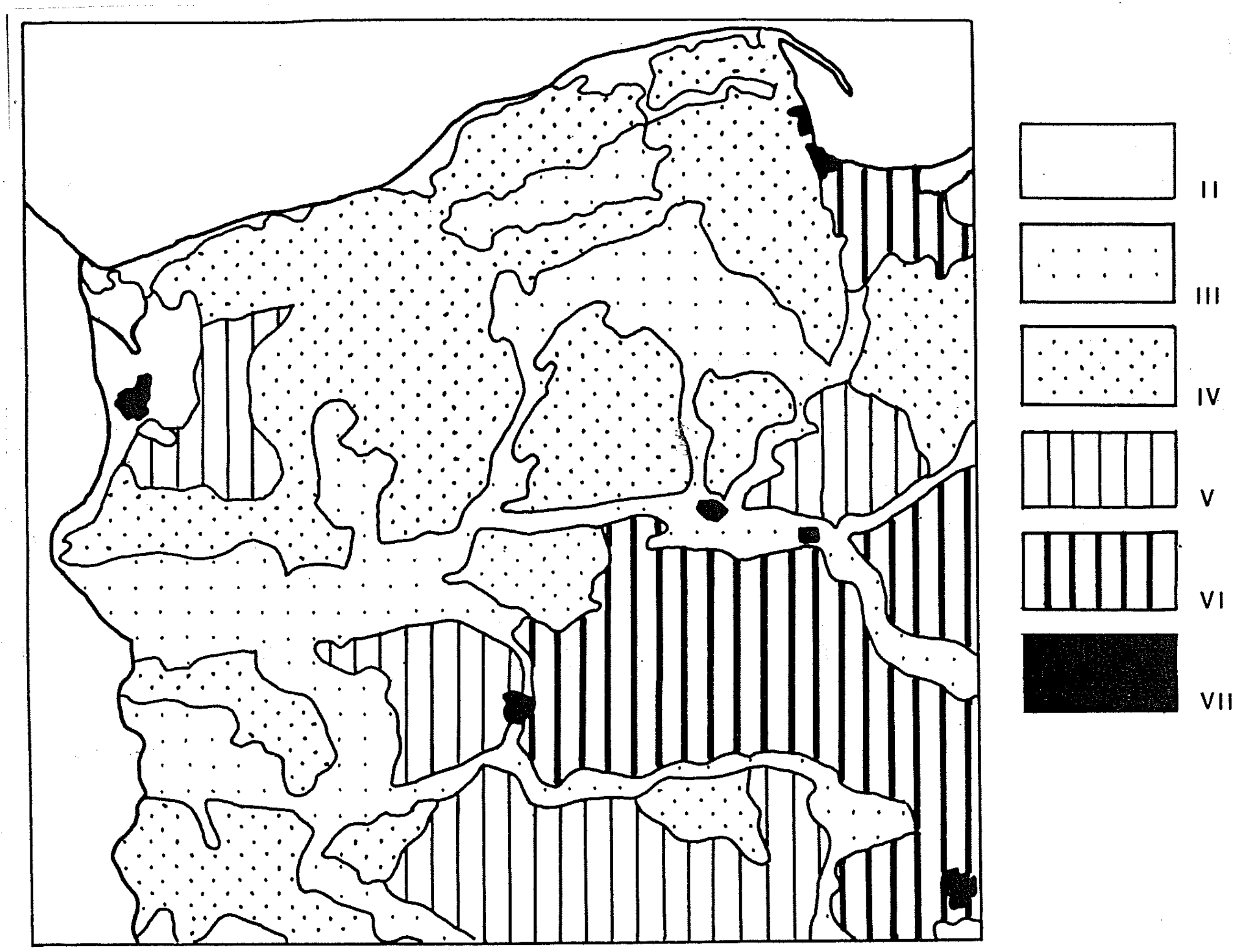


Fig. 16. Stages (II-VII) of anthropogenic transformation of the vegetation in North-West Poland (simplified from Faliński 1998).

II – Territory with large complexes of natural vegetation with a predominance of communities of altered structure or secondary origin; semi-natural and synanthropic vegetation with numerous primitive traits.

III – Territory with fragments of natural vegetation remaining only at extremely arid sites, sites inaccessible to agriculture or sites of habitation. At most sites it has been replaced by a semi-natural substitute forest vegetation or grassland communities.

IV – Territory with fragments of natural vegetation remaining only at extremely arid sites inaccessible to agriculture and sites of habitation. At most sites it has been replaced by synanthropic vegetation.

V – Territory in which the natural vegetation has been almost completely replaced by synanthropic vegetation.

VI – Territory in which the synanthropic vegetation replacing the natural one is itself undergoing degeneration owing to human activity.

VII – Territory with an intensively cultivated vegetation horticulture, municipal green areas), recultivated postindustrial waste land and fragments of ruderal vegetation or areas devoid of plant cover.

The concentration of glacial relicts in Pomerania are shown in Fig. 17. Along the lower part of Odra and Wisła valleys (and also on slopes of Toruń-Eberswalde ice-marginal valley) the distribution of many xerothermic species can be found (Fig. 18). Many of them belong to Czubiński (1950) classifications of postglacial relicts (*Prunus fruticosa*, *Stachys germanicus*, *Campanula sibirca*, *Adenophora liliifolia*, *Scorsonera purpurea* and others).

The synanthropic flora in Pomeraina and in Central Great Poland (Wielkopolska) are rich in various species. For example, in Poznań (of 243 squares of a side of 1 kilometer) have found 1300 species (Jackowiak 1993). Among the synanthropic species, one can predominately distinguish between two main groups: **Apophytes** – synanthropic plants of indigenous origin (e.g. *Agropyron repens*, *Equisetum arvense*, *Tussilago farfara*), and **Anthropophytes** – synanthopic plants of alien origin. Unfortunately, there is no time to discus the fascinating history of synanthropic flora and vegetation or to follow the important problems concerning the present-day migrations of synantropes. We will be able to present only two examples: the percentage of apophytes to anthropophytes in relation of number of synathropic species (Fig. 19) and the Malva alcea as a cultivation relict (Celka 1998), closely linked to different prehistoric and historical habitats (Fig. 20).

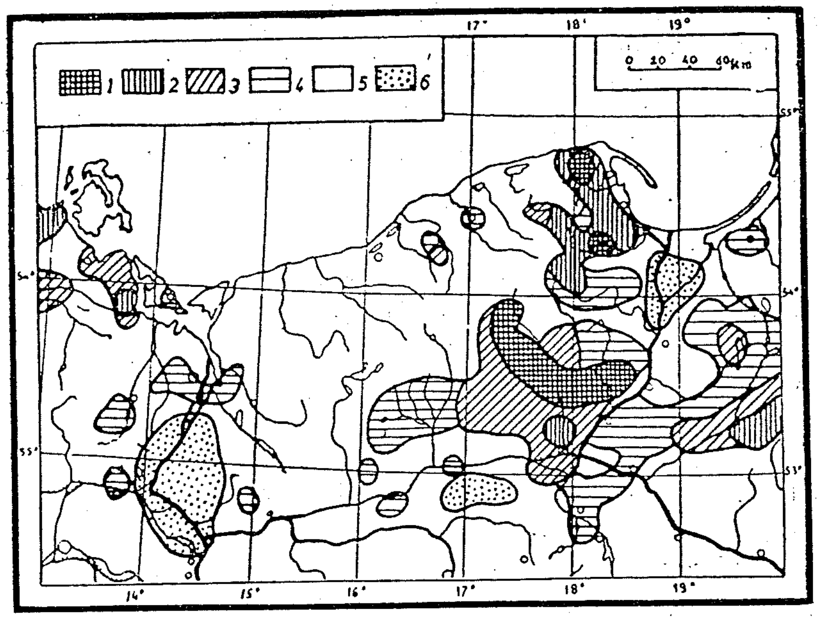


Fig. 17. Density of glacial relicts in Pomerania (Czubiński 1950).1- more than 12 species, 2- 9-12 species, 3- 6-9 species, 4- 3-6 species, 5- 1-3 species, 6-lac of glacial relicts.

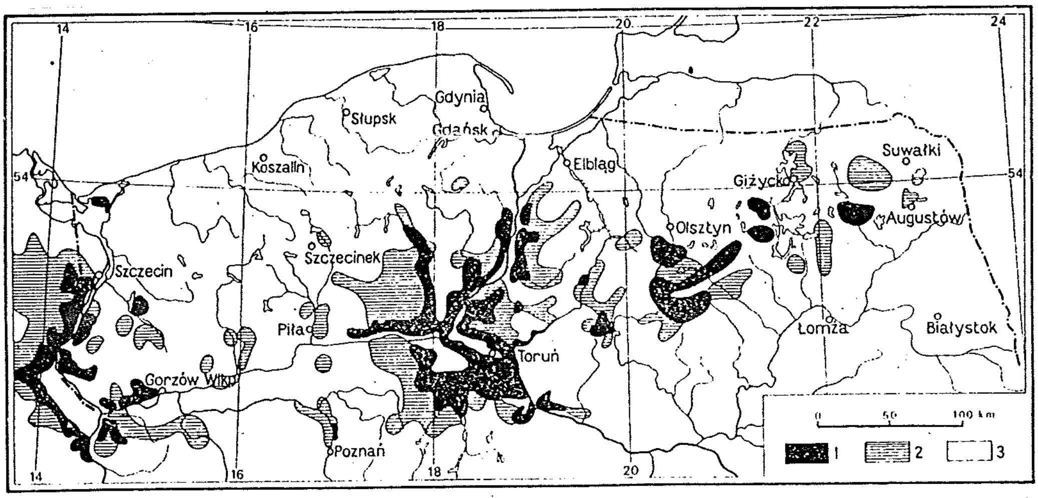


Fig. 18. Distribution of xerothermic (steppe) species in Northern part of Poland (Szafer 1972). 1-dense, 2- dispersed, 3- lac of Steppe species.

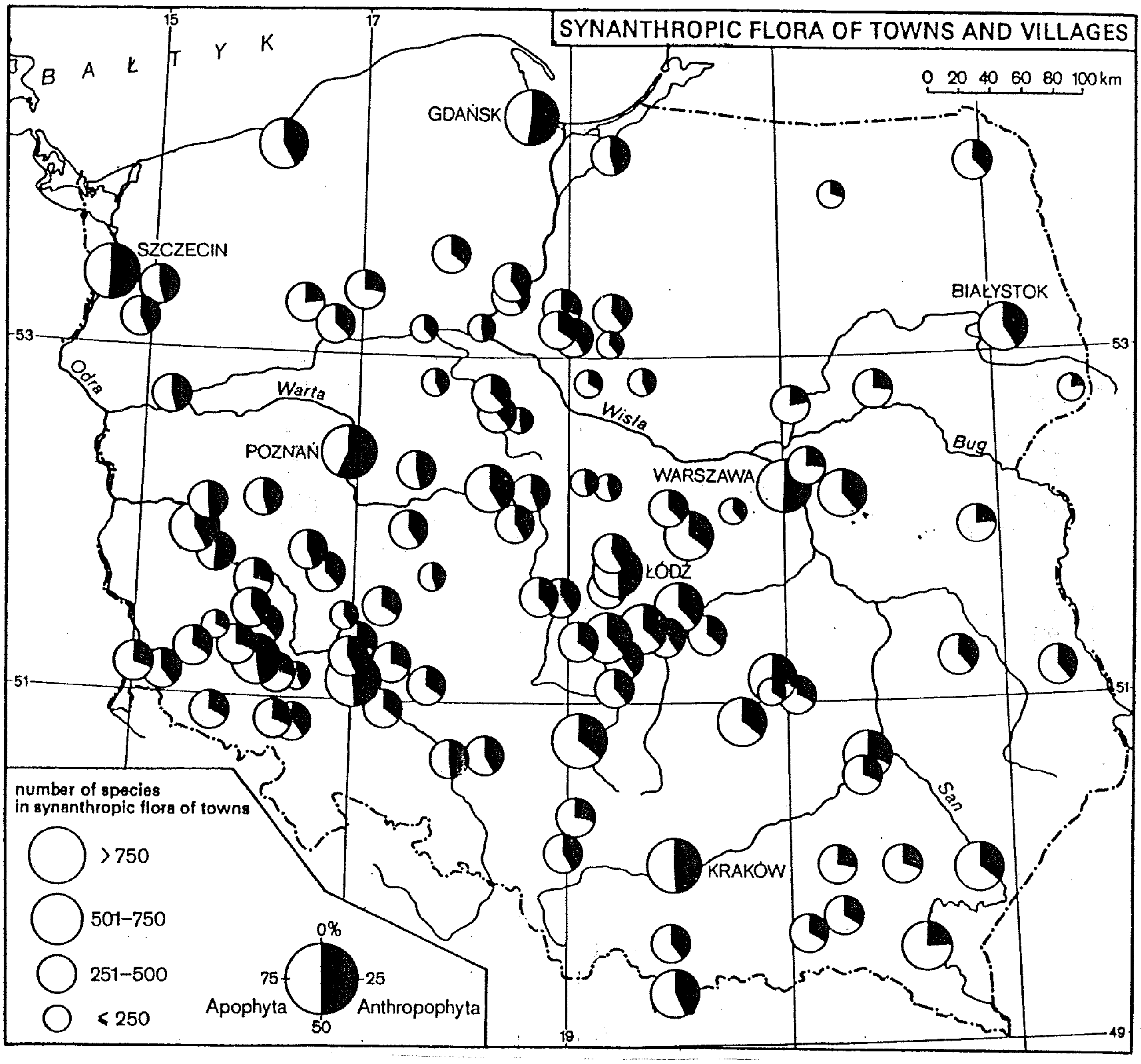


Fig. 19. Composition of synanthropic flora of selected towns and villages (Faliński 1998).

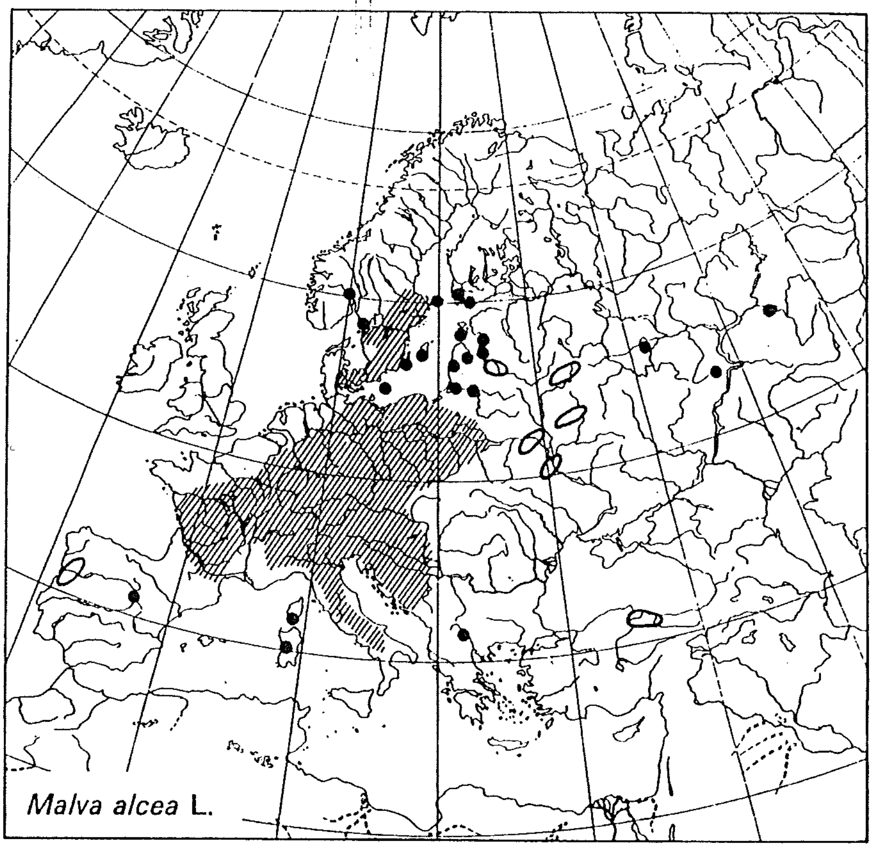


Fig. 20. The distribution of *Malva alcea* in Europe (Celka 1998).

Recent plant cover and postglacial vegetation development in an outwash-plain area

Introduction

The bedrock of the Bory Tucholskie landscape is connected with fluvioglacial erosion and accumulation at Pomeranian Phase at the last glaciation. In many parts of the outwash surface are isolated patches of ground-moraines, mostly deforested and used for agriculture. The northern part of the outwash surface lays on 175 m a.s.l. and the southern part on 153-155 m a.s.l. In the outwash, there was found distinguishable levels that were connected with fluvioglacial and river drainage. The outwash-plain was cut by many subglacial channels filled with lakes of different size. Its surface was also transformed by eolian processes, river activity and melting dead-ice blocks during the early Postglacial Phase. The southwest part of Tuchola Pinewood is bordered by end morains with the highest hill of the region (Góra Wolność, 206.1 m a.s.l.). The endmoraine zone surrounding the terminal depression of Lake Charzykowskie.

The soils originate predominantly in fluvioglacial, eolian and peatlands deposit. On sandy substatum they are mainly podsols with a thin, mostly very acid humus layer.

Recent plant cover and nature protection

The Tuchola Pinewoods (Bory Tucholskie) is a large forest complex covering approximately 1.5% of Polish territory. The dominant pine forest stands with a mixture of *Betula pendula, Alnus glutinosa, Fagus sylvatica*, *Picea abies* and others elements, which are enriched by numerous lakes and peatlands. These are characterized by valuable natural features which were decisive in setting up many of the areas of the Tuchola Forest as a protected nature area. Pine forests forms several associations depending upon the soils and moisture condition.

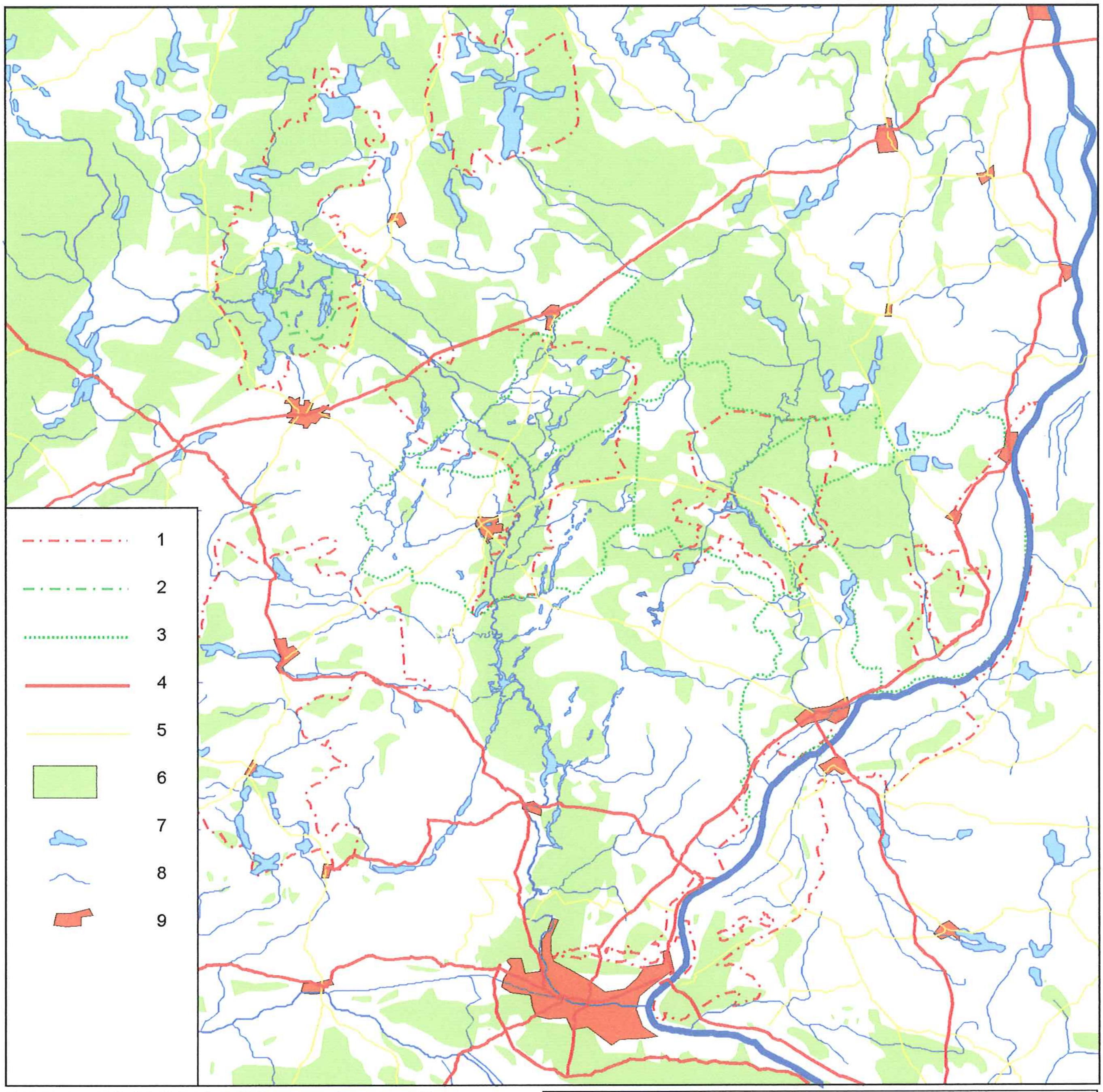
Large areas are protected in the form of several nature reserves - five landscape parks and one national park „Bory Tucholskie" (Fig. 21).

The national park was founded in 1996 on an area of 4798.23 ha with a buffer zone of 12980 ha. The dominant landscape feature is the forest cover, partly monoculture of pine, comprising 79% of the Park area. The aquatic biotopes comprise 11% and the unforested areas 2% (Fig. 22). Among the aquatic biotopes, there occur a considerable variety of trough lake sizes as well as smaller reservoirs of melt-out origin filled with oligotrophic lakes with *Lobelia dortmanna* and *Isoëtes lacustris.*

The state of palaeoecological research

The first results of palinological investigated were published before the Word War II. The stages of research are shown on Fig. 23. The modern palaeoecological investigation started with the turn of 70/80 with the interdisciplinary research of Lake Gacno Wielkie, initiated by B. Berglund and published by Hjelmroos-Ericsson (1981).The side, among two others, was involved in the IGCP 158B, which represents a primary reference site (Fig 24A, 25). The first synthesis (Fig. 24B, Fig. 26, Table 2) was published by Miotk-Szpiganowicz (1992) and Bogaczewicz-Adamczak (1990). Recently, interdisciplinary research of limnic and telmatic sediments has been continued with international cooperation, as well. In recent years, the most numerous studies have been performed in the eastern part of the Tuchola Pinewoods.

Kazimierz TOBOLSKI



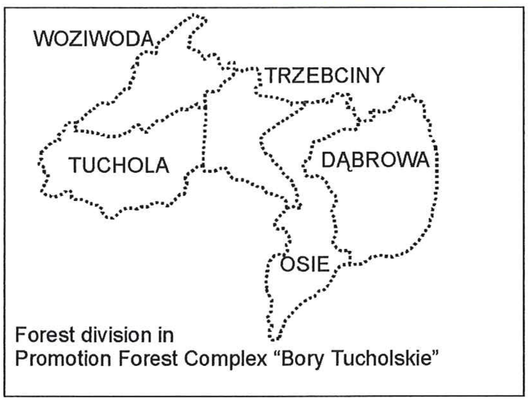


Fig. 21. Tuchola Pinewoods. Protected areas.

1 - boundary of Landscape Parks

2 - boundary of National Park

3 - boundary of forest division in Promotion Forest Complex "Bory Tucholskie"

4 - main roads, 5 - secondary roads

6 - forests, 7 - lakes, 8 - rivers, 9 - towns

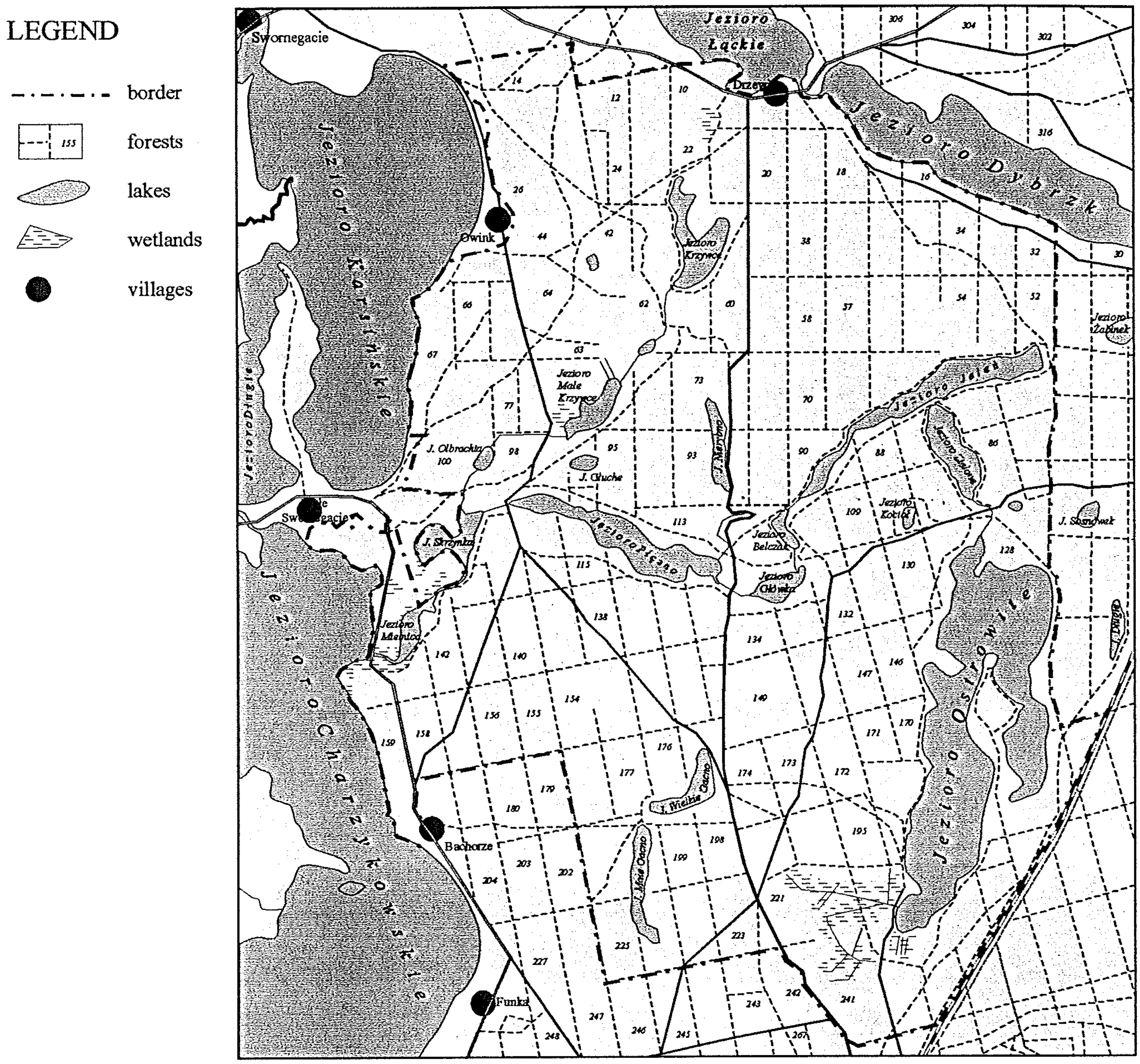


Fig. 22. "Bory Tucholskie" National Park

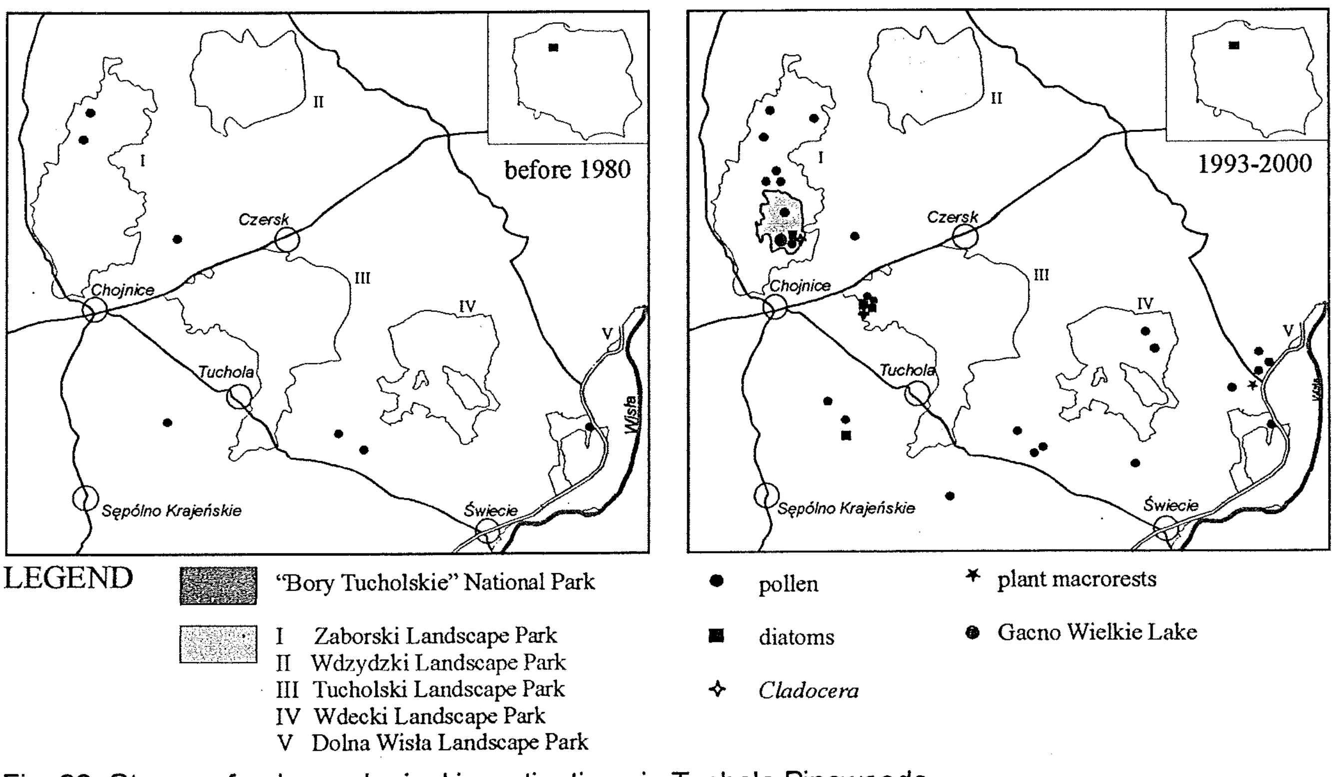
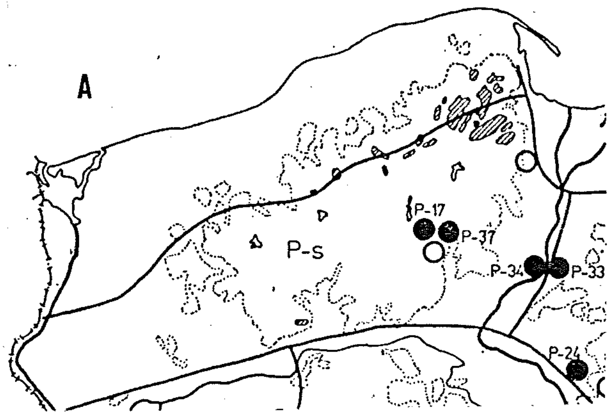


Fig. 23. Stages of paleoecological investigations in Tuchola Pinewoods

A



B

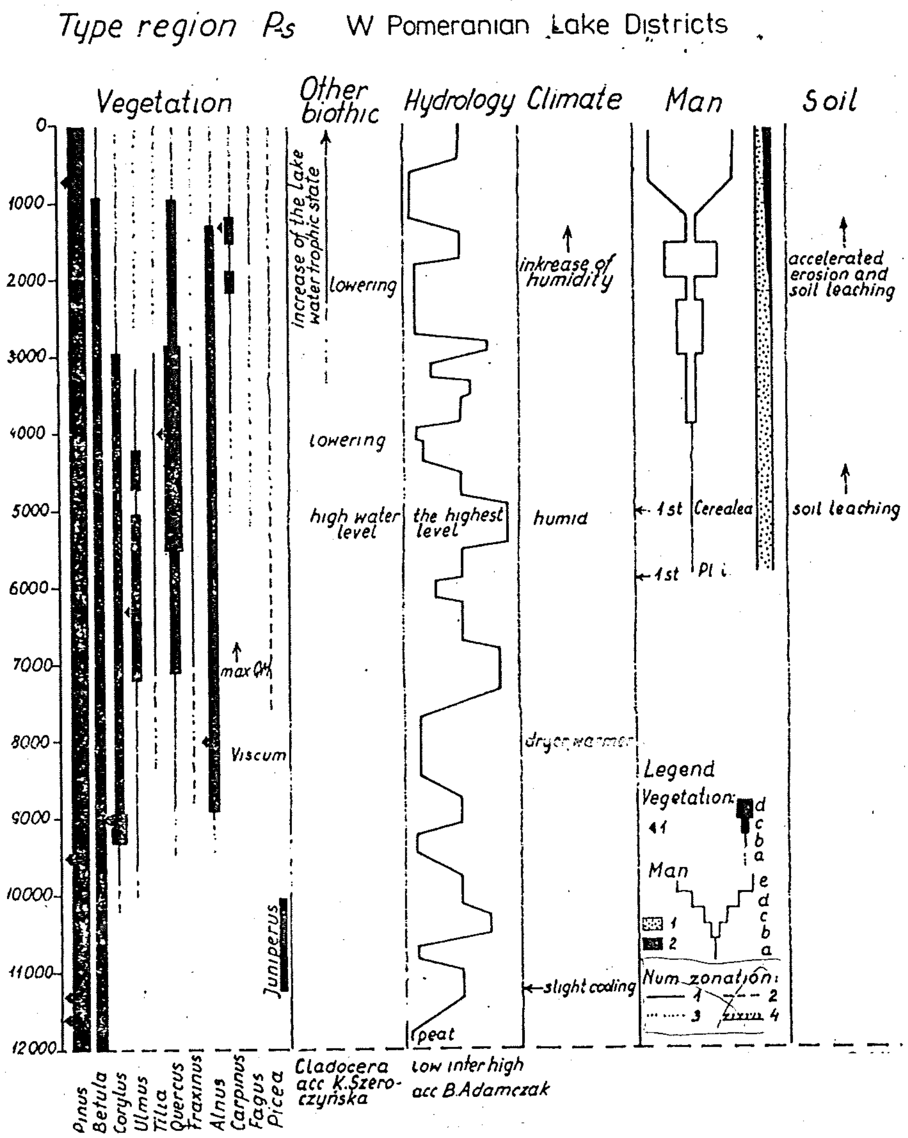


Fig. 24. A- Reference sites in Tuchola Pinewoods: P-17 Gacno Wielkie Lake; P-34 Fletnowo; P-37 Mały Suszek (M. Ralska-Jasiewiczowa 1989)

B- Event stratygraphy: Vegetation a- presence hypothetical or slight, b- present, c- expansion or important part, d- common, 1- maximum; Man – human impact :a- slight, b,c,d.e, increase in settlement and deforestation, 1- grazing, 2- agriculture (Miotk-Szpiganowicz 1989).

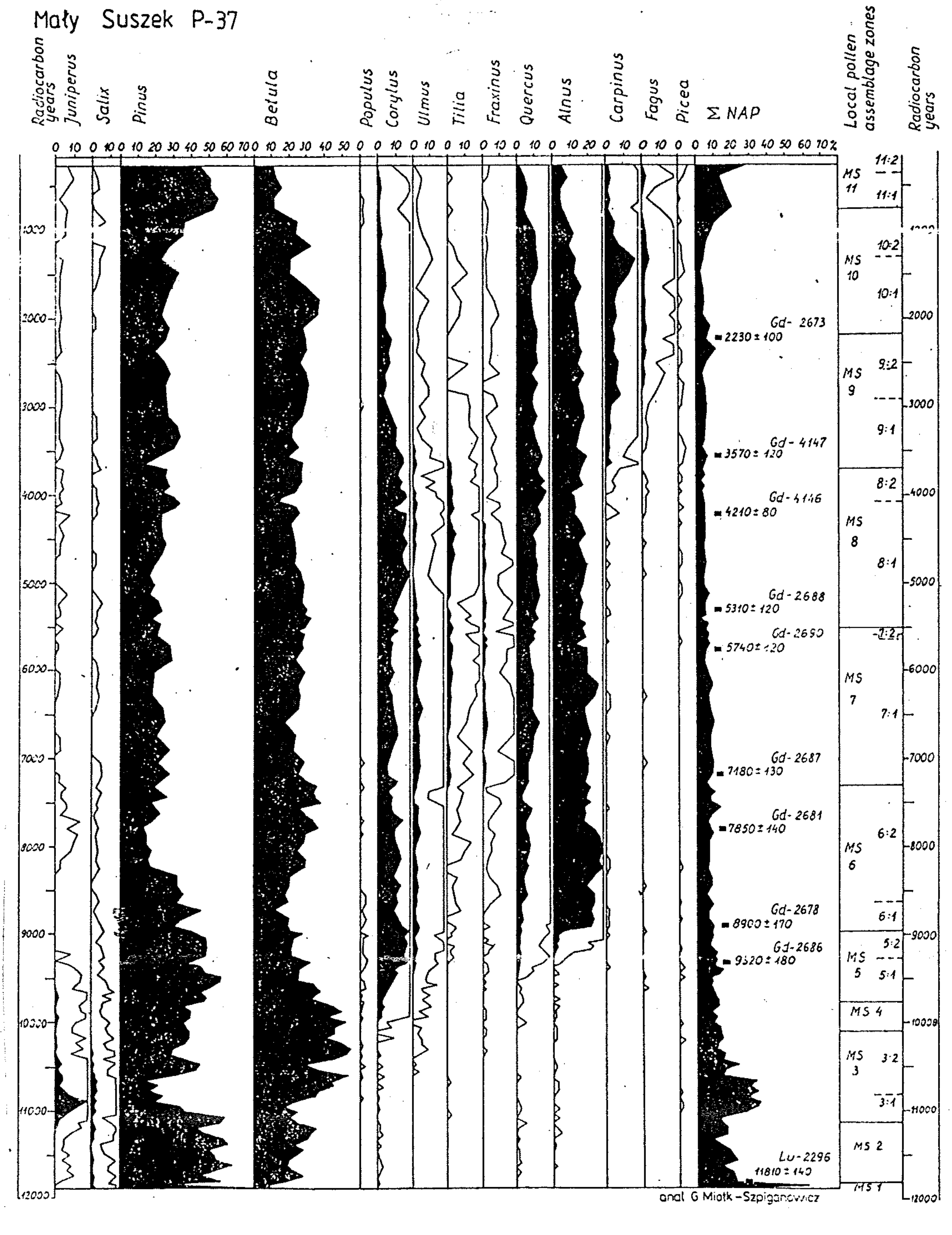


Fig. 25. Mały Suszek. Simplified pollen diagram (Miotk-Szpiganowicz 1989).

History of the lobelian lakes – Wielkie Gacno

The vegetational changes in the area surrounding Lake Wielkie Gacno are synthesized by applying Iversen's palaeoecological model and terminology. Full glacial time is followed by the protocratic stage of the Late Glacial and the first part of the Holocene. During this time the low-competitive and light-demanding pioneer plants immigrated on to the neutral, unleached mostly minerogenic soils.

In the Wielkie Gacno area the protocratic stage is assumed to have finished around the chronozone boundary Early/Late Pre-boreal. By that time *Corylus*, *Ulmus*, *Alnus* and even *Quercus* had immigrated. The steppe-like vegetation with Juniperus had already retreated and almost totally disappeared somewhat earlier. The herb vegetation, indicating open communities and unleached soils (e.g. *Rumex* and *Artemisia*) and the vegetation which preferred moist meadows near waterbodies (e.g. *Filipendula*, graminids and sedges) was only present a few individuals.

The pioneer stage followed by a mesocratic stage comprising the greater part of the Holocene. In the beginning the immigrating forest trees were competiting for growing space, and only reached a well-balanced conditions gradually. Later when the climate reached its optimum, slightly acid soils developed and soils leaching began. According to Iversen the climax forests achieved their maximum shade during the Late Atlantic and Early Sub-boreal periods.

In the investigation area Corylus was as common as the *Quercetum mixtum* species during the Late Pre-boreal, Boreal and earlier part of the Early Atlantic chronozones. The climax forests developed during the Middle and Late Atlantic chronozones, a feature which is also indicated by the low pollen influx-values. During the time of the climax forests *Corylus* had to retreat to the marginal forest zone, *Ulmus* was as common as *Tilia*, but the *Quercetum mixtum* forests were dominated by *Quercus*, which has a greater life amplitude forming and was able to form associations with both *Pinus* and *Betula* on the one hand and with the other QM-species on the other. Herbs and graminids were found almost exclusively in the moister and more fertile broad-leaved forests and along the water sources.

The beginning of the last stage, the telocratic stage, is often placed at the beginning of retrogressive development in the forest vegetation. Accelerated leaching and soil degradation caused by increasing humidity and climatic deterioration are characteristic of this stage.

In Lake Wielkie Gacno Area the boundary between the mesocratic and telocratic stages are not sharp. The nemoral broad-leaved forests reached their climax and the retrogressive forest development began around the Atlantic/Sub-boreal chronozone boundary. However, the transition phase was rather long. The representation of *Quercus* remind virtually unchanged. During the Sub-boreal chronozone it reached a somewhat higher representation than before, while *Ulmus*, *Tilia* and *Fraxinus* show a distinct recession. At the Sub-boreal/Sub-atlantic chronozone boundary *Fagus* expanded with a simultaneous slight increase in *Betula*.

The human impact during the later part of the mesocratic and earlier part of the telocratic stages was fairly slight and its influence on the natural vegetation did not cause as great changes as did the climatic factors. Probably in the later part of the telocratic stage, is the first time, when human impact was so strong as to be the primary reason for large scale changes in the forest in the forest vegetation.

Because of the characteristic dune topography and the naturally poor, sandy soils, the vegetational development of the Lake Wielkie Gacno area is somewhat different from that of the forests in South Scandinavia. It is thought that, throughout the whole of the Holocene, the forest vegetation consisted of a mosaic of several different kinds of associations growing partly on the poor, sandy soils of the dunes and partly on the more fertile and favourable places between the dunes and along the rivers and lake shores.

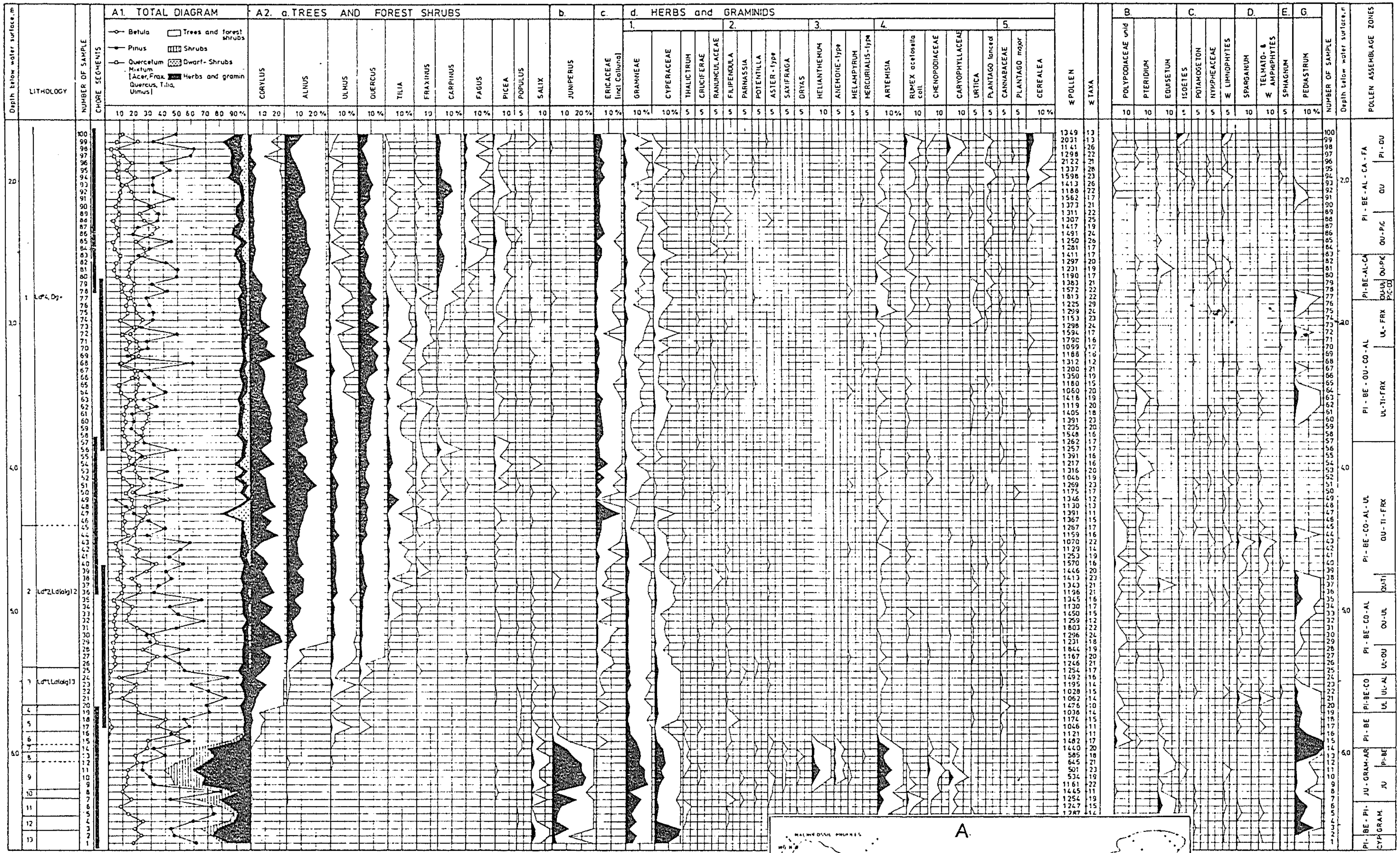
The regional forest development is clearly seen in the pollen diagram and it should be stressed that the nemoral broad-leaved forests were well developed even on the natural (that is, unaffected by man) soils of the Lake Wielkie Gacno area. However, the forest communities were more or less dominated by *Pinus* during the whole of the Holocene.

The succession was rather sensitive to the changes in the level of the ground—water. Because of this water-level changes have in important impact on the forest communities. Five major low-water periods have been established in Lake Wielkie Gacno. As a whole Lake Wielkie Gacno seems to have been considerably shallower during the earlier part of the Holocene, while during the Late Atlantic chronozone the lake became generally deeper and the level of the ground-water generally higher.

As is evident from the palaeolimnological results the productivity of the lake itself has bee fairly low throughout the whole of its development and, because the soils around the lake are poor, it can be predicted that during the major part of the Holocene, the vegetation around the lake has obtained its nutrients from the ground-water. The phosphorus and carbonate contents of the lake sediment in particular were considerably higher during the Holocene than they are today, while the nitrogen content has remained low. Thus it is thought that nitrogen has been the limiting factor in lake productivity. The supply of the nutrients seems to have depended greatly on the fluctuations in ground water level and thus also on those of the lake water-level.

In the Pre-boreal chronozone the organic layer in the soils was fairly thin and the ground-water level was relatively low. On the dune-slopes a mull horizon developed which, during the Boreal chronozone, became even thicker and appeared closer to the lake shores. On the dune-slopes a raw humus horizon developed. The number of forest species was considerably higher than before. During the Atlantic chronozone especially, when the ground-water level is thought to have been higher, the nemoral broad-leaved associations were able to expand onto higher ground and *Pinus* was forced onto the poorest places, mainly on the higher dune-tops. During that time the mull layer of the sandy soils was thicker and richer in nutrients. Retrogressive development of the forest vegetation started at the beginning of the Sub-boreal chronozone, and is thought partly to have caused the increased values for the pollen influx. This was probably due to climatic deterioration, more active soil leaching and human interference with the forest. On the higher places the mull layer became thinner and the broad-leaved forests which were not destroyed by man were forced onto the lower levels along the watercourses. Acidophilous *Pineto-Quercetum* association began to develop and, on the more mature places, *Querco-Carpinetum* associations began to appear. In the Middle and Late Sub-atlantic chronozones humidity increased and the exploitation of arable land resulted in accelerated erosion and soil leaching and thus a reduction in the nutrient capital. Except on the advantageous moister places between the dunes and along the watercourses the mull layer was very thin and such areas could no longer serve as agricultural land. The forests became naturally occupied by associations dominated by *Pinus* and were gradually exploited for forestry purposes. The modern forest communities of which the *Vaccinium myrtilli-Pinetum* is the most common, were largely formed artificially.

Mervi Hjelmroos-Ericsson (1981)



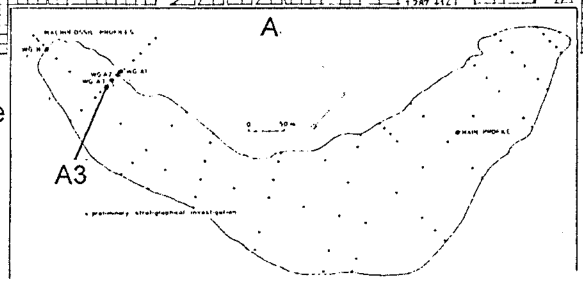


Fig. 27. Pollen diagram Wielkie Gacno A3 and (A) its location in the lake

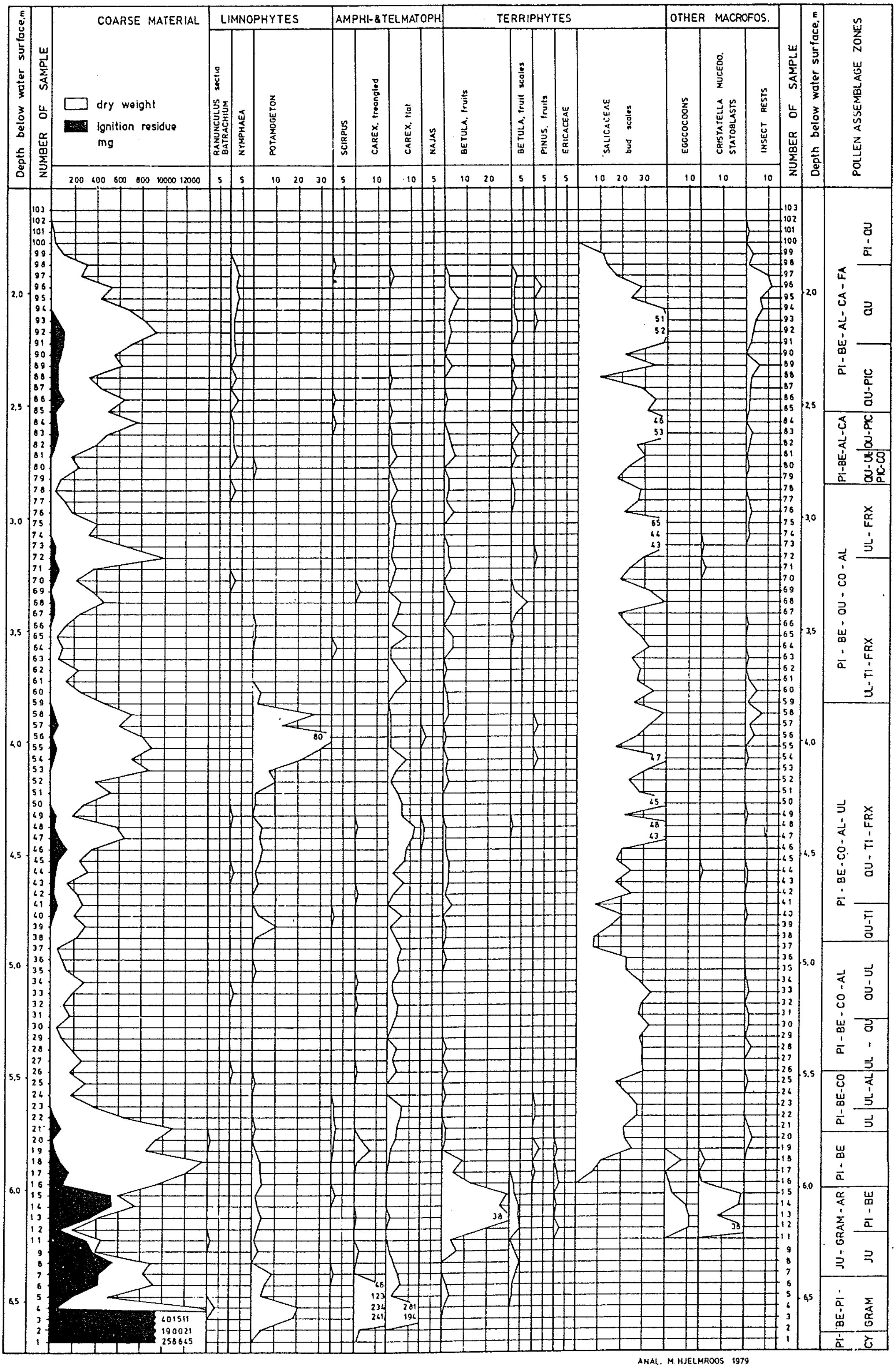


Fig. 28. Macrofossil diagram Wielkie Gacno A3.

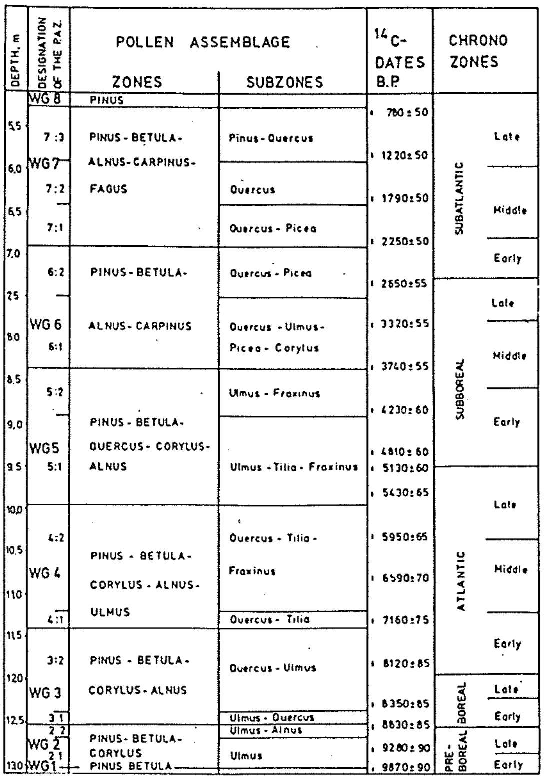


Fig. 29. Comparison between the pollen assemblage zones of Lake Wielkie Gacno and the chronozones as well as the C^{14} dates (only the Holocene).

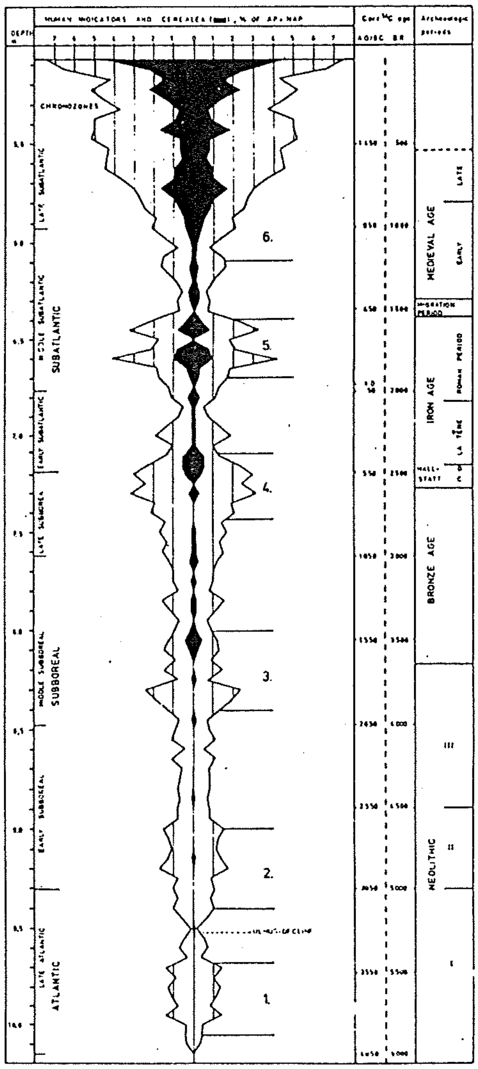


Fig. 31. Human impact diagram with the local anthropogenous phases, Lake Wielkie Gacno.

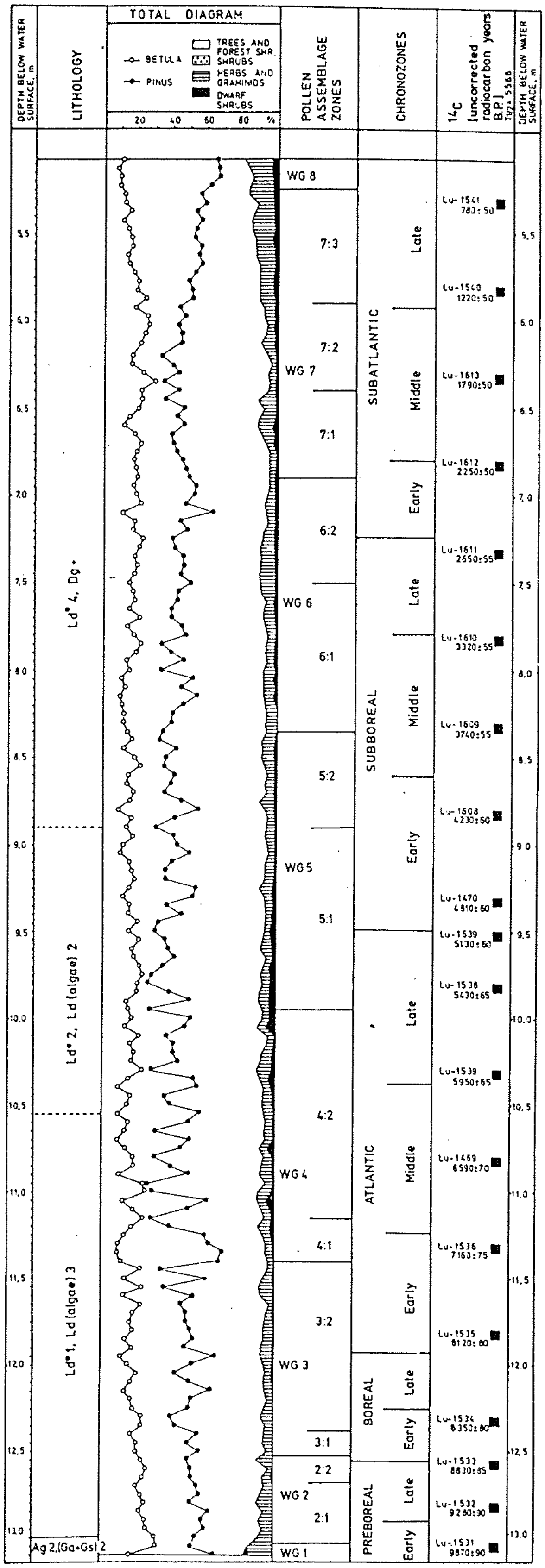


Fig. 30. Comparison between the Holocene PAZ's of Lake Wielkie Gacno and the chronozones and their relation to the main vegetational features in the area.

History of the lobelian lakes – Nierybno

Bory Tucholskie are the area of large and interesting forests with differentiated geology, geomorphology, plant cover and a lot of rare species with the range limited to the small area in Poland or, even, in Europe. Oligotrophic, lobelian lakes are one of the exceptional phenomena existing in Bory Tucholskie. There are about 150 of such lakes in Poland and most of them are situated in Pomerania within Bory Tucholskie area.

There have been done some palaeoecological investigations in Bory Tucholskie, but only one of them, documented research of Lake Wielkie Gacno, concerns to the oligotrophic lake. It was a good reason to take up studies in that subject. The main problems to solve are: history of the lobelian lakes in Poland, changes in range of *Lobelia dortmanna*, *Isoëtes lacustris* and *Litorella uniflora*, characteristic macrophytic species of such reservoirs, their representation in pollen diagrams, comparison with the other, investigated lakes in Europe and comparison of the representation depending on the location of the site within the range of distribution of given species. It would be also very interesting to get knowledge, why there are some lakes and mires with still poor trophy status in spite of continuous, strong eutrophication of environment, originated in human activity from several centuries.

In 1998 the first core in Lake Nierybno was taken. Unfortunately, because of technical problems lower part of the core was the only possible to get. The upper one was half-liquid and impossible to take with the standard coring equipment. Next, upper part of the sediments was taken in 1999 year by a group of geologist from GeoForschungsZentrum in Potsdam.

The sediments of core Nierybno 98 were accumulated in the end of the Late Glacial and during the older part of the Holocene. The deepest part contains a lot of mineral elements, which were overlayed by calcareous, fine, detritous gyttja.

The Late Glacial part represents a plant cover in Younger Dryas with high pollen content of *Juniperus* and NAP. There are also curves of *Salix* and *Helianthemum* clearly marked. Preboreal Period is seen in a thin layer of sediments where *Betula* pollen grains are of the great importance. Beginning of the curves of *Corylus*, *Ulmus* and *Quercus* is the sign of improvement of climatic conditions during the Boreal Period. Mixed, deciduous forest with oak, elm, lime, hazel and pine was dominant in climatic optimum during the Atlantic Period.

The plant cover of the younger part of the Holocene is mirrored in the sediments of core Nierybno 99. The diagram shows vegetation during the last about 4 000 years, when an important feature of forest in Bory Tucholskie was predominance of *Carpinus betulus*. A slight growth of influence of human activity on vegetation can be seen in the upper part of the diagram. There are higher curves of NAP and Pinus.

Through the whole diagrams, only a few sporomorphs of *Lobelia dortmanna*, *Isoetes lacustris* and *Litorella uniflora* have been found. One can observe them mostly in the beginning of Holocene and in the youngest layers of sediments. The same phenomenon is found at the diagram of Lake Wielkie Gacno.

Krystyna Milecka

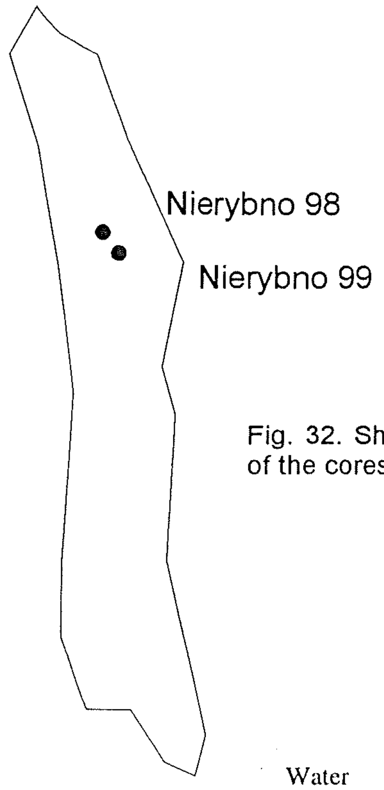


Fig. 32. Shape of Lake Nierybno and location of the cores Nierybno/98 and Nierybno/99.

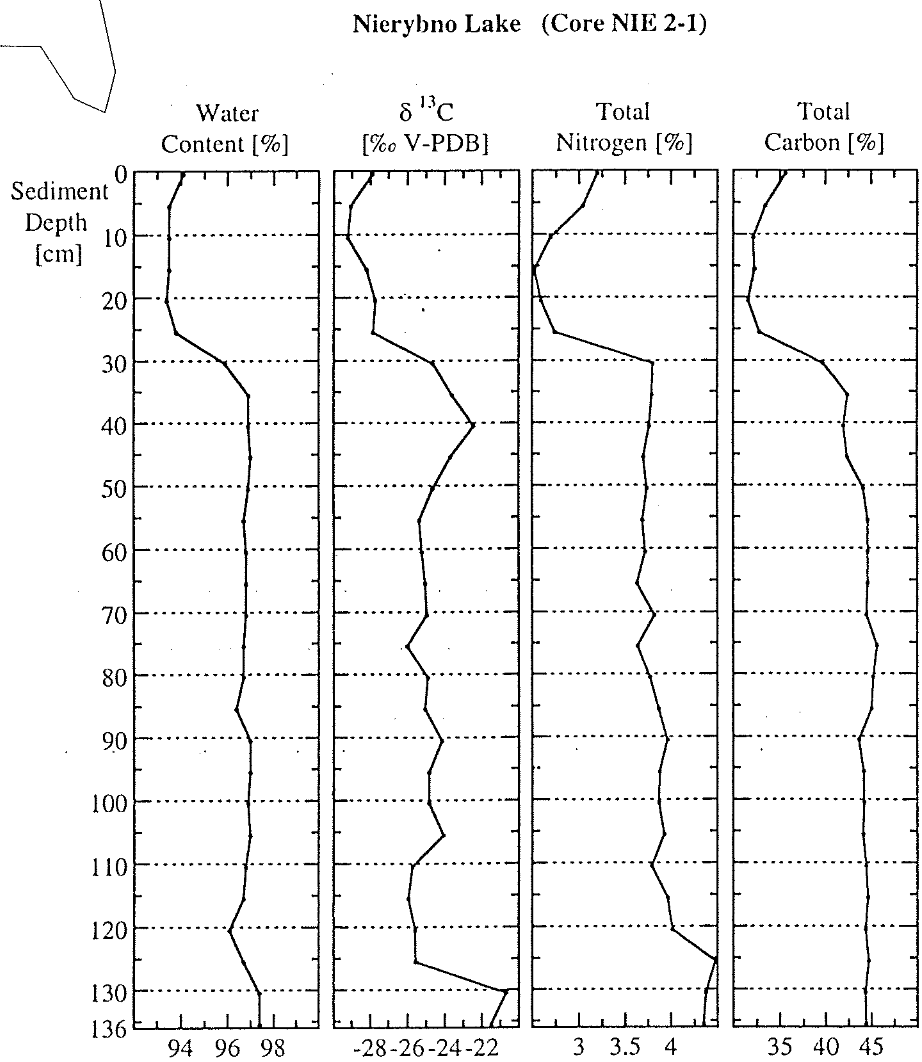


Fig. 33. Some results of chemical analysis (T.Kulbe).

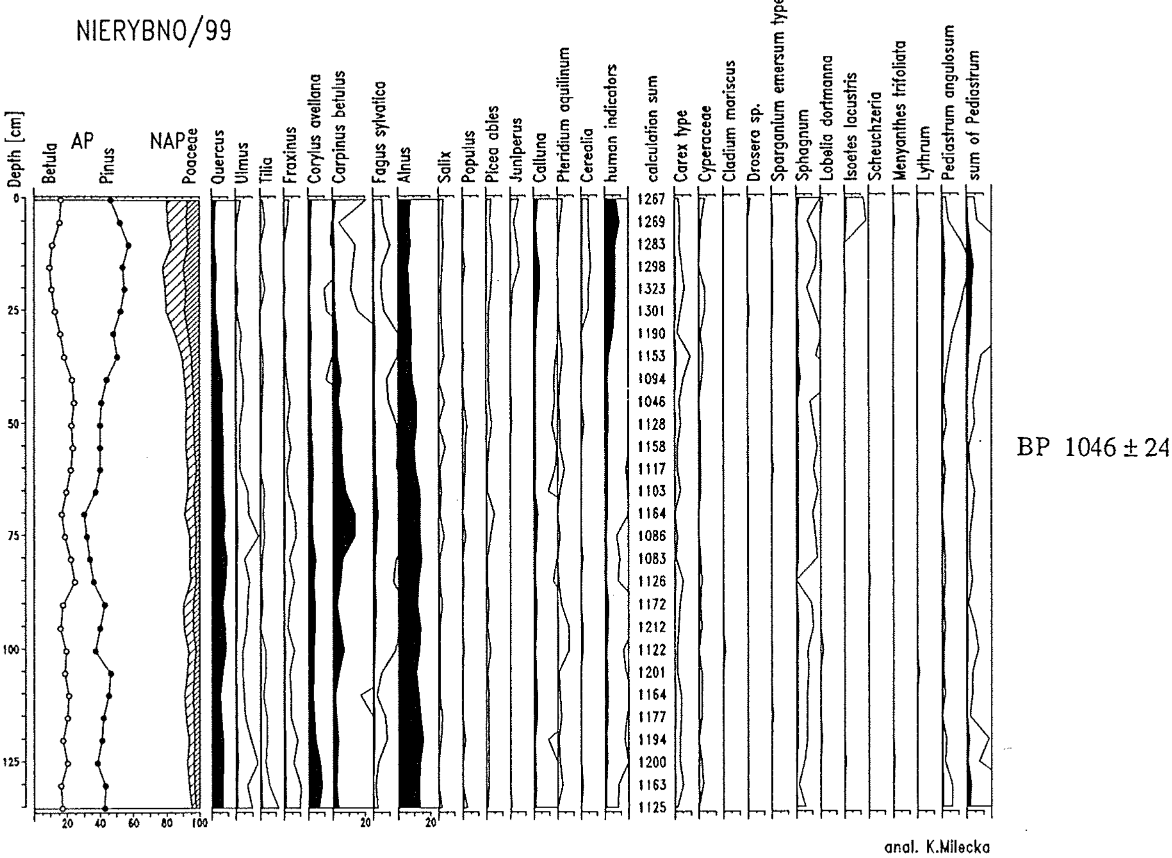


Fig.34. Pollen diagram of the core Nierybno/99

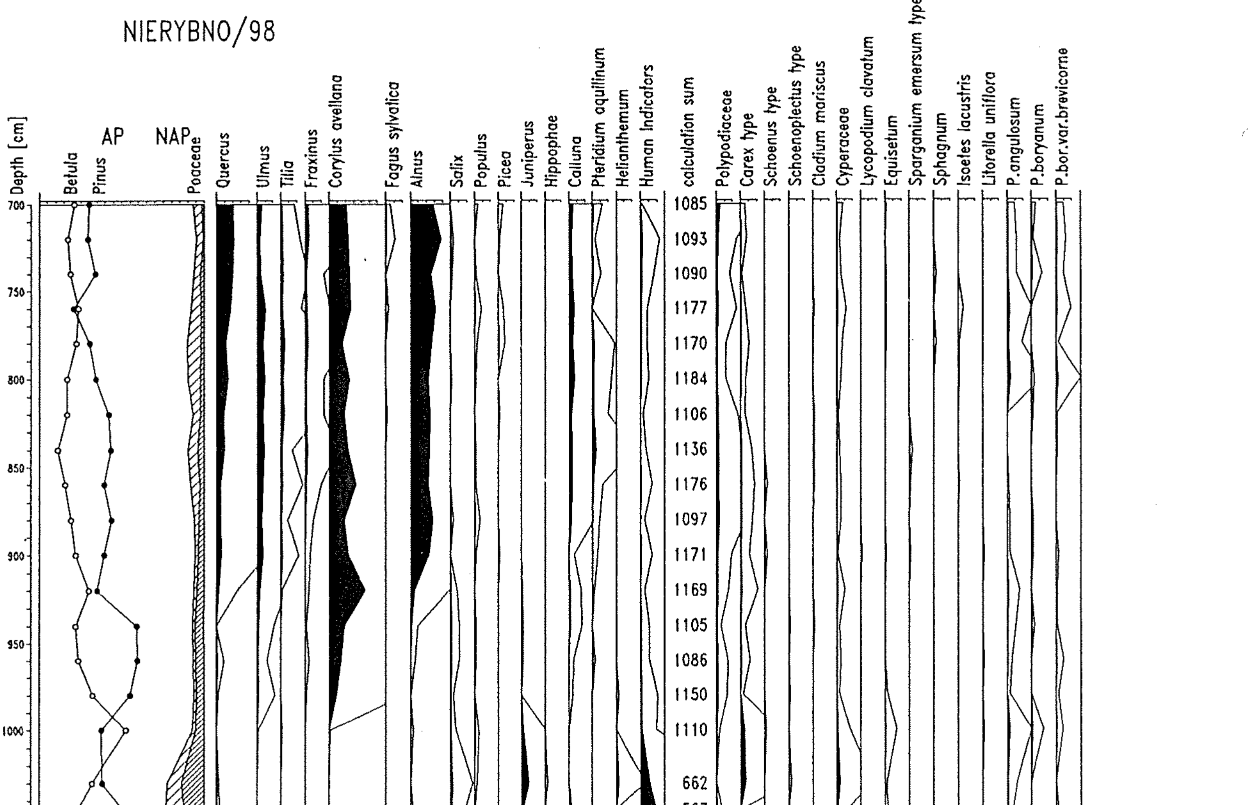


Fig.35. Pollen diagram of the core Nierybno/98

Palynological research in Lake Ostrowite

In May 1999 there were taken some cores of bottom sediments from the oligotrophic lakes in Bory Tucholskie (Tuchola Pinewood). The only deep core (13.85 m) was taken from Lake Ostrowite at the place of 47 m water depth. There are six different parts of core, which are correlated on the base of pollen and *Cladocera* analysis and some physical analysis, which are done in GeoForschungsZentrum in Potsdam by dr Thomas Kulbe. There are also two levels dated (OST 4-3 657 cm and OST 4-6 1377 cm) on the base of piece of wood and macroremains. Next ten dates are going to be done in autumn.

Ostrowite is a very large lake in Poland, with the area 272,27 ha. It has differentiated shore line and a big peninsula, which divide it into two parts. Probably this situation caused an interesting differentiation within the reservoir. There are some parts containing calcareous gyttja at the bottom and in the other side we cannot find calcium carbonate in sediments. This phenomenon is one of the planned research problem to solve in nearest years. There are also parts differentiated as to trophy, although generally it has a mesotrophic water.

Mesotrophic state of the water of the Lake Ostrowite is confirmed by the communities with *Cladium mariscus*. This species is characteristic for telmatic part of the lake. It needs mesotrophic water and moderate climate, although it is thought to be a cosmopolitan species. According to W. Szafer there is an east limit of the range of *Cladium* in Poland. It likes an organic soil and is often accompanied by peatbogs. Low, but continuous curve of *Sphagnum* show the permanent presence of bog in the area adjacent to the lake. Low, but continuous presence of *Cladium mariscus* from the depth of ca 8.5 m upwards tell us about the mesotrophic status of the lake since several thousands of years.

Low curve of *Pediastrum* is also the confirmation of not high trophy of the water. A big volume of water have not allowed to develop numerous items of flora and fauna plankton species in $1m^3$, so the frequency is not high, but the variety of specimen is rather big (see also description of *Cladocera* analysis). Microscope pollen analysis let me observe many, different species of diatoms, which are present through the entire core and show a great taxonomic variety. It means that differentiation of the conditions of the lake Ostrowite: low or high depth in any given parts of the lake, variety of microclimatic conditions like an exposition to sun light and heating, or local changes connected with sediments features and content of calcium carbonate caused possibilities of existence of many different species of planktonic organisms but not in big amounts relatively

As to chronology – Ostrowite core contains sediments accumulated during the Late Glacial and Holocene, but the former one is really thin (in comparison with the whole core) and represent short, ending part of Late Glacial. The Holocene sequence is full and long and it has not any hiatus. Ostrowite diagram shows the regional vegetation history in its classical form of Bory Tucholskie. It proves, that generally succession of forests is like at the area of Central Europe and the status of pine forests at that region is the sign of not so old historical time and not the Holocene history. During the climatic optimum *Quercus*, *Ulmus*, *Tilia* and *Corylus* were the dominant trees and *Viscum* appeared as an indicator of good temperature conditions. Pine was not so important, it appeared in bigger amounts at some sites because of soils only. It is the reason, why we have the *Pinus* pollen grain content at the level ca 40% of calculation sum. Pine forest became more and more important in the youngest part of the Holocene and this phenomenon is closely related to human economy.

Krystyna Milecka

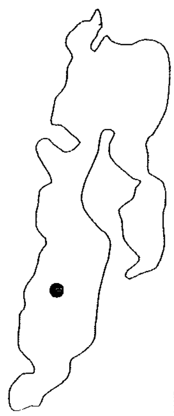


Fig. 36. Location of core in Lake Ostrowite

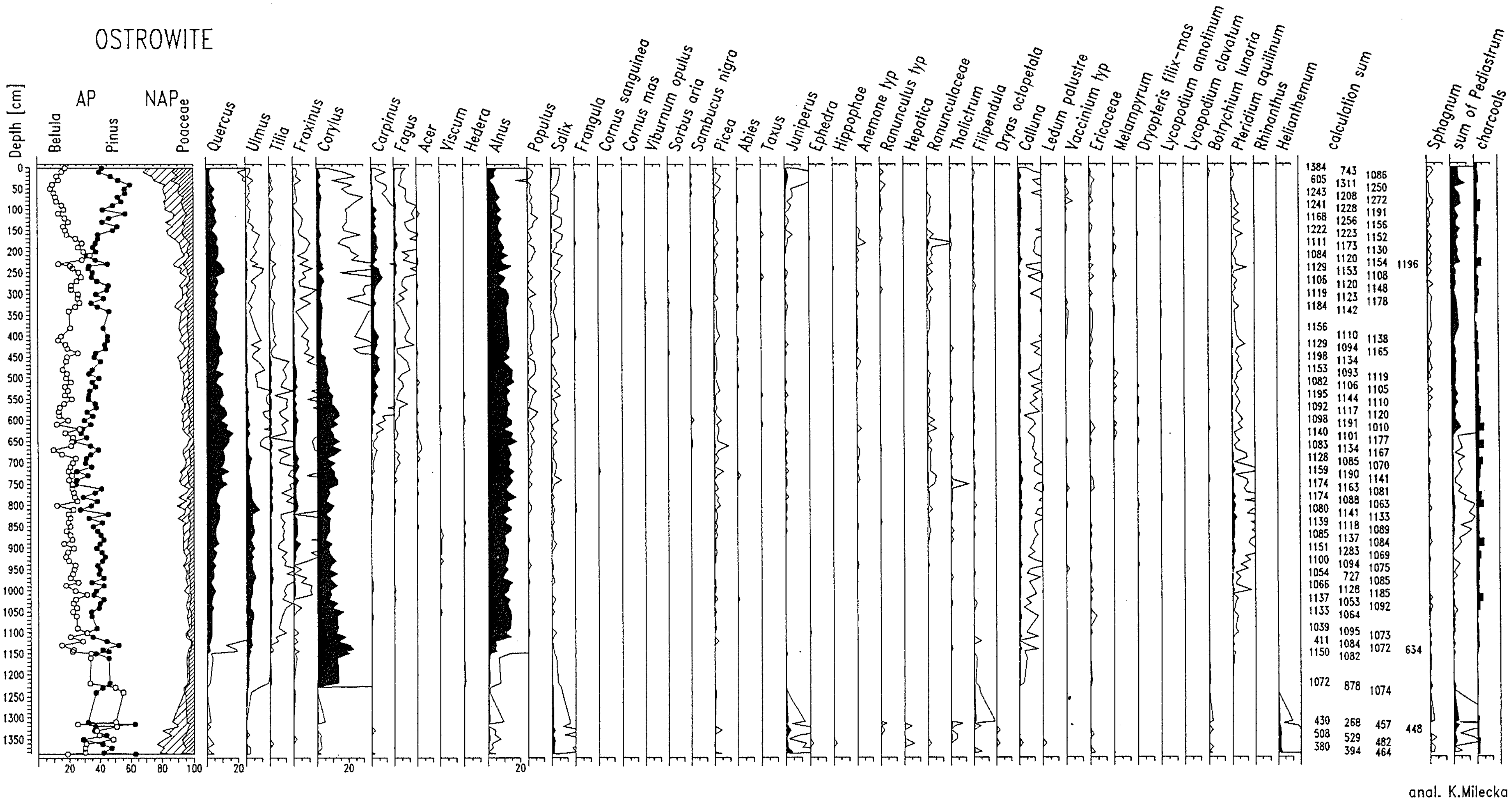


Fig.37. Pollen diagram of Lake Ostrowite

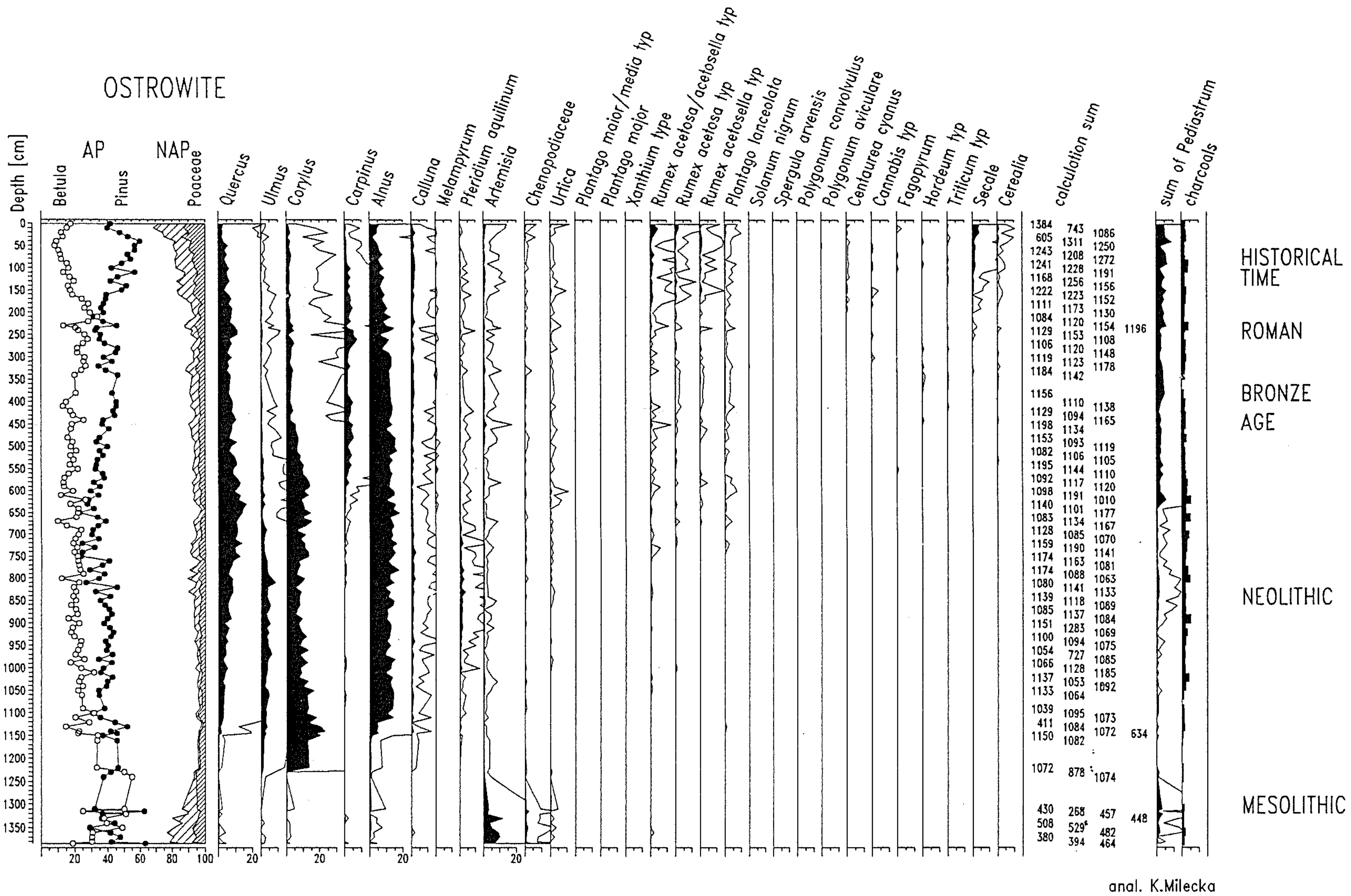
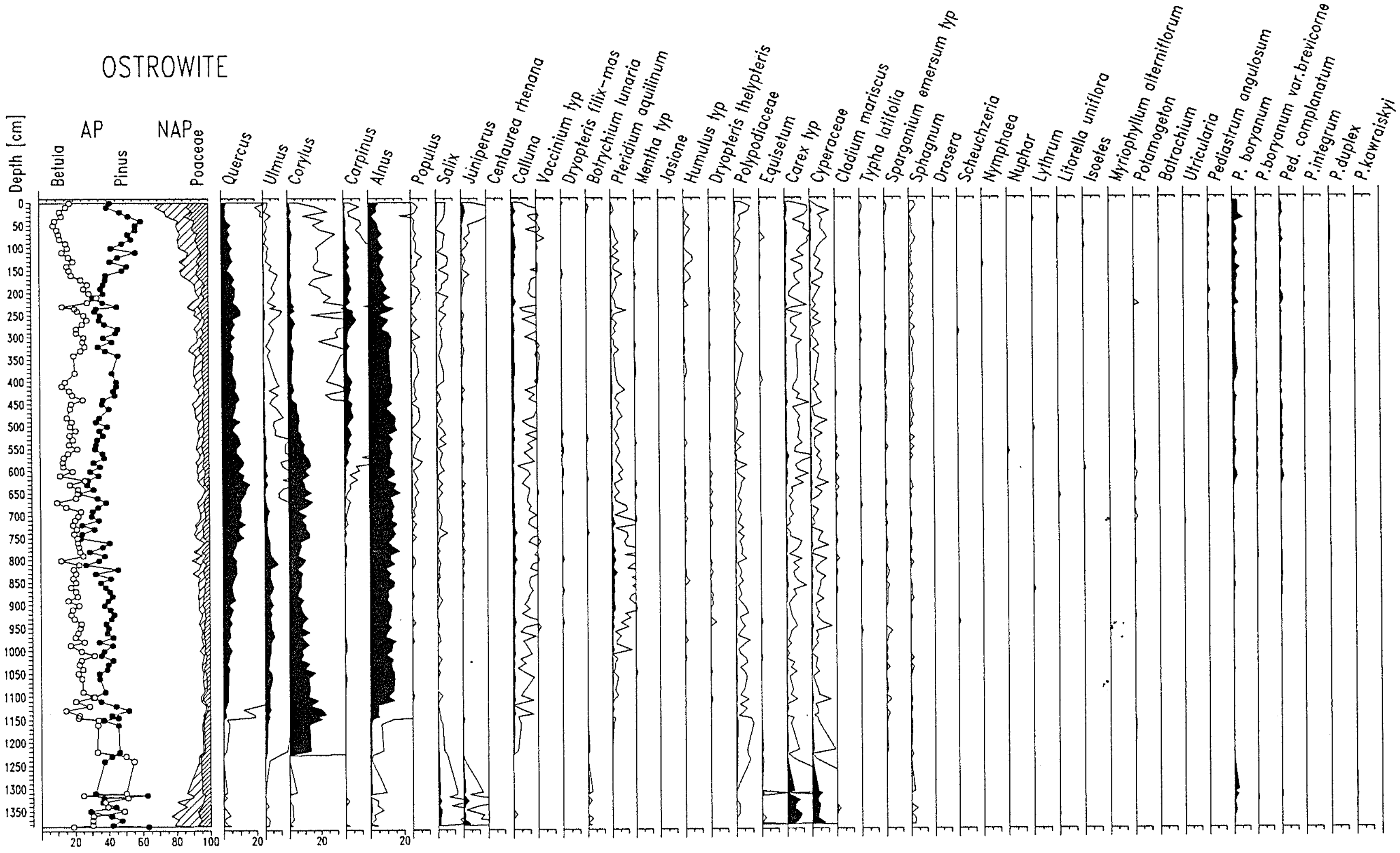


Fig.38. Pollen diagram of Lake Ostrowite – indicators of human activity



anal. K.Milecka

Fig.39. Pollen diagram of Lake Ostrowite – local sporomorphs

Fossil Cladocera of Ostrowite Lake – preliminary results

Cladocera analysis is powerful method supports paleoecological studies. The chitinous remains of Cladocera carapaces, frequently found in lacustrine sediments, are valuable materials for these studies. It gives information about past trophy, water level, pH and paleoclimatic conditions. It also helps to detect and understand anthropogenic impact of environment.

In Ostrowite Lake, all sediment profile was examinated for Cladocera abundance and diversity. The Ostrowite Lake occurred one of the most interesting cladoceran-site in Poland. 34 species belongs to 5 families were found in all profile and up to 27 species on single level (650 cm). Planktonic species remains are dominant in each sample, but littoral species are also quite numerous. Some very rare species (in lakes in Poland) like *Acroperus elongatus*, *Chydorus piger, Peracantha truncata, Rynchotalona sp.* are noted.

At this stage of studies, five faunal zones were distinguished on the basis of cladoceran data (fig. 40):

- sediments belongs to **zone I** (up to 930 cm) are studied with low resolution; however, first data indicate relatively low abundance of Cladocera in this period; pioneering species are *Bosmina longirostris*, *B. coregoni*, and some chydorids (*Alona affinis, A. guttata, Chydorus sphaericus* etc.)
- fundamental changes in frequency both in planktonic and littoral assemblages occurred above the level 970 cm; this zone (**zone II**, 930-720 cm) is started with increasing of remains' total concentration; *Bosmina longirostris* and *B. coregoni* dominated; *B. coregoni* with "long mucro" and littoral species *Chydorus piger, Ch. globosus* and *Peracantha truncata* are occurred;
- on the beginning of **zone III** (720-560 cm) rapidly change in *Bosmina coregoni* varieties is observed – "short mucro" variety is almost completely replaced by "long mucro" variety; *Bosmina longirostris* attained maximum value (over 25,000 individuals per cubic cm) at the level 650 cm; moreover *Chydorus sphaericus* number increase significantly; *Sida crystalina* and *Alona affinis* attained its maximum
- in **zone IV** (560-150 cm), "short mucro" variety dominates again in species *Bosmina coregoni*, but "long mucro" variety is still present; number of littoral species like *Alona affinis*, *A. quadrangularis*, *Chydorus piger* and *Pleuroxus uncinatus* is significant;
- **zone V** (above 150 cm) is marked by decreasing of Cladocera remains number; however, diversity of Cladocera assemblages increase and attained maximum value at the level 120 cm; it may be related to a little decrease of trophy.

In conclusion, following patterns and ecological events can be noted:

1. Planktonic species are dominant in all profile and it is unusual for recognized lakes of northern Poland. *Bosmina longirostris*, which is often founds in all type of freshwater bodies, is most numerous (fig. 41). However, the turbid water littoral species like *Alona rectangula* and *Leydigia acanthocercoides* are very rare. Mesotrophy species *Monospilus dispar* is noted quite often, but is also not numerous. These all data indicate the low trophy status in Ostrowite Lake history.
2. Profile of Ostrowite sediments starts with low Cladocera remains number. It could be a effect of high oligotrophy and low nutrient concentration in lake's water, which can also suggests cool climate.
3. Optimal conditions for Cladocera development existed in period related to zones III and IV. The absolute domination of *Bosmina longirostris* at this time indicates the highest trophy in the history of the lake.
4. The transition and "retransition" in sub-species of *Bosmina coregoni* is recorded first time in Poland. The character of the change suggests its ecological, not evolution reason.
5. The increasing of species *Chydorus sphaericus* (220-200 cm) can be related to anthropogenic influences. It is also detected by pollen analysis – increase of *Pediastrum* abundance indicate higher trophy too.
6. In general, results of Cladocera analysis indicate the changes trophy between oligotrophy and mesotrophy in all history of Ostrowite Lake.

Krystyna Szeroczyńska & Michał Gąsiorowski

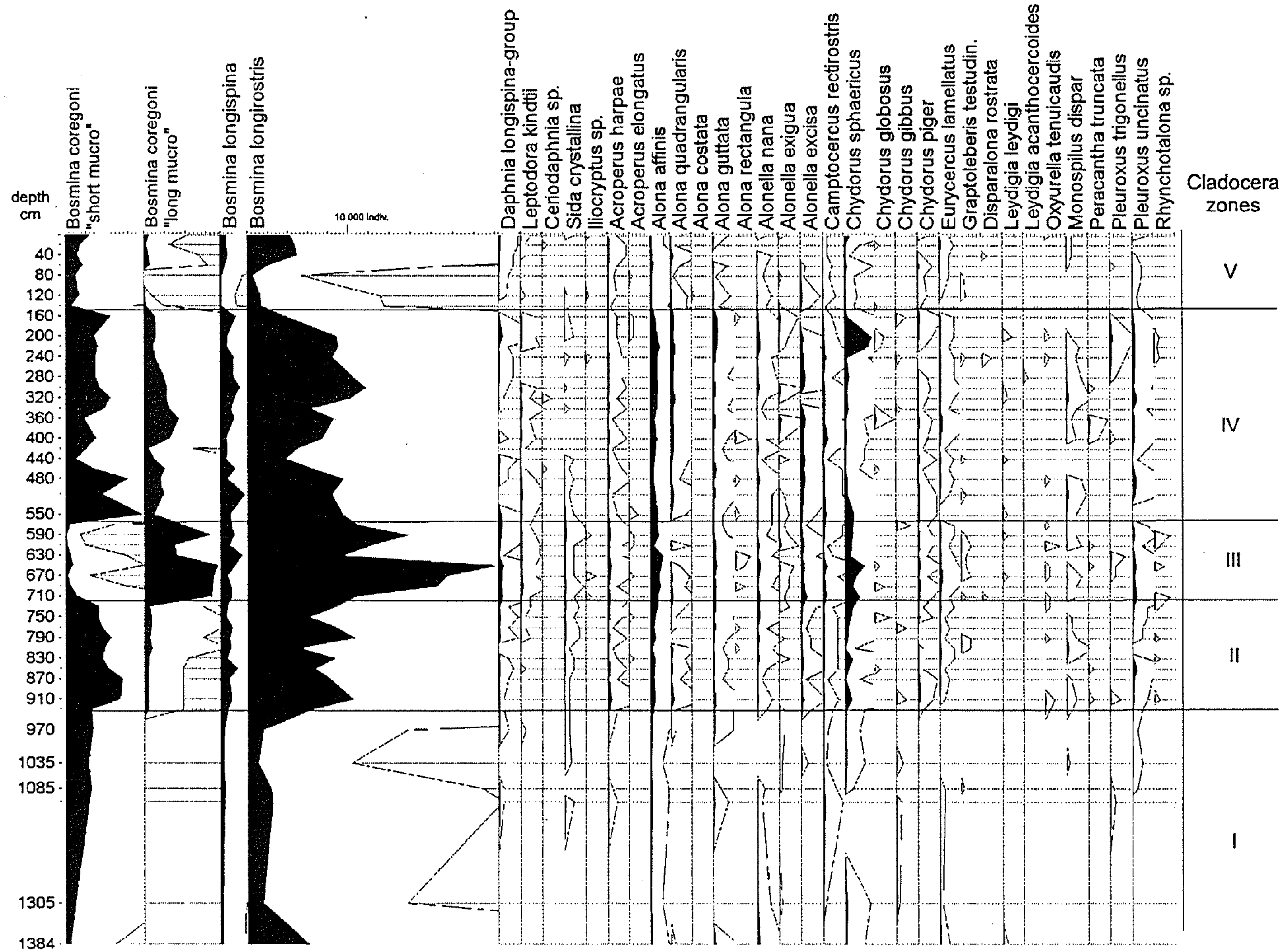


Fig. 40. Cladocera total concentration diagram for Ostrowite Lake.

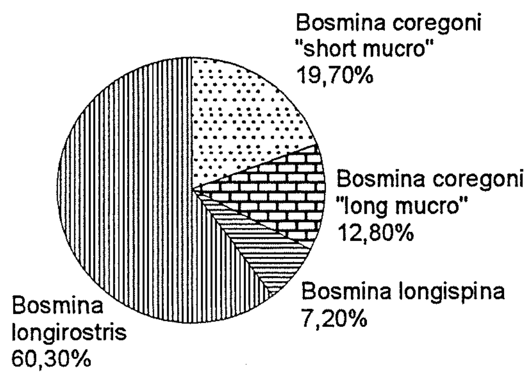


Fig. 41. Summarized percentage diagram of planktonic Cladocera for sediments of Ostrowite Lake.

Peatland Complex developed in Stążka River Nature Reserve

Nature Reserve "Bagno Stążka" is about 478.45 ha area, and it was brought into being to protect wetland vegetation and peatland complex along Stążka River. In the northern part of the Reserve 4 mires of different size, origin and hydrology are situated. These mires form peatland complex called "Jelenia Wyspa" (ang. Deer Island). In the central part of "Jelenia Wyspa" a peninsula exists being 20 m higher than Stążka River basin.
The wetland complex consists of following mires:

- ✓ fen, in Stążka River basin;
- ✓ spring mires, south-east of the peninsula;
- ✓ peat bog, north-west of the peninsula in a postaglacial channel;
- ✓ kettle hole bog, west of the peat bog.

All above mentioned mires have not been subject to any economic activity, yet. That's the reason why they have features of natural wetlands and where the peat accumulation still takes place. Fig. 42 shows the location of described objects and Fig. 43 shows topografic profile through the northern part of the peatland complex.

The peatbog area is covered by Sphagnum cover including: *Ledum palustre*, *Empetrum nigrum*, *Scheuchzeria palustris*, *Carex limosa*, *Rhynchospora alba*, *Andromeda polifolia*, *Vaccinium oxycoccos*, *Calluna vulgaris*, *Sphagnum magellanicum*, *S. papillosum*, *S. fuscum* and *S. cuspidatum*. In this accumulation basin, top of the sediments is described as high and transitional peat. In the central part of the bog (core JW/S) there has been recognized 1 meter layer of the faintly decomposed peat underlain by vast water lens, containing weakly consolidated sediment. The bottom part is created by detritus gyttja (Fig. 44). Along with increasing depth (Fig. 45), a number of macrofossils of Pine (*Pinus sylvestris*) and birch (*Betula spp*) is decreasing but larger number of aquatic plant fossils (*Nuphar* sp., *Nymphaea* sp., *Potamogeton* sp.) has been revealed. Detritus gyttja transforms itself in calcareous one (50% $CaCO_3$) at the depth of 900 cm. Sediment thickness exceeds 1000 cm, so it hasn't been scrutinised well, so far, because the drilling hasn't reached the mineral bottom.

In the core JW/A thickness of the peat layer amounts to 335 cm, and it is divided by a water lens (3 cm thick) at depth 324-327 cm. Occurrence of the water lens was recorded also between the cores JW/S and JW/A. The water lens divides transitional peat at a depth of 320 to 335 cm. Transformation of limnetic sediments of shallow mezotrophic lake into peat sediments took place by floating mat ingression. *Scheuzeria palustris* was a very important component of that vegetation. Floating mat ingression process occured 2500 years BP at the turn of the Subboreal and Subatlantic period. Palynological investigations of core JW/B revealed the age of transformation of calcareous gyttia into detritus gyttia at the turn of the Atlantic and Subboreal period. (6500-5000 years BP). Quite sharp border between these two layers is located at depth 287 cm.

In the kettle hole bog (westwards from highbog) late glacial sediments are present In the core taken from the central part of the basin at depth 580-680, following layers were recorded:

- o 580 – 610 cm – olive-grey gyttia with clay;
- o 610 – 680 cm – navy-black gyttia (grey when dry), sandy with clay (with ferrous sulfide)
- o under 680 – sand.

Palynologically studied sample from a depth of 680 cm revealed typical Allröd composition of the sporomorphs. In the pollen spectrum *Pinus sylvestris* (54.7%) and *Betula spp* (25.2%) dominate with a small number of *Juniperus communis* (2.8%) and *Salix sp.* (1.2%). The total sum of heliophyts reaches 3.5%, including the highest amount of *Arthemisia spp.* (2.3%). Features of the boreal forest are confirmed by the fragments of pine needles with stomata. Numerous diatoms were present at that time. Physical and chemical conditions gave the possibility for precipitation of pyrite crystals.

The sample from a depth of 630 cm reveals Younger Dryas sporomorphs composition (11510-12650 years BP). Comparing it to the former sample, AP sum decreased to 79.5 %, showing less forest stand density, where *Juniperus communis* played considerable role (16.7%). Amongst the *Betula* sp. pollen grains (28.1%), (bushy) *Betula nana* was present. NAP curve reveals large number of heliophyts (to 6.7%) including 0.8% of pollen grains of *Helianthemum.*

In the NE bay laying north of the main basin limnic and peat sediments and some interesting deposits of spring mire occur. A geological cross-section (Fig. 46) show its geological structure. Hypsometric map shows dome of spring mire (Fig. 47).

Accumulation of gyttja filling elongated basin (along axis SW-NE; profile Y-Y') in northern part of the bay began no later than in Preboreal period (9600-9700 years BP) and it took place to Atlantic period (około 6000-6500 years BP). Slightly later accumulation of mineral-organic deposits underlying deposits of spring mire began (about 9000 lat BP in Boreal period). It changes fairly rapidly to peat accumulation, what lasted to the beginning of Atlantic period (about 8500-8600 years BP). Accumulation of peat on a flat mineral bed SE from spring mire began in Subboreal period, about 3800-4000 years BP.

In the main basin of Stążka River fen complex one drilling transect (M-M`) was done. The transect was 166 m long and it nearly reached the trough of Stążka River. Fen vegetation along the transect included mostly: *Caliergonella cuspidata*, *Drepanocladus* spp., *Mnium* sp., *Calla palustris*, *Carex rostrata*, *Carex paniculata*, *Typha angustifolia*, *Lemna minor*, *Rannunculus flammula*, *Eqiusetum palustre* and *Galium uliginosum*. Edge of steep slope bordering the fen from the west was covered by *Alnus glutinosa* belt.

Drillings made drawing of the geological profile possible (fig. 42 & 48). The sediments of every core were analysed in the field. In M1 core Menyanthes and Carex peat was found at the depth of 0-110 cm. There was also some sand interbedding, comming perhaps from the slope erosion. The largest thickness of 138 cm the peat reached in M4 core. Instorf hasn't reached the mineral bottom there. In the same core, peat is underlain by detritus gyttia and at a depth of 400 gyttja with clay, of which thickness is decreasing westwards (M8-M11). The mineral bottom hasn't been reached in cores M5, M6, M7 as well, in spite of very succinct clay/gyttja sediments. The core M7 showed the presence of floating peat raft (0-50 cm), composed of *Menyanthes trifoliata* (mostly) and sedges *Carex spp.* roots, underneath the water lens was present 25 cm thick. Water lens was present also in core M8 where the greyish sand layer was recorded (416-500 cm), underlain by gyttja/clay under with was found organic sediment similar to peat. At a depth a 178-182 cm many *Mollusca* shell parts were recorded. At M9 core the water lens wasn't present and mineral bottom was reached at depth 332 cm. In this part of the transect peat sediment consisted of fragments of *Equisetum sp.*, *Menyanthes trifoliata* and *Carex* spp. roots. Sandy bottom was reached in M10 at depth of 320 cm, in this core thickness of the peat strata was larger (50-100 cm), and in the last core M11 (16-100 cm).

This transect reveals deep basin between cores M3 and M8, and shows the origin of this basin being lake in its postglacial history.

Kazimierz Tobolski, Grzegorz Kowalewski, Mariusz Lamentowicz, Tomasz Schubert

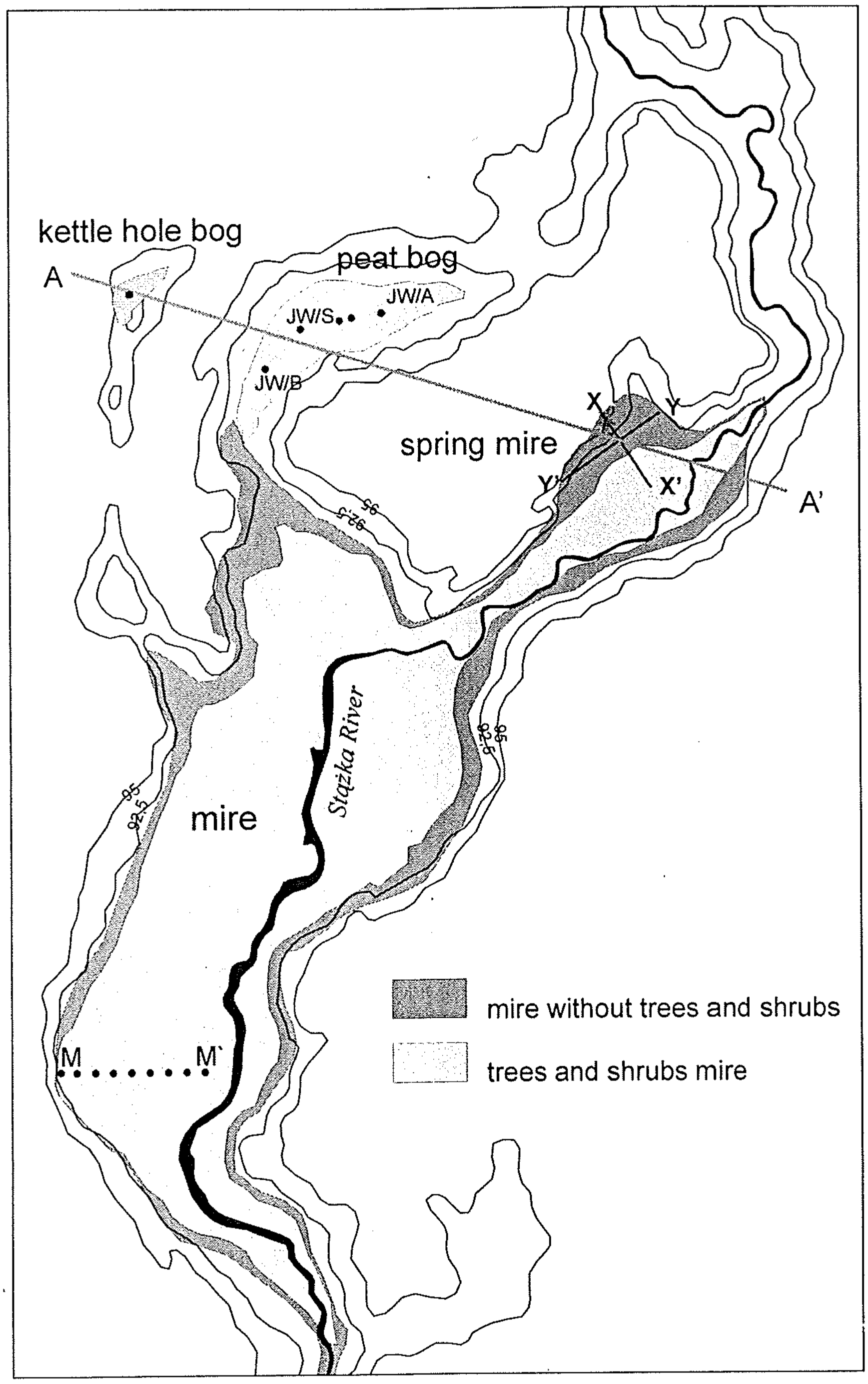


Fig. 42.
Location of mires and bogs
in "Bagno nad Stążką" reserve

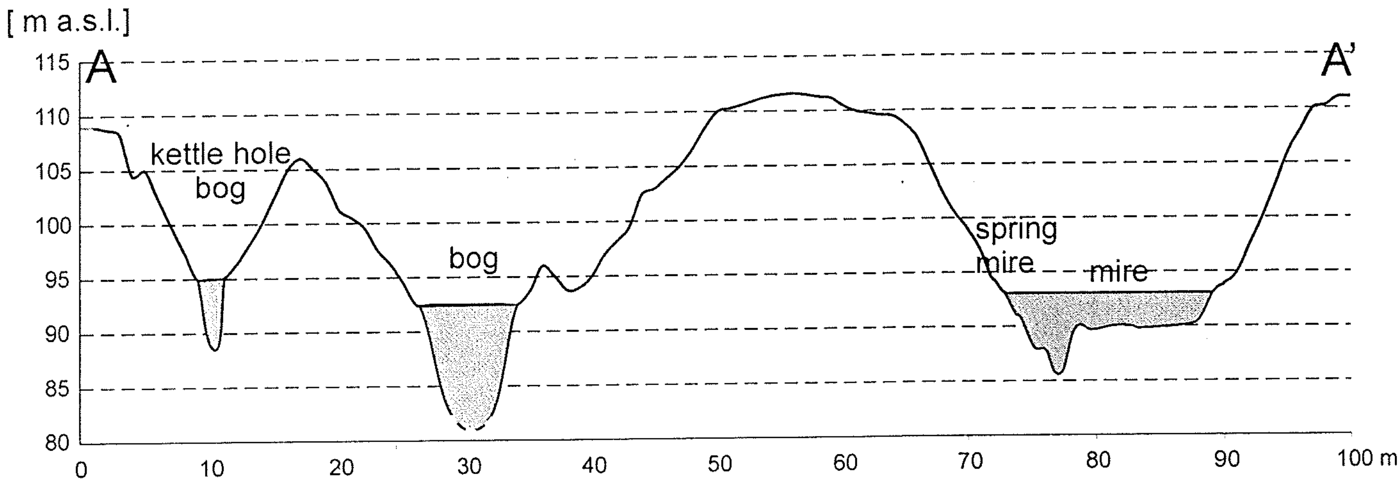


Fig. 43. Topografic profile A-A` through the northern part of the peatland complex

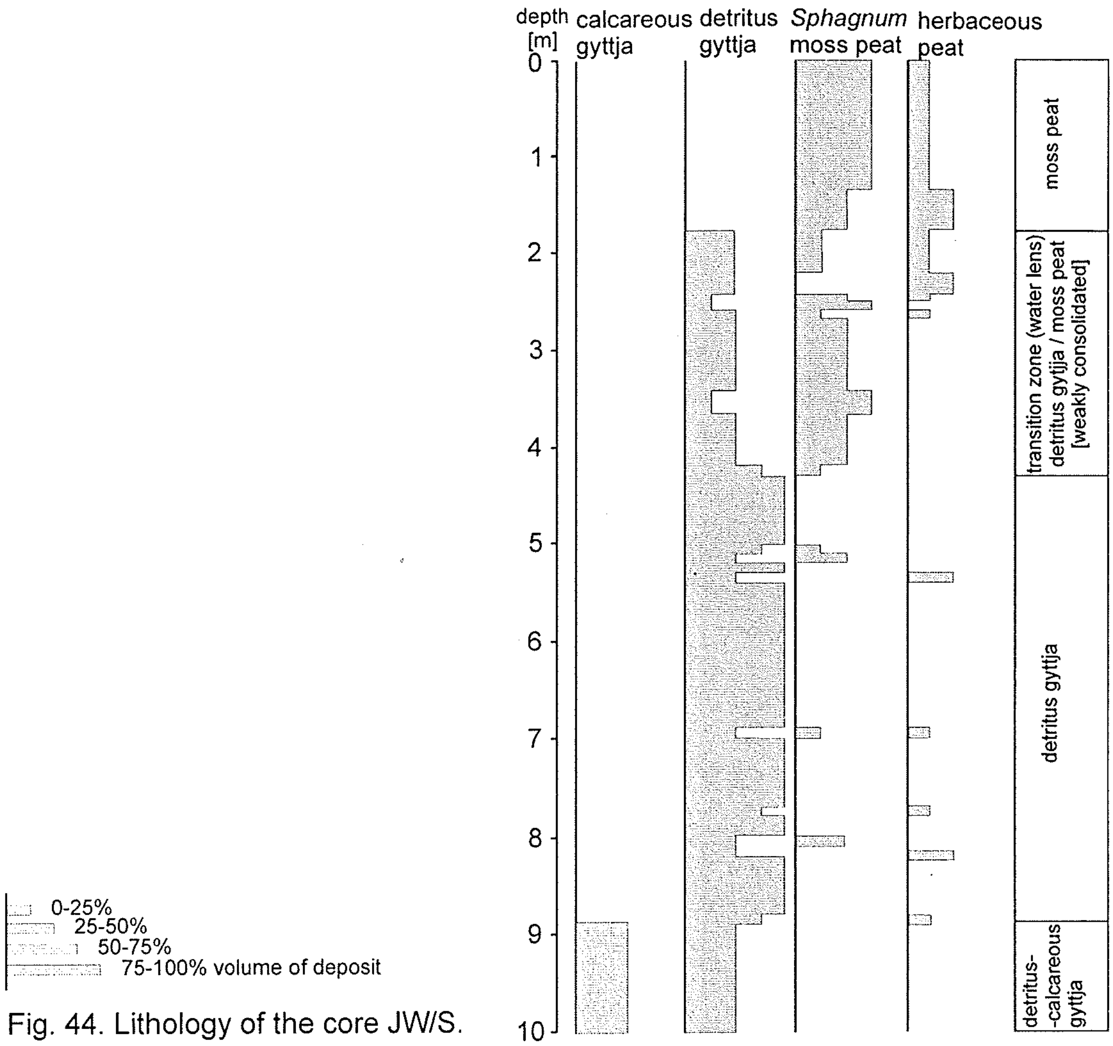


Fig. 44. Lithology of the core JW/S.

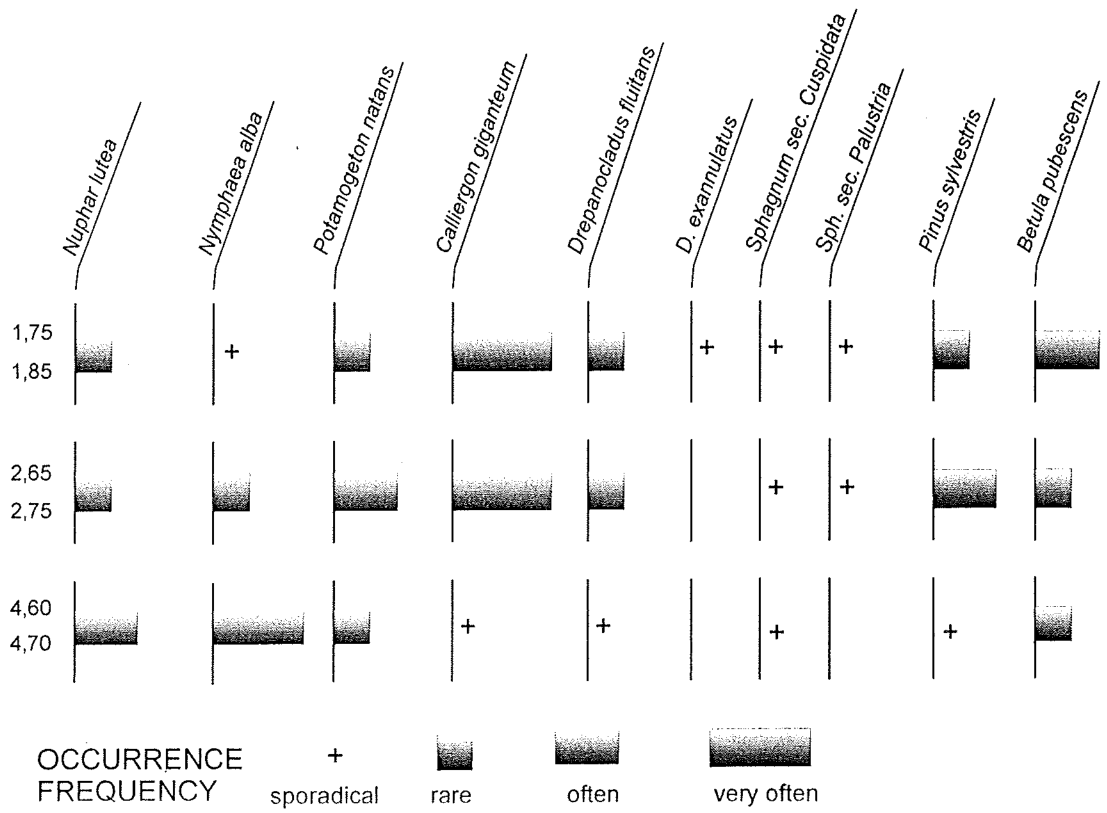


Fig. 45. Main plant macroremains in selected strata of the core JW/S

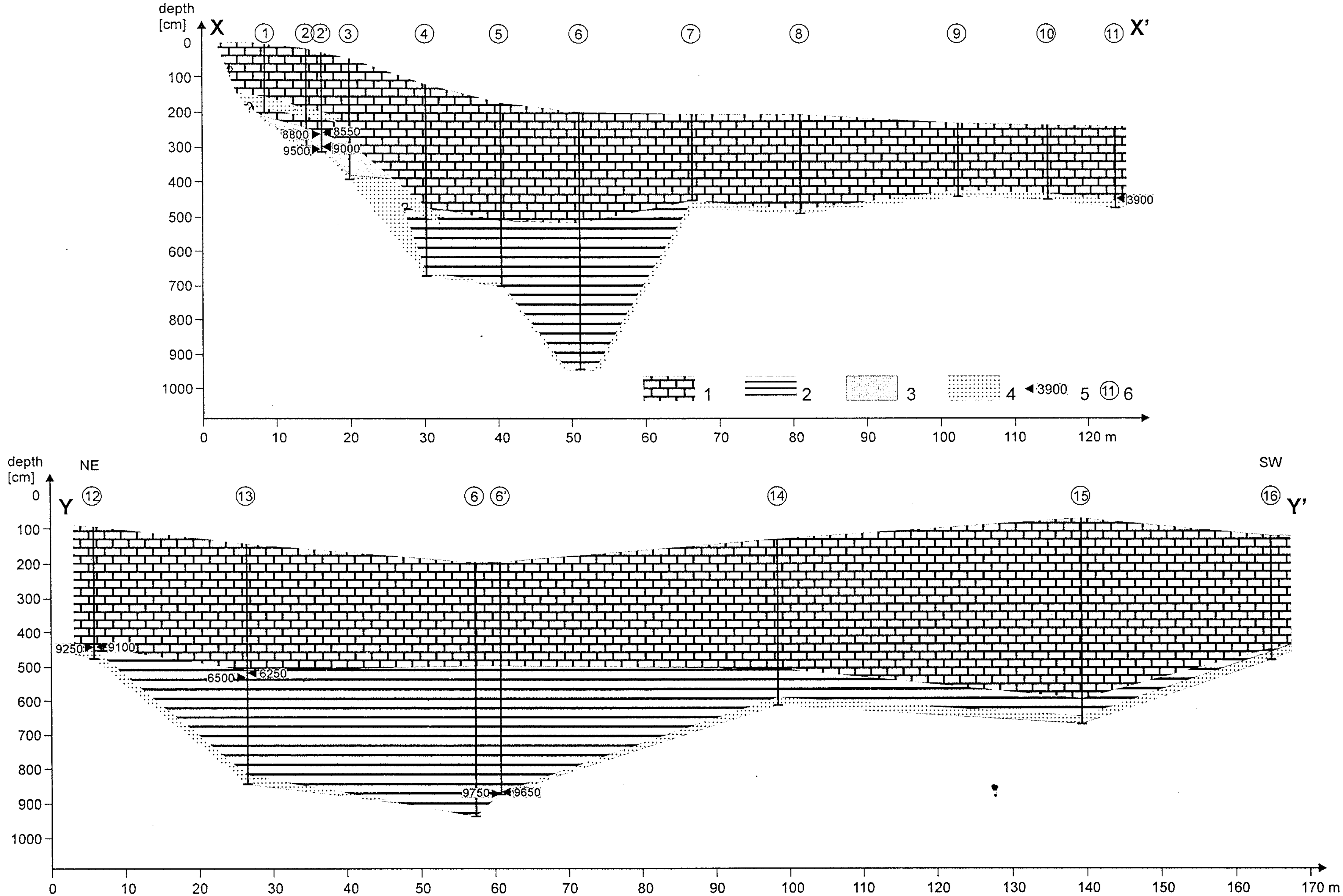


Fig. 46. Geological cross-section through spring mire:1 - peat, 2 - gyttja, 3 - organic-mineral layer, 4 - clay and sandy bottom, 5 - palynological chronology, 6 - number of core. Location see Fig. 42.

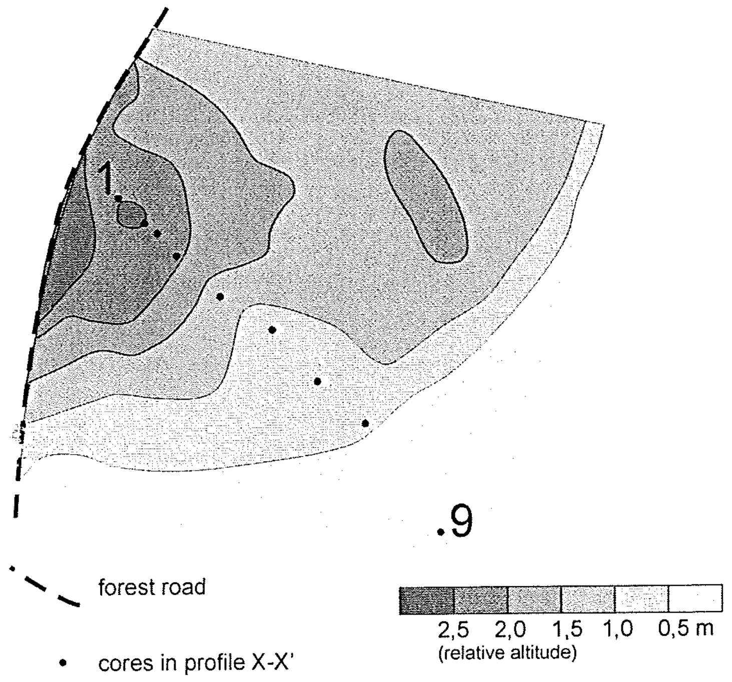


Fig. 47. A hypsometric map of spring mire

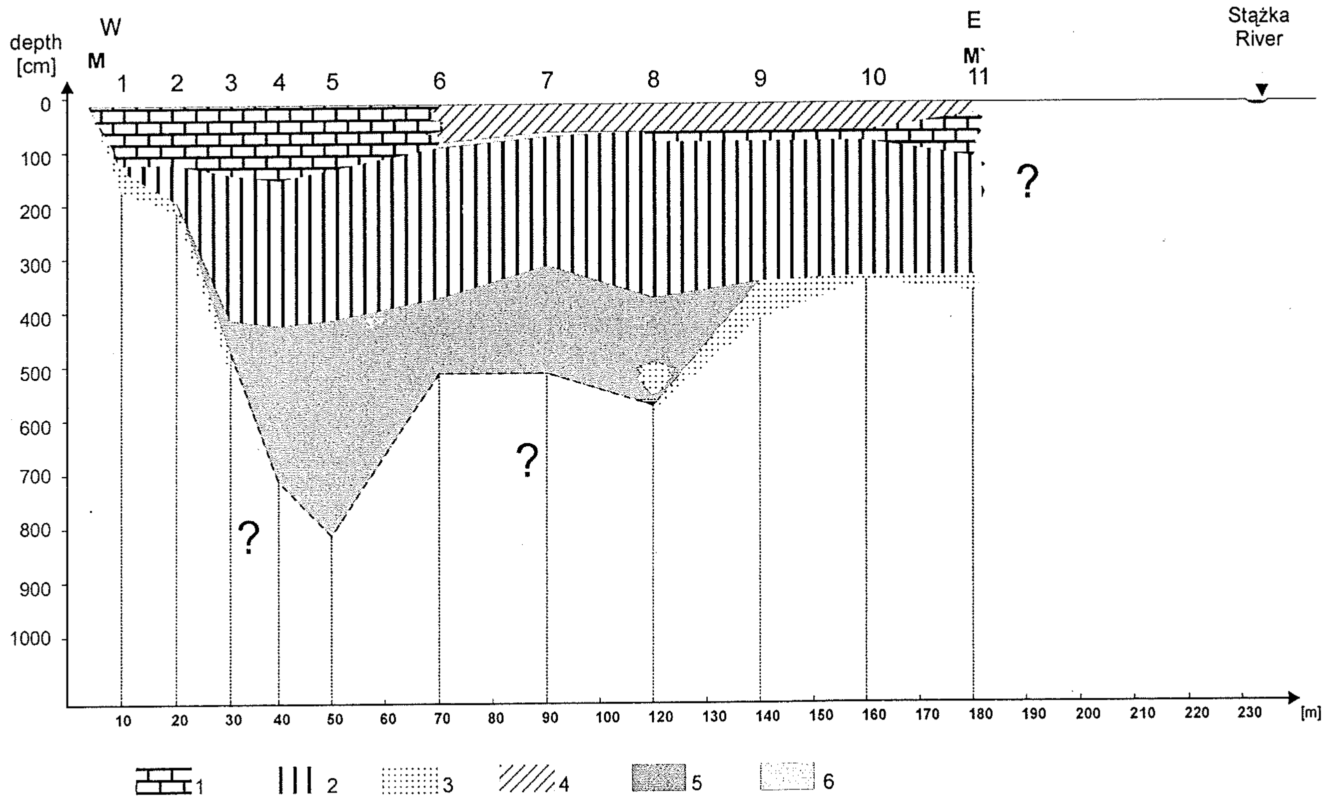


Fig. 48. Geological cross-section M-M` of southern part of the main basin of Stążka mire:
1 - peat, 2 - gyttja, 3 - sand, 4 - vegetation mat, 5 - clay with gyttja, 6 - water lens

Peatlands in the Świecie District. Distribution, history, preservation

Świecie Districtincludes in the north-western part an outwash-plain belonging to Tuchola Pinewoods and a ground moraine plateauin the south. In the east side the District is bordered by the Lower Vistula valley. On such differentiated surfaces (with total area 1473 km^2) there are distrubuted numerous peatlands. According to the last inventory, 652 mires were geologically and floristically documented on about 70% ofthe area (Fig. 49). Together with the small mires of the area less than 05 ha, which are not included in the inventory, the number of peatlands in Świecie District can grow to about 1500.

A great number of the mires has still an undisturbed hydrological structure with natural and seminatural biotopes. In the northern part of the District there are 8 mires protected in a form of nature reserves (Fig. 50). One of them is called "Rezerwat Dury" and it contains transition bogs with distrofic lakes, partly surrounded by floating vegetation mat.

An intensive cataloguing work, based mainly on geological structure of peatlands with regard of their history and competence in actual peatforming process is in progress.

Most of the peatlands are developed on former lake basins, in which different kinds of limnogenic sediments were accumulated. Calcium carbonate gyttjas are very rare in the northern part of the District and they were accumulated only in the Late Glacial and early Holocene period. Fen bogs are the most common peatlands, mostly distributed in river valleys and along the lake shores. Kettle-hole bogs belong mainly to the raised bogs and transitional ones. They have often an limnogenous genesis (Fig. 51).

Jarosław Pająkowski & Kazimierz Tobolski

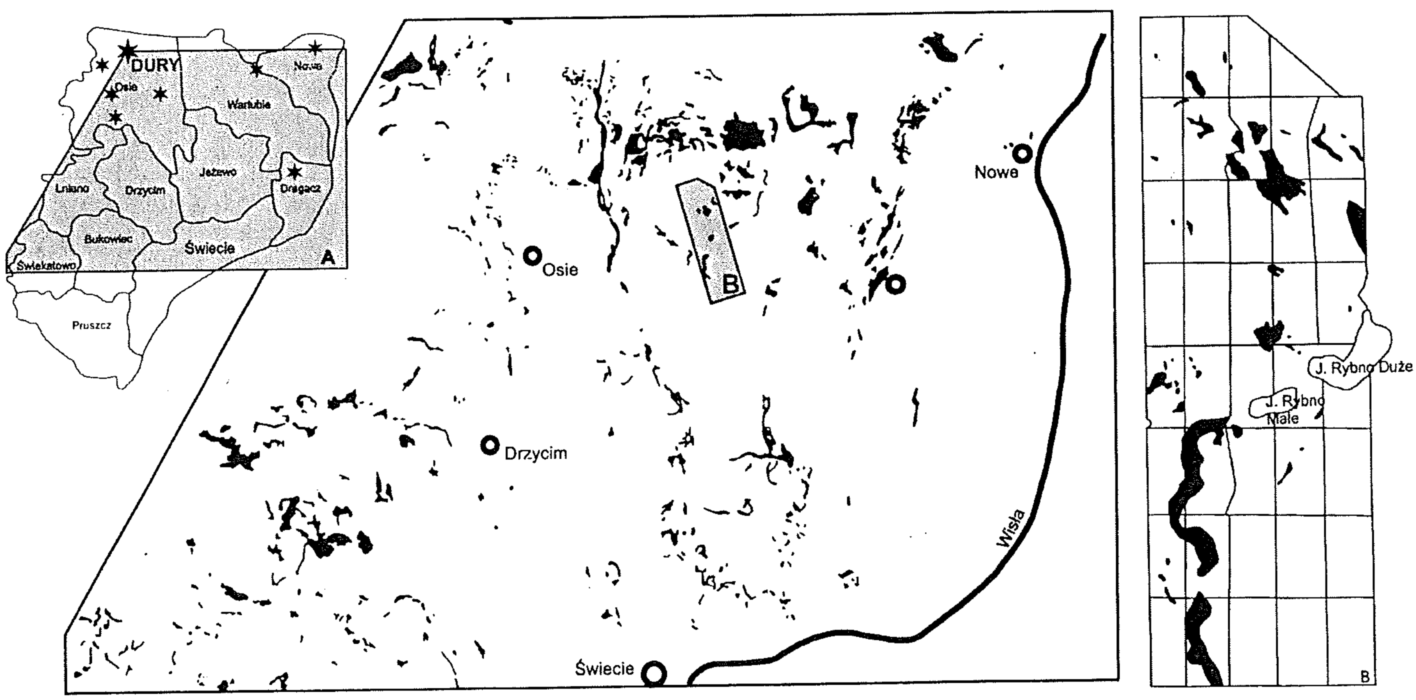


Fig. 49. Distributionof peatlands (A) according to the documentation collected on 70% of the Świecie District and (C)the localities of peatland nature reserves; (B) test area presenting a contemporary cataloguing in the forested part of the District

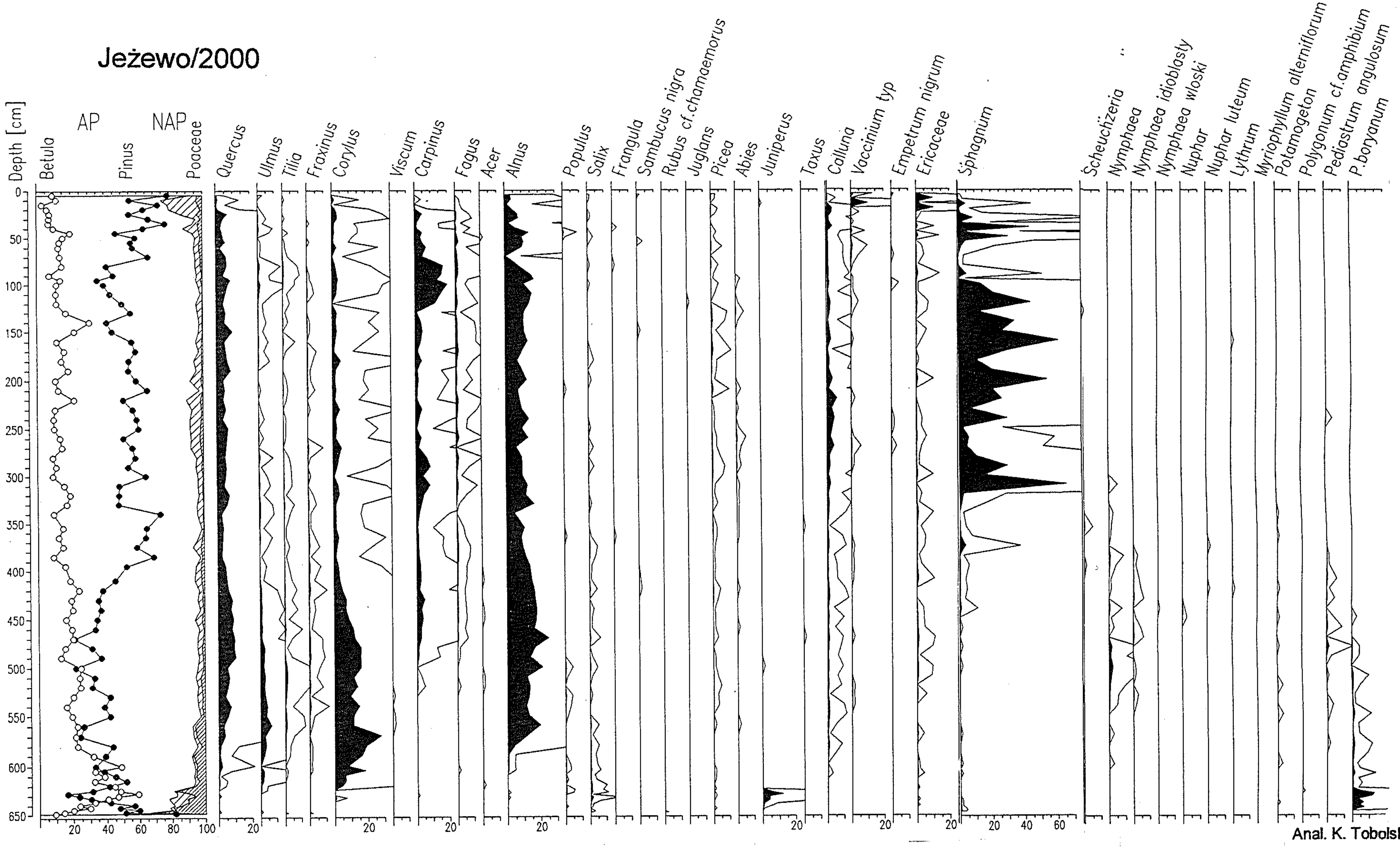


Fig. 50. Jeżewo. Simplified pollen diagram from a kettle-hole raised bog located on an outwash-plain.

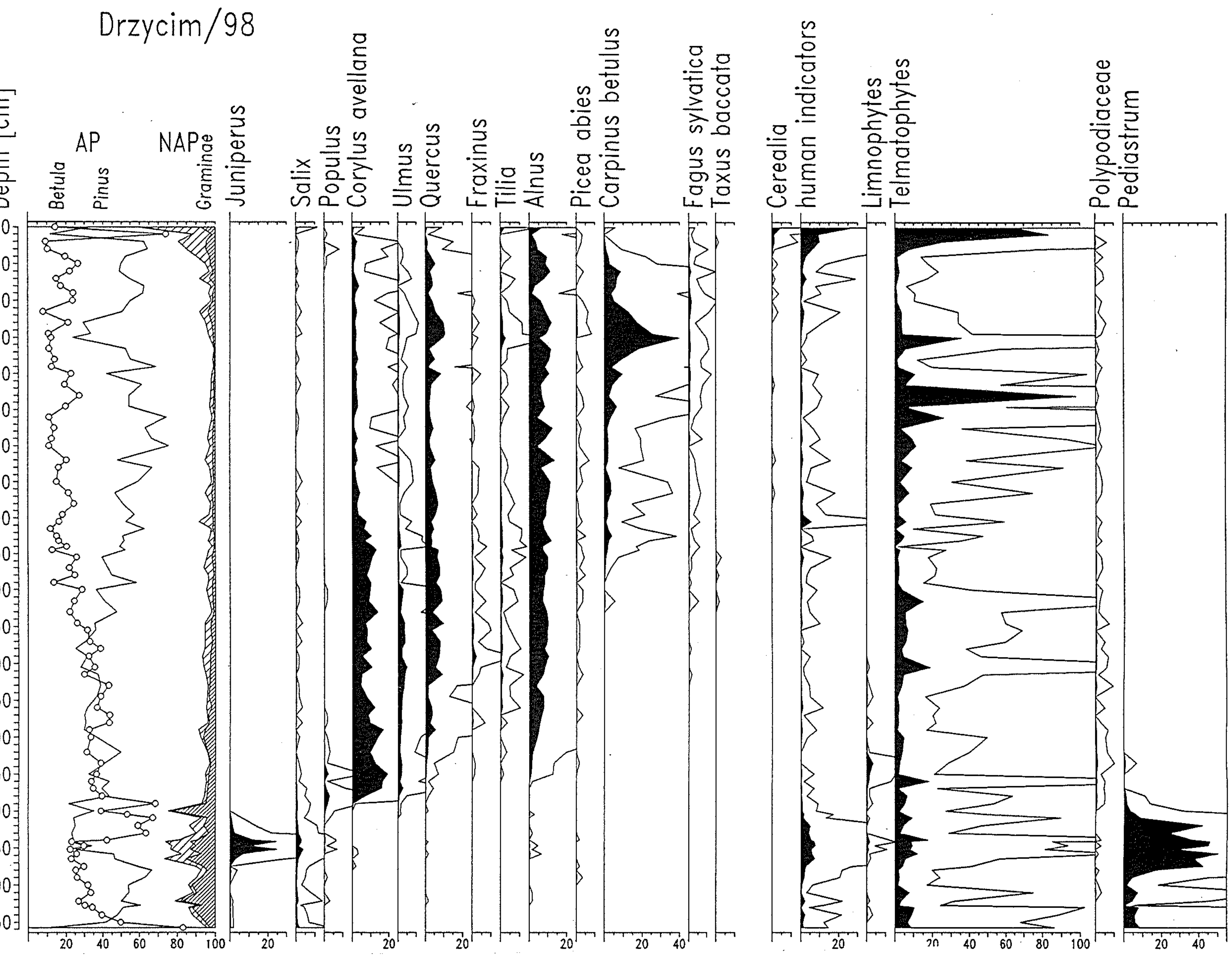


Fig. 51. Drzycim – a kettle-hole transition peat-bog on a ground moraine. Simplified pollen diagram. anal. K.Tobolski

Geology of Peatlands in "Dury" Nature Reserve

Area of „Dury". nature reserves is 12,59 ha (Fig. 52). There are 5 moors protected and they are situated in small stagnant water basins, filled with organic sediments. The basisns are surrounded by pine forests growing on the outwash-plain area. Located at the highest level, central pool (D3) has already been filled with organic sediments but on others dystrophic lakes floating *Sphagnum* mat occurs. Sediments thickness range from 350 cm in the lake D2 to 950 cm in the lake D1 (Fig. 53). In every lake gytia layer is underlaid by thin decomposed organic matter and sand coming from dead ice. It has been dated by pollen analisis on Allröd. At the initial stage palustrine mires existed and peat was accumulated on the surface of dead ice. Organic sedimentation was interrupted by sand accumulation, coming from slope erosion (check: sand layer in cores D4&D5). It probably shows short cold climate fluctuation in the late glacial time. Along with ice thawing shallow lakes were forming what is proved by macrofossils of aquatic mosses as: *Calliergon* sp., *Drepanocladus* sp. and *Scorpidium scorpioides* in gytia bed (cores D1, D2&D3 – few centimetres thick). Layer of fine detritus gytia consisting of small plankton organisms proved deep-water accumulation conditions. Progressive shallowing caused the change of character of the sedimentation. Aquatic plants roots and *Sphagnum* mosses growing on the shallow lake bottom or on floating mat occurred. In the top of the sediments of the cores D4 and D5 well preserved *Sphagnum* sp. macrofossils make up nearly 75% of gyttja composition. Top layer is built of peat sediments of various thickness in different cores, consisted by mosses belonging to Cymbifolia section of *Sphagnum* genus and fragments of *Eriophorum* sp. In the core D1 interesting peat layer of 286 cm thick occurred. The beginning of peat accumulation in the core D1 during the first half of Subboreal (according to Milecka in this volume) is probably caused by decreasing water level what took place in this region (Bogaczewicz-Adamczak 1990).

Layer of thick detritus gytia between peat stratum in cores D1, D2 is the evidence of water level change. It's the best distinct in the core D3 because this lake is situated at the highest level (a.s.l.).

Overall, development of these lakes was determined by local factors related to drainage area. Every bog is located near the watershed but the highest water level occurs in lake D5 and is decreasing in direction to D1. Water level fluctuations are less distinct in cores D4 and D5. The organic layer sequence (stratygraphy) in the described lakes allows to classify those bogs as the kettle hole bogs (Succow 1986). The greatest number of such bogs one can find in southern part of Kaszuby region – north of Tuchola Pinewoods (Jasnowski and Jasnowska 1981).

The dystrophy status can stop the development of lakes and bogs for many years. The aerial phot interpretation from the years 1951-1996 show small variability of shore lines of the dystrophic lakes for 45 years (Fig. 54). Prusian map coming form XIX/XX century (scale 1:25000) also shows the similar situation. The shape of shore line od such lakes is difficult to determine on the map, even on detailed one. Aerial photos are of great help in such cases. They make precise measurment of shore line possible (Fig. 55). The area of lakes in the reserve, the length of its shore line and index of shoreline development are shown in the table.

ake see ig. 1)	area on tha basis of map 1:10000 [m^2]	area on tha basis of aerial photo [m^2]	length of shoreline on tha basis of map 1:10000 [m]	length of shoreline on tha basis of aerial photo [m]	index of shoreline development on the basis of the map 1:10000	index of shoreline development on the basis of the aerial photo	area of the whole bog [m^2]
1	5296	4913	264	364	1,02	1,46	28323
2	3012	2848	200	271	1,25	1,43	37768
3	0	0	0	0	-	-	22535
4	3808	3779	243	346	1,11	1,59	12587
5	8142	8490	330	506	1,03	1,55	25590
SUM	20258	20030	1037	1487			126803

Grzegorz Kowalewski, Tomasz Schubert

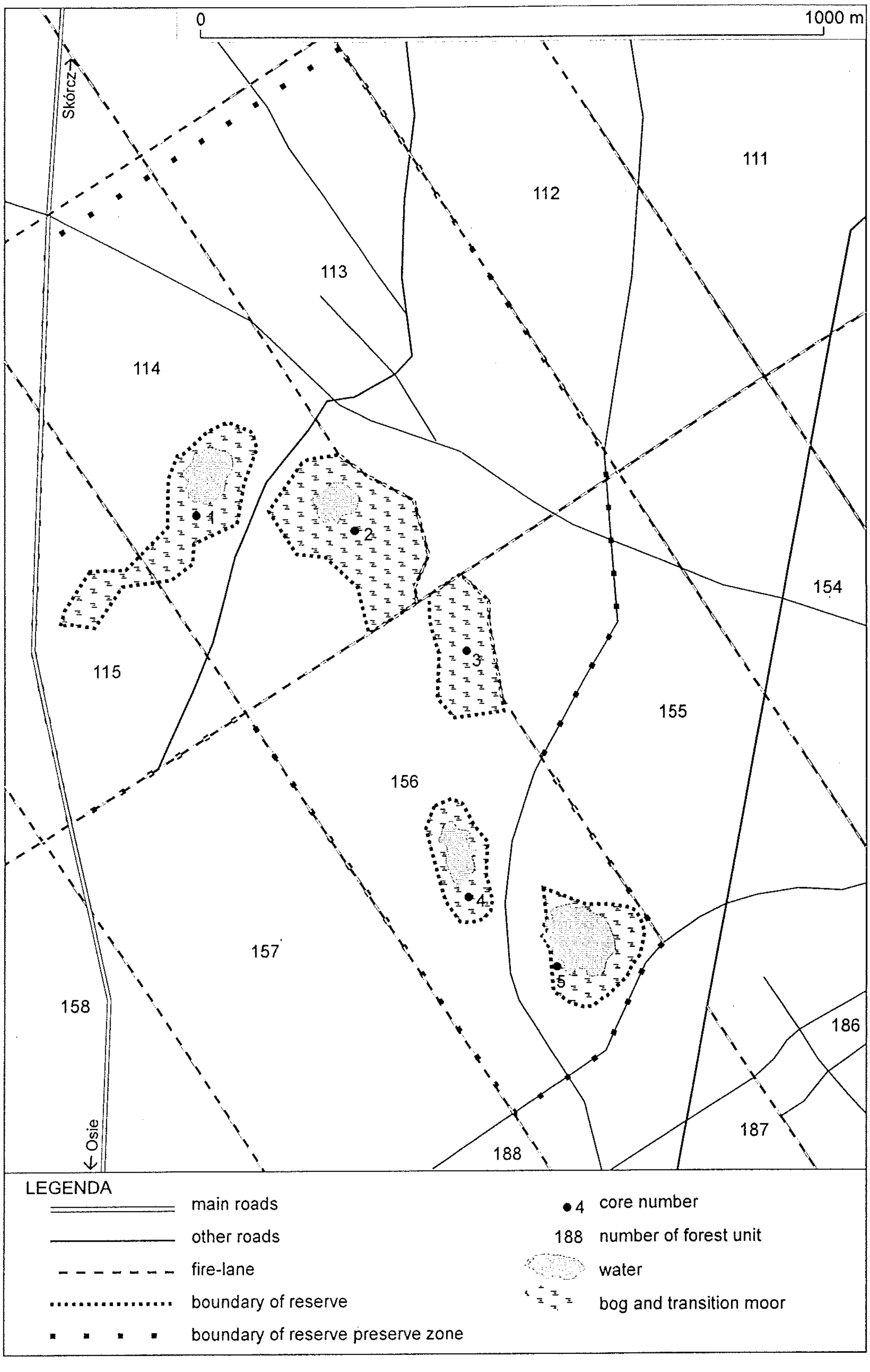


Fig. 52. Location of cores in "Dury" reserve

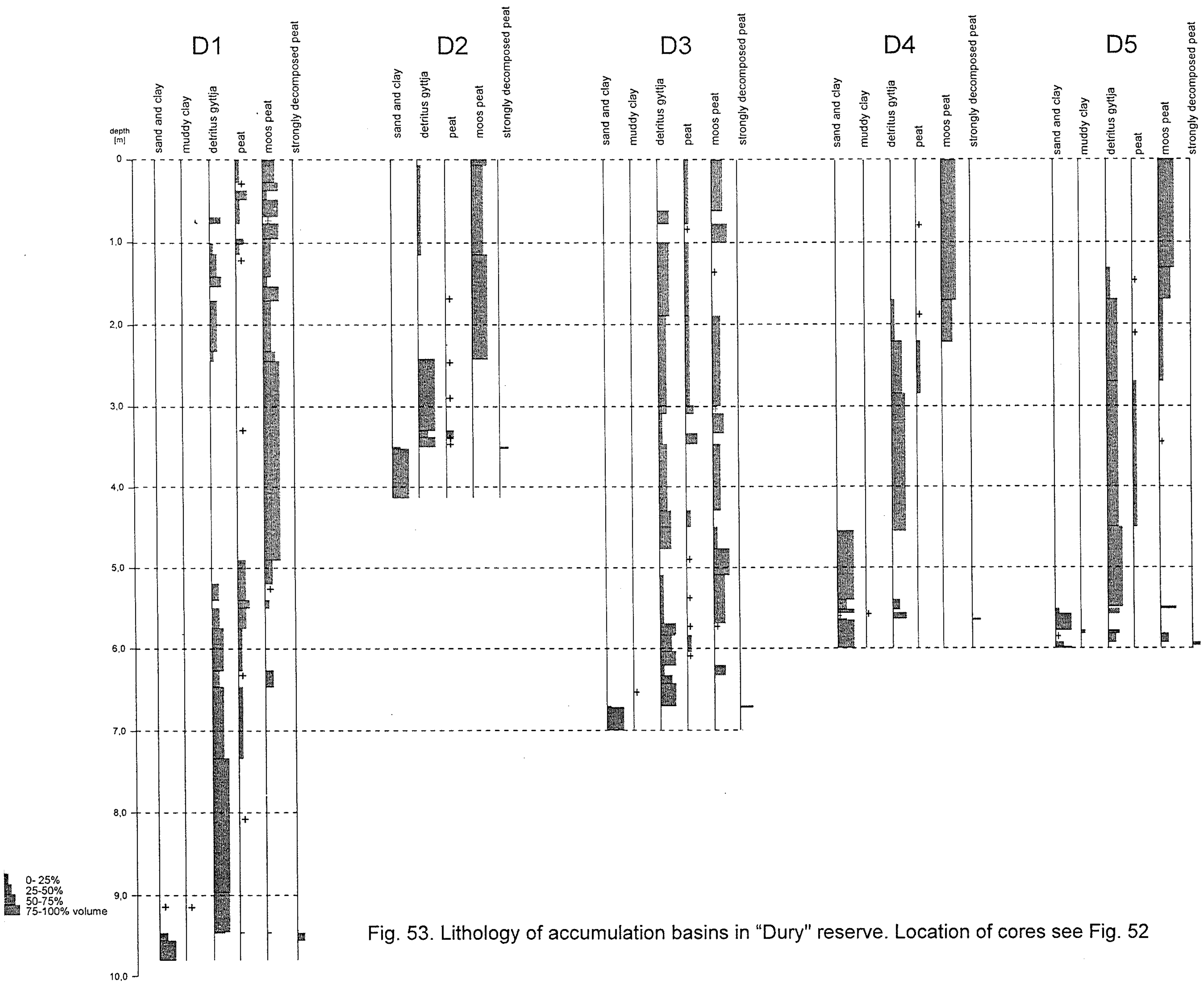


Fig. 53. Lithology of accumulation basins in "Dury" reserve. Location of cores see Fig. 52

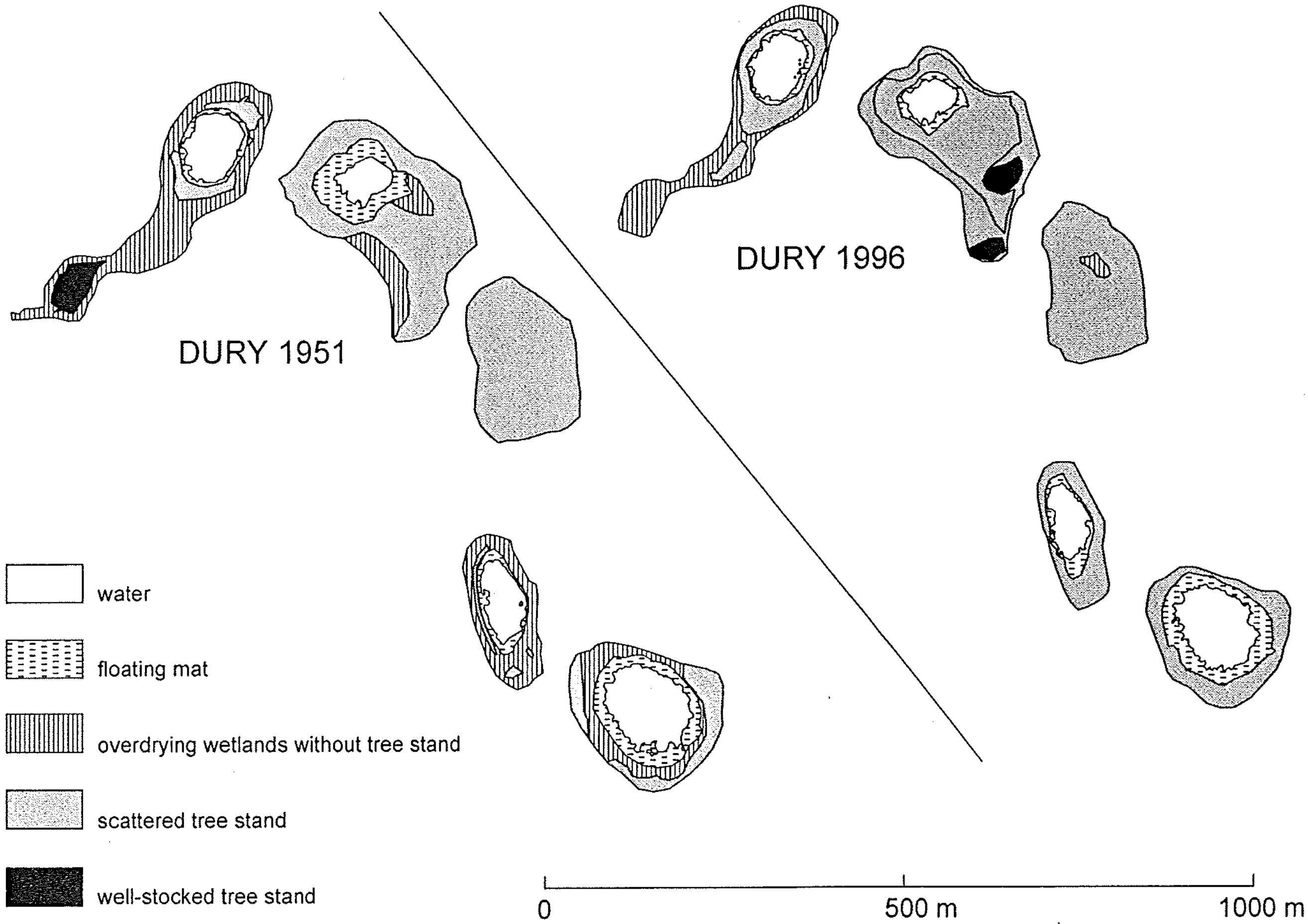


Fig. 54. Bogs and lakes changes in "Dury" reserve in the years 1951-1996 on the basis of aerial photo interpretation.

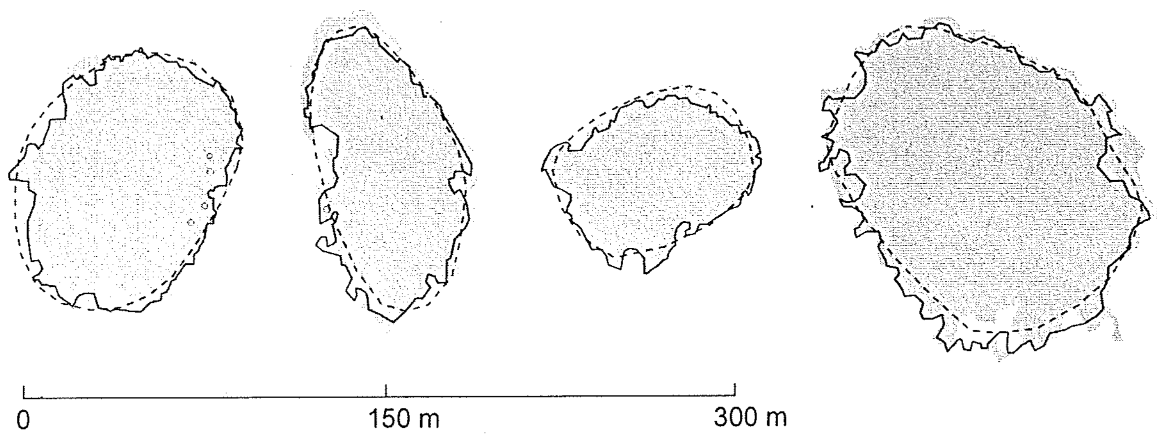


Fig. 55. The shape of lakes shore line in "Dury'" reserve
on the basis of aerial photo and topographical map interpretation
Grey color - area on the basis of aerial photo form 1951
Black solid line - area on the basis of aerial photo form 1996
Black dashed line - area on the basis of topographical map in the scale 1:10000

Pollen analysis of D1 core of sediments from Dury peatbog

Choosing of the core to pollen analysis was the next stage after the geological research. The core D1 was chosen because of big thickness and it showed a clear division into two different parts: detritous gyttja in the bottom and peat in the upper part. Every diagram contains curves of *Sphagnum* and *Pediastrum*, which divide the accumulation of sediments on the lacustrine and terrestrial part. In the other words, their curves show the change of the lake into the bog.

There are 13 local Pollen Assemblage Zones differentiated, depending on the regional as well as local changes of the plant cover because of their importance on the area surrounding the peatbog. So, e.g. regional changes dominate in L PAZ IV, where the lower limit is marked by growth of *Corylus* curve and L PAZ VII begins together with high content of *Sphagnum* spores, which proves a basic and great change but a local one.

The bottom part of the core illustrates the accumulation of sediments at the hot period of Late Glacial, probably in the end of Alleröd. A pine forest dominated then with lower proportion of birch and light demanding herbaceous plants like *Poaceae*, *Artemisia*, *Rumex* and *Cichorioidae*. Younger Dryas is seen in the diagram very clearly with the high content of *Juniperus* pollen grains (ca 15%) and *Betula* (up to 55%). NAP exceeds 20% because of numerous pollen grains of *Poaceae*, *Artemisia*, *Chenopodiaceae*, *Rumex* and *Ranunculaceae*.

Diminish of the curve of herbaceous plants signs the beginning of Holocene. Preboreal Period is mirrored in a very thin layer of sediments. High curve of *Betula* is still there, but *Pinus* pollen grains are more frequent instead of *Juniperus* and NAP. Density of the forest was growing then in comparison with the Late Glacial time.

The upper part of the core shows the accumulation of sediments in the time of great importance of deciduous forest at the area of Bory Tucholskie. At first *Corylus* immigrates and content of its pollen grains creates the highest curve. Later mesophilous trees like *Quercus*, *Ulmus*, *Tilia* and *Fraxinus excelsior* were more frequent. In the middle of Subboreal Period the proportion of *Corylus*, *Quercus* and *Alnus* decreased and *Carpinus* and *Pinus* were the trees of greater importance.

There was no intensive human activity at the area surrounding Dury peatbog. The pollen diagram shows strong anthropogenic pressure on plant cover as late as in the uppermost part only. Since the Neolithic one can observe single or not numerous pollen grains of cultivated plants or pasture indicators. Bory Tucholskie were penetrated then, but settlement was not long lasting and frequent and signs of human activity came from sites of greater distance. More intensive economy of last centuries is reflected in several upper spectra mainly by content of pollen grains of *Artemisia*, *Chenopodiaceae*, *Plantago lanceolata*, *Rumex* and *Secale*.

1. The bottom part of the diagram is probably not the beginning of the existing of organic sediments reservoir. High *Pediastrum* curve suggests the lake was formed some time before the accumulation of the oldest part of the core sediments.
2. At the depth of 575 cm a clear change is marked. The lake finished its existence and bog was formed at the place of research core. Accumulation rate is much bigger in the upper part of core at the time of peatbog functioning.
3. The lake and peatbog at the research site has had an oligotrophic character. Sporomorphs of *Sphagnum*, *Drosera rotundifolia*, *Lycopodium clavatum* proves it. Low curve of *Pediastrum* in the lake stage is also a feature of no eutrophic waters.
4. There is some correlation between AP content and water level changes. Diminish of curves of main trees is often synchronous with growth of *Sphagnum* spores in spectra. In two short periods of lower water level local culmination of *Calluna vulgaris* ocurred. Probably the less density of forest caused growing level of groundwater and rapid development of *Sphagnum* communities. Not so wet areas were better for *Calluna*.

Krystyna Milecka

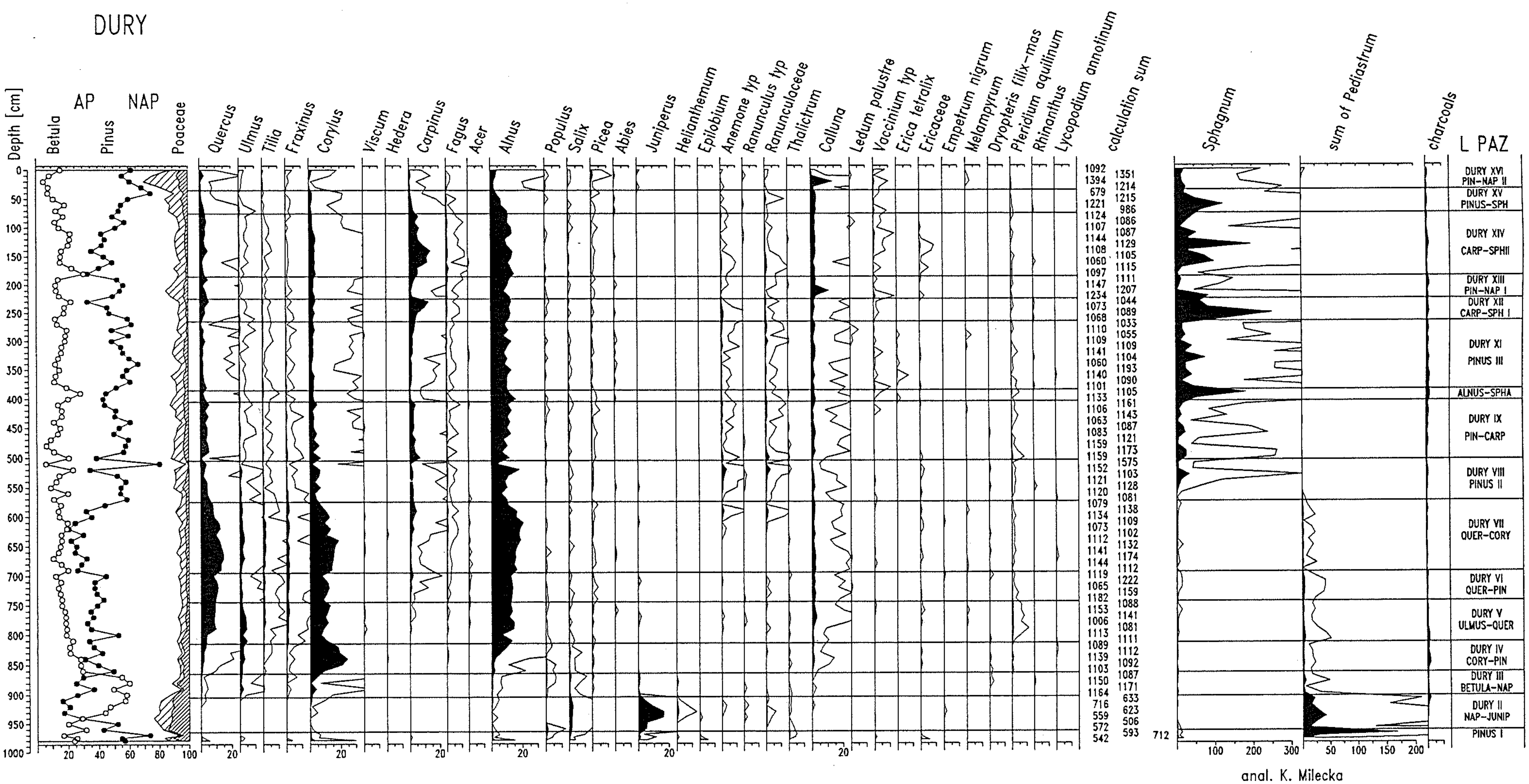


Fig.56. Pollen diagram Dury

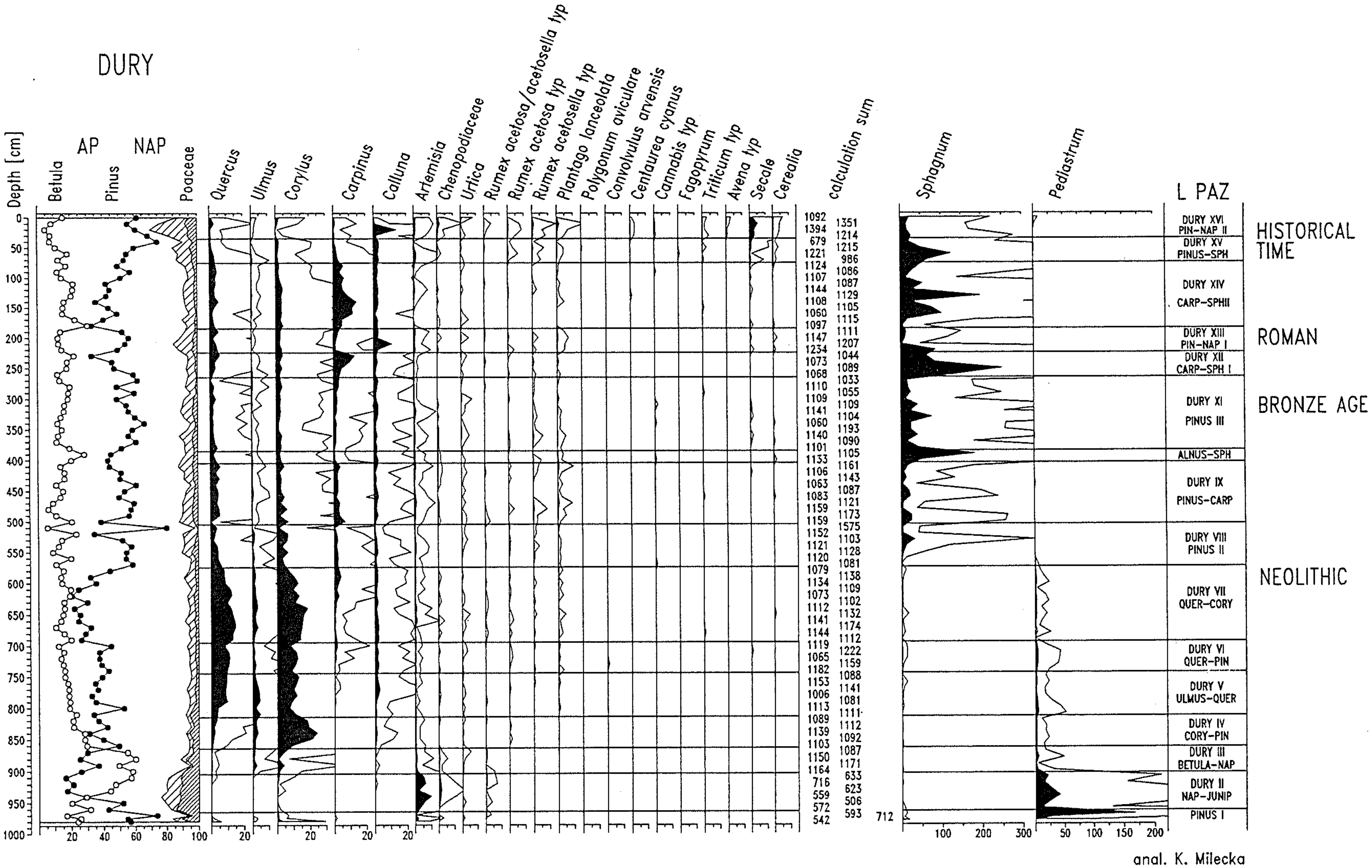


Fig.57. Pollen diagram Dury – human activity indicators

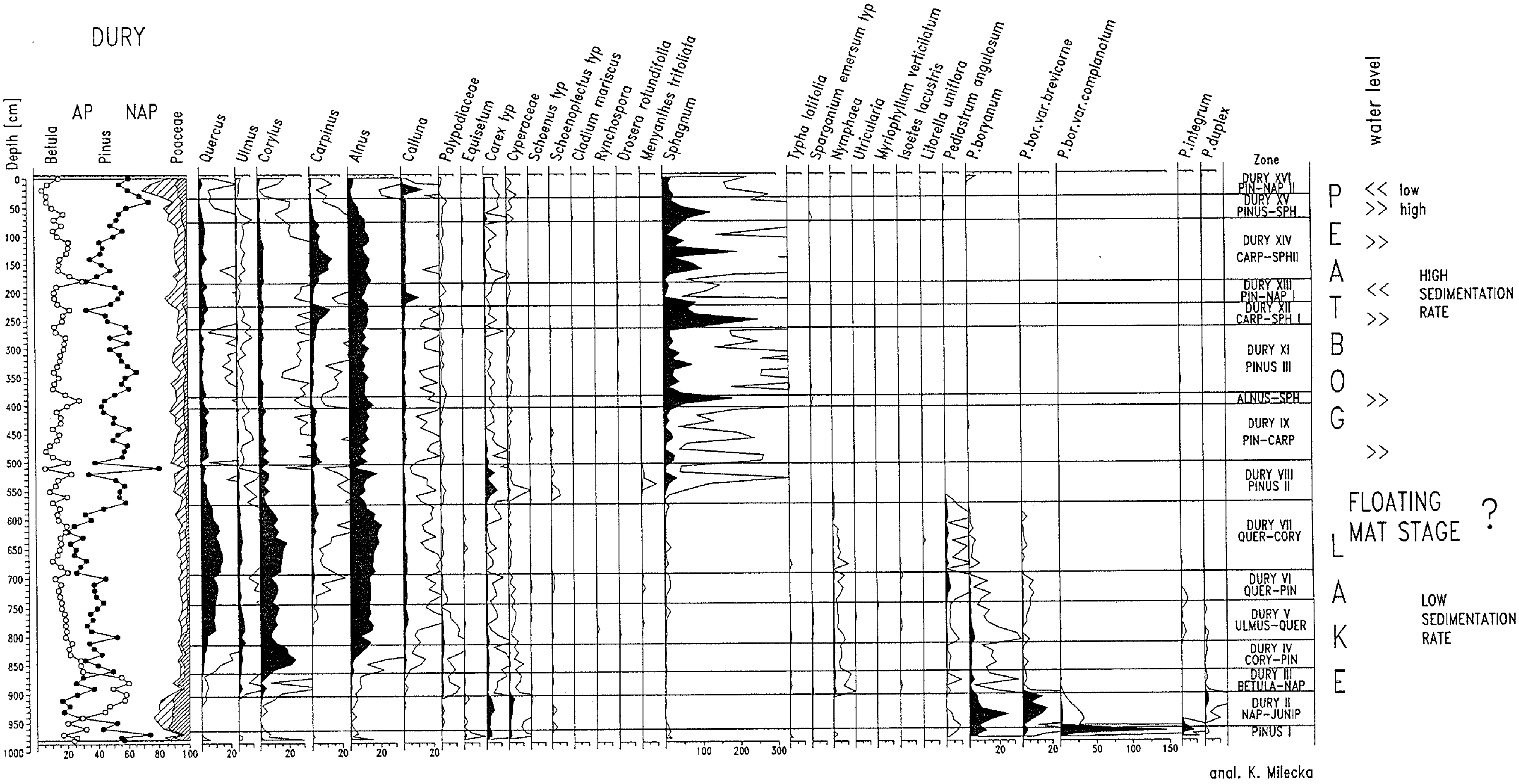


Fig.58. Pollen diagram Dury – local sporomorphs

The history of the yew in the Wierzchlas on the basis on palynological research

The station is located in the Leon Wyczółkowski "Cisy Staropolskie" forest reserve which makes the biggest natural stand of the common yew in Poland (*Taxus baccata* L.). The reserve lies in the South Pomeranian Lake District in the South-eastern area of a well-stocked forest complex of Tuchola Forest (fig. 1). It is the oldest and at the same time one of the most valuable protected forest areas in Poland. Nearly all types of trees and shrubs growing wild in the Polish Lowland appear in this area. The reserve, which is a multispecies forest with the yew making the lower layer, is the remains of former Tuchola Primeval Forest. Following phytosociological studies four forest assemblages were identified in the yew reserve in Wierzchlas (fig. 2).

The pollen analysis of two profiles of biogenic sediments from Mukrz Lake was the foundation for the reconstruction of the history of the Wierzchlas area plant cover. The Lake borders forest phytocoenosis with the yew specimen from the South. The cores that were received uncovered sediment bed of considerable volume, i.e. 21.65 meters in the central part of the lake, and 10 meters in the profile located closer to the lake shore where the yew grows at the contemporary max lake depth of 3 meters.

These sediments register the history of the plant cover of Mukrz Lake starting from late Vistulian glacial period through the Holocene until the contemporary times (Fig 3,4,5,6). The successful location of the investigated cores (central and shore area of the water body) made it possible to analyse both the history of the regional and local vegetation as well as to follow the history of Mukrz Lake origin. The oldest fragment covers the breach of the Oldest Dryas and Bölling and characterises the assemblage of shrub tundra mainly with sea buckthorm and willows (1 L PAZ). In the shore profile this level corresponds the layer of peat, which reflects the melting character of this water body. Within the rank of one common unit (2 L PAZ) the Alleröd/Bölling inter-stage complex was left and the cooling of the Older Dryas was separated as a sublevel (2B L PASZ). It is most vividly distinguished in the density diagram and the analysis of the main elements of the sediment. The youngest part of the late glacial period covers the cooling of the Younger Dryas, that is strongly marked, which resulted in the recession of the pine forest and the renewed widespread of the park-like tundra, mainly in the form of juniper scrubs (3 L PAZ). The Holocene regional history of the entire Tuchola Forest vegetation shows many similarities, which among others made it possible to use radiocarbon dating of the sediments from Mały Suszek Lake (Miotk-Szpiganowicz 1992). It was already at the beginning of the Holocene that in the region of Mukrz Lake birch-pine forests spread. With the improvement of climatic conditions, high-growing, multispecies forest became dense. Consequently, the importance of photophilous birch was limited and it gave way to pine and partly hazel. In the climatic optimum one may observe a considerable transformation of the vegetation cover. A noticeable increase in the share of deciduous trees such as *Ulmus, Quercus, Fraxinus* and *Tilia* takes place. Latest of all, i.e. in the Subboreal period, there appear trees such as the hornbeam, the beech and the yew. The latter's single sporomorphs appear simultaneously with the first *Carpinus* and *Fagus* pollen grains. The percentage of the beech (*Fagus sylvatica*) at the Mukrz station (M_I and M_{II}) never exceeded 2% (1.9 and 1.7% respectively). Thus, it can be assumed that the beech appeared in the forest stand only as an addition to deciduous forests. The theory that the contemporary forest community in the reserve makes a beech wood of the tree stand transformed antropogenically as a result of cutting the beech out was not confirmed in palinological research. Therefore, it must have been a deciduous forest in the past, the type of contemporary *Tilio-Carpinetum* dry-ground forest with the share of the yew.

A continuous curve of the yew starts with the beginning of the growth of the last (3) hornbeam maximum, which falls on the forest regeneration phase relating to the period of Migration of Nations. The maximal participation of the yew was 1.6% in the main profile and 3.1% in the Mukrz II profile. These values should be linked with the historic times reflecting a documented selected protection of the yew and its artificial planting in Wierzchlas. The samples from the bottom of Mukrz Lake taken by means of Kajak's tubular catcher also showed low percentage of the yew, i.e. 1.5%, 2.1% and 1.8% respectively.

The comparison of the surface spectra from different habitats of this reserve (lake, forest bed and peatbog) reflected big discrepancy in the share of the yew (fig. 7). On the one hand, these differences are related to the habitat from which the material originated, but on the other hand they are connected with the distance between the place from which the material was taken and the location of a male specimen. The biggest percentage of the yew is noted in the samples originating from the *Tilio-Carpinetum* assemblage and the lowest percentage in alder forests and on meadows, which corresponds to the absence of the yew in these plant assemblages. The differences in the yew percentage, which appear within the *Tilio-Carpinetum* assemblage, are the reflection of a different distance from a pollinating specimen (Noryśkiewicz A.M. 1998).

This conclusion is confirmed by the research carried out in Wierzchlas on the dispersion of yew pollen grains. The samples were taken in the section from under one male yew specimen, relatively isolated from other male trees of this species. The big participation of yew pollen grains appears in the spectra that represent samples taken directly from under the tree-crown 24.l-35% (3-meter range) and decreases gradually with the increased distance t 5.7-1.9%. A considerable tree stocking also limits pollen grains spreading outside the forest boundaries.

The presence of yew pollen grains in surface materials from the reserve in Wierzchlas depends, thus, on both the distance between the sample taken and a male yew specimen as well as the stand density.

The phytosociological survey of the surface of 200 sq. meters documents that around the tree under research there only grow a yew, an elm, a linden, a hornbeam and a maple (Noryśkiewicz A.M. 2001). It turns out that pollen grains of the remaining trees come from transportation. Pine pollen grains originate from further transportation and do not react to the local presence of the pollen yew. The birch, which does not appear on the survey surface, but its numerous specimens grow in the distance of app. 100m in the meadow and forest edge and its considerable concentration is located about 200m away, reacts markedly to the yew frequency fluctuations. It also displays reverse relation in relation to the yew. The percentage of herbaceous plants is lower and comparable in all samples. Thus, it may be concluded that trees being rich sporomorphs emitters are responsible for pollen count in the forest.

The participation of human activity indicators in pollen spectra made it possible to determine the influence of human activity on natural plant cover. Six so-called settling phases relating to the increased human activity in the area of Wierzchlas were distinguished (Noryśkiewicz A. M. 1999, 2001).

Two contradictory tendencies can be noted with the attempt to interpret the course of the yew curve in relation to the phases of human activity. In the fourth and sixth phase the yew curve corresponds to the run of the summary curve of anthropogenic indicators, whereas in the fifth phase it disappears nearly entirely. Such a situation may result from a different human environmental interference. Pollen grains migration of plants from the lower forest storey including the yew, that makes the lower layer of trees, is easier thanks to forest thinning. This might explain the increased participation of the yew in the periods of human activity. In the sixth phase the yew reaches the max. value at the depth of 3.15m. This growth occurred already in the historic times and seems to be the reflection of selective yew protection originally conducted in this area or even planting the yew here. A nearly complete disappearance of the yew pollen that happened in the fifth phase can, however, result from the increased cutting of the tree for economic reasons. Yet, too few yew grains in the diagrams from Mukrz Lake, despite its abundant pollination, limits its indicative usability for human activity.

Agnieszka Noryśkiewicz

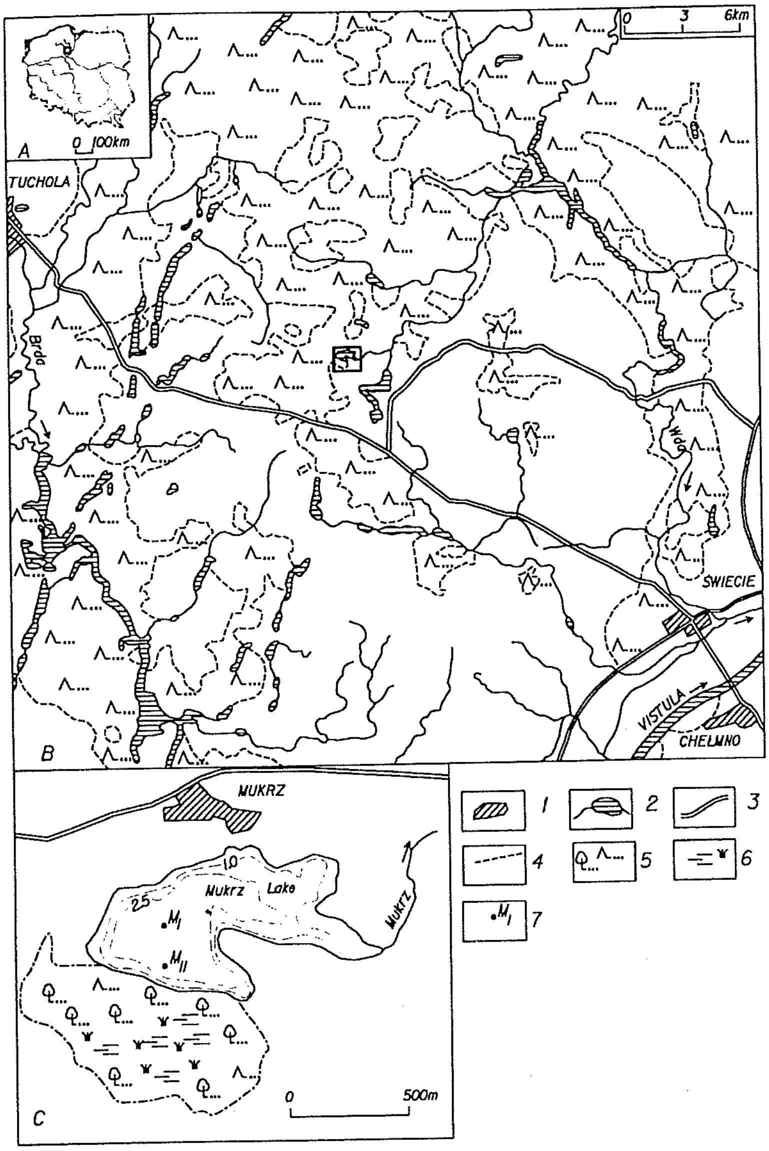


Fig.1.
Location of the investigation area in Poland (A) and against the background of forests (B) and the location of the profiles marked on a bathymetric map of the lake (C):
1 – villages,
2 – lakes and rivers,
3 – roads,
4 – arable lands,
5 – deciduous and coniferous forests,
6 – wet area,
7 – location of the profiles M_I i M_{II}.

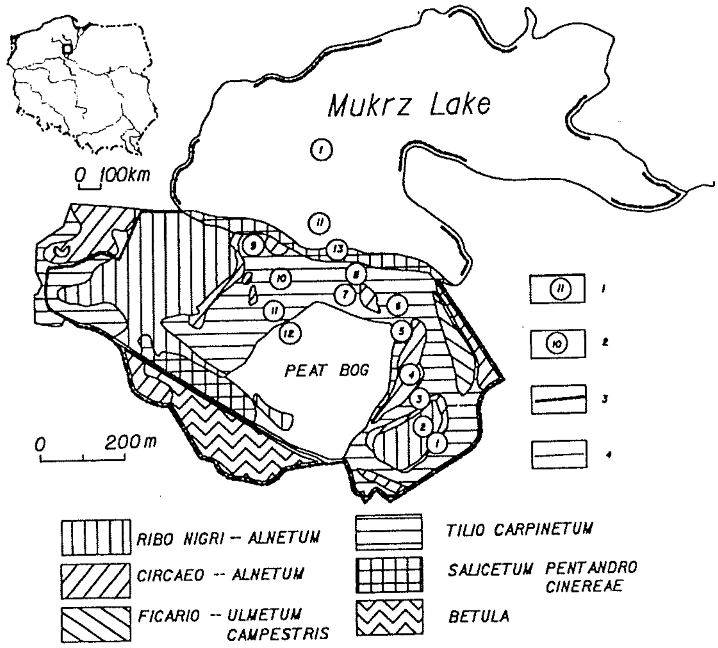


Fig.2.
Plant communities in Leon Wyczółkowski „Cisy Staropolskie" Reserve, after Boiński (1997):
1 – profiles location (M_I i M_{II}),
2 – sampling stations (1-12),
3 – reserve boundary,
4 – roads.

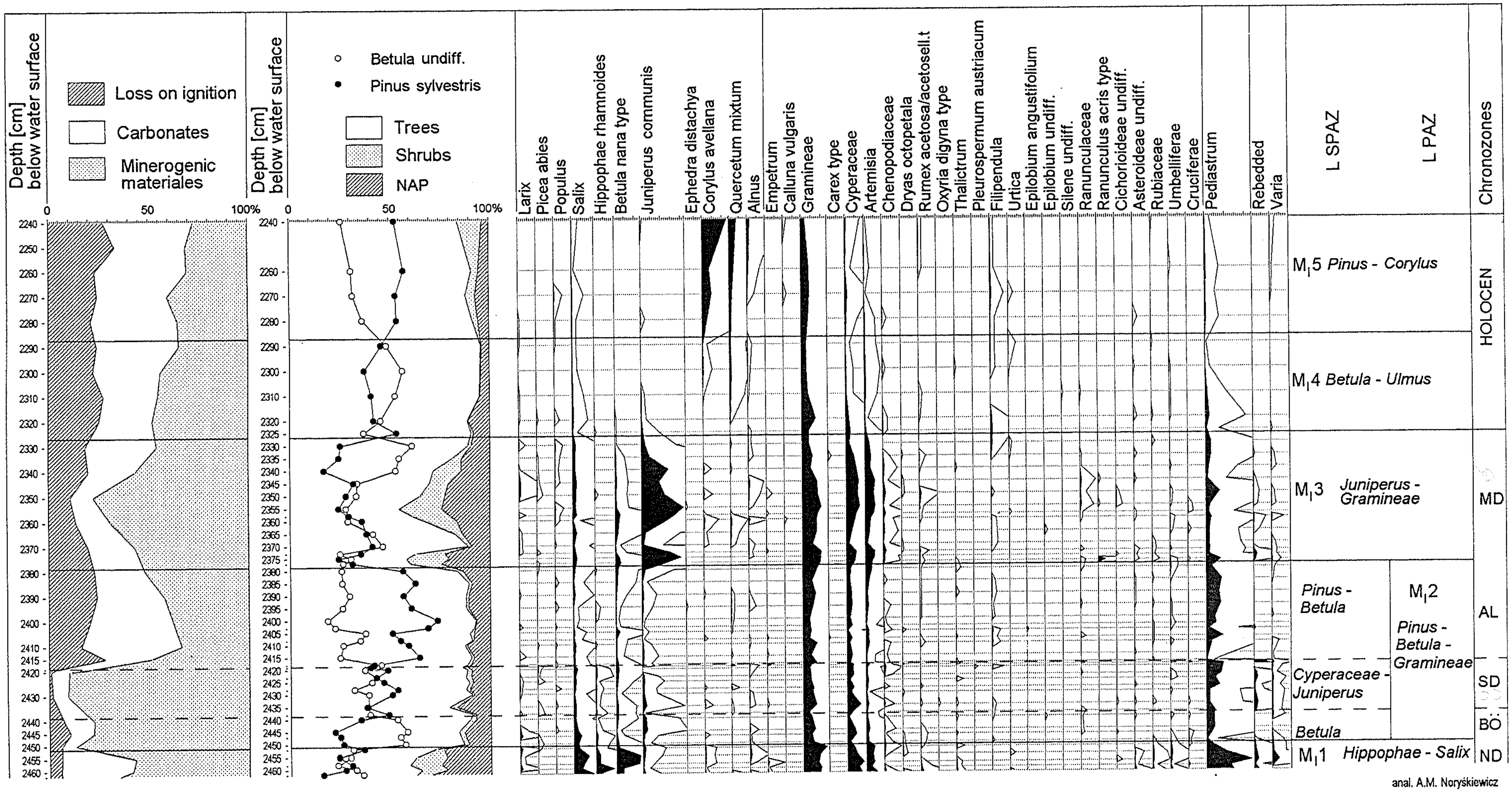


Fig.3. Pollen diagram (selected curves) from the bottom part of the main profile (M_I)

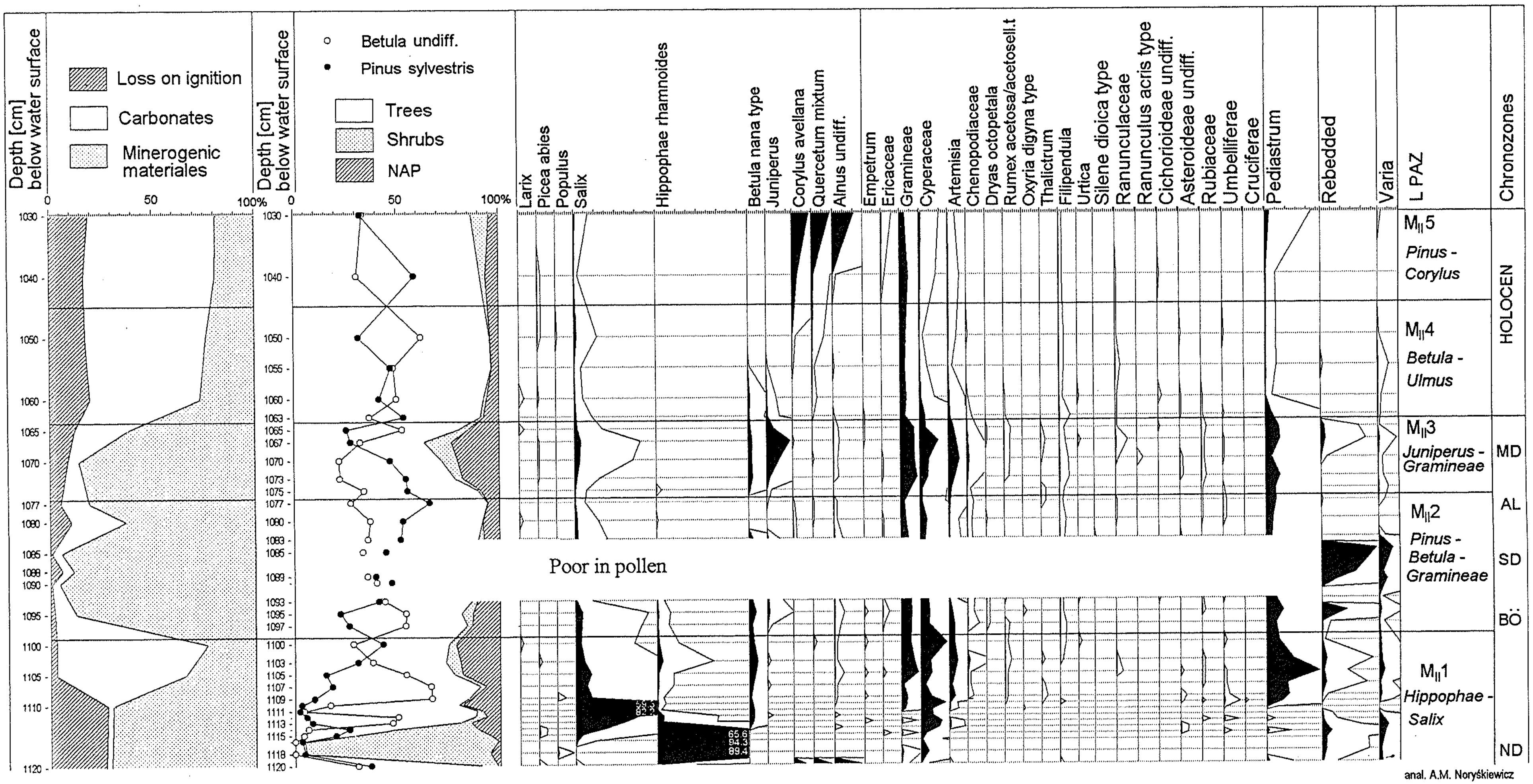


Fig.4. Pollen diagram (selected curves) from the bottom part of the profile „Mukrz II"(M_{II})

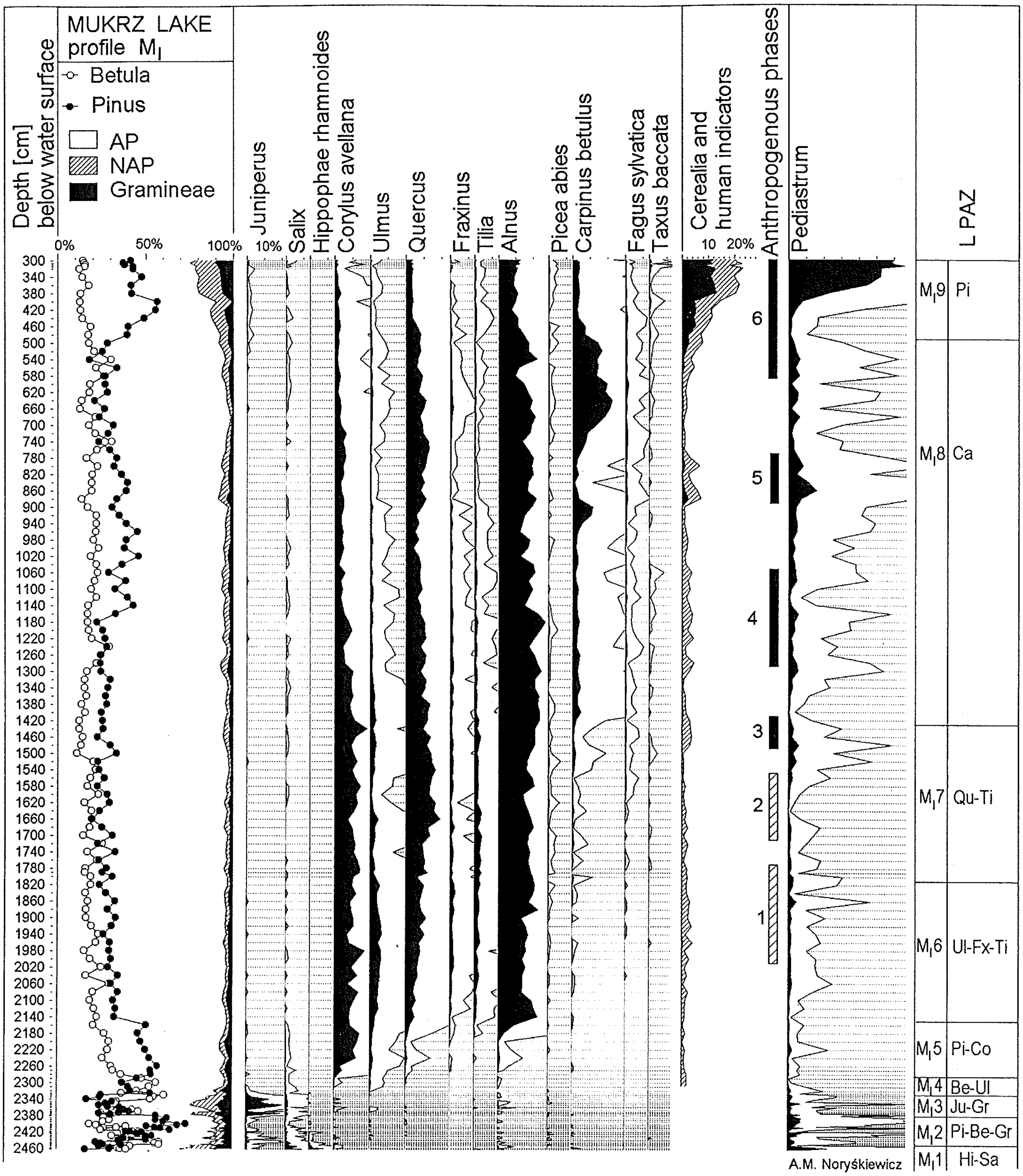


Fig.5. Simplified pollen diagram from Mukrz Lake – profile M_I

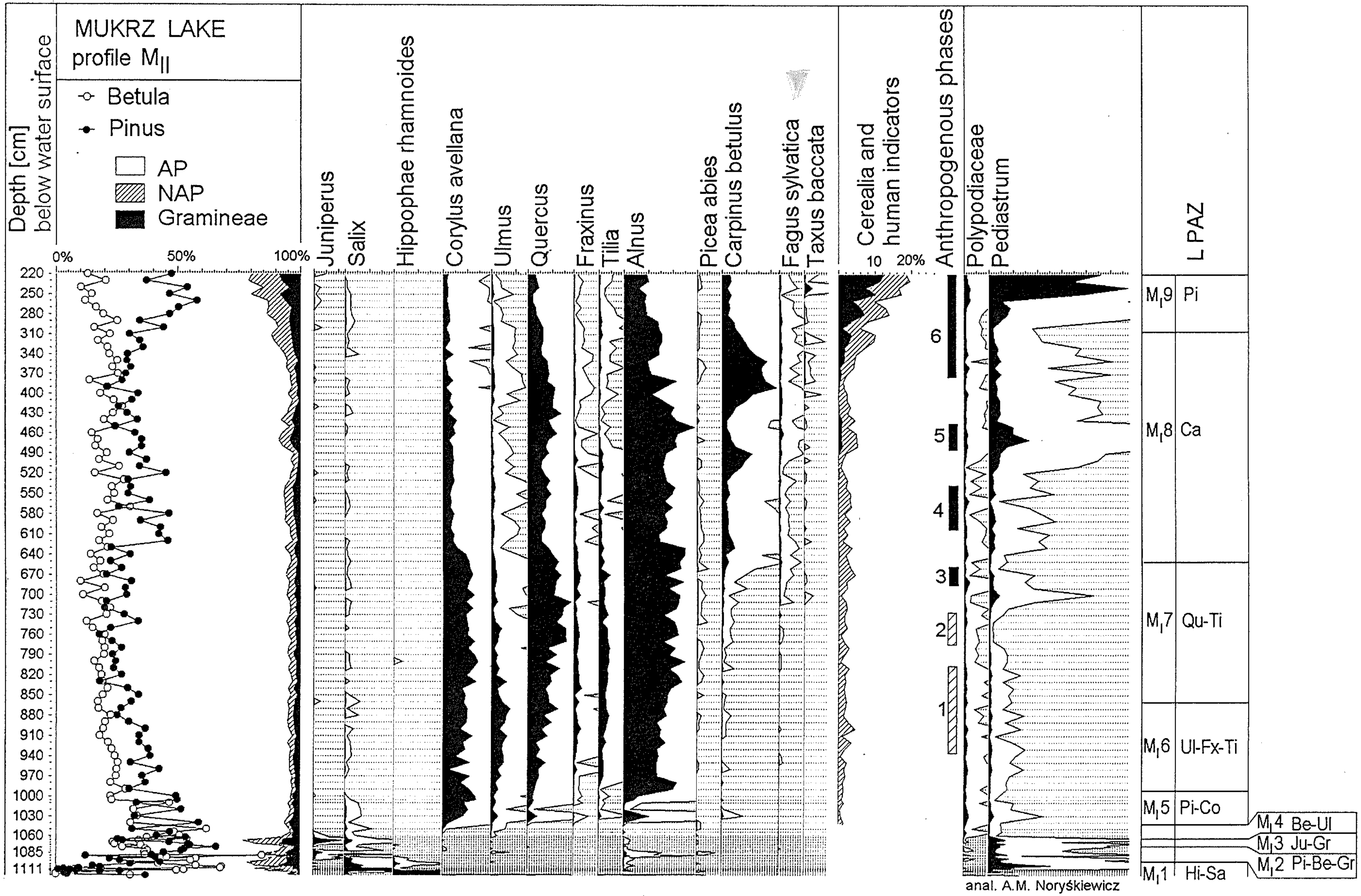


Fig.6. Simplified pollen diagram from Mukrz Lake – profile M_{II}

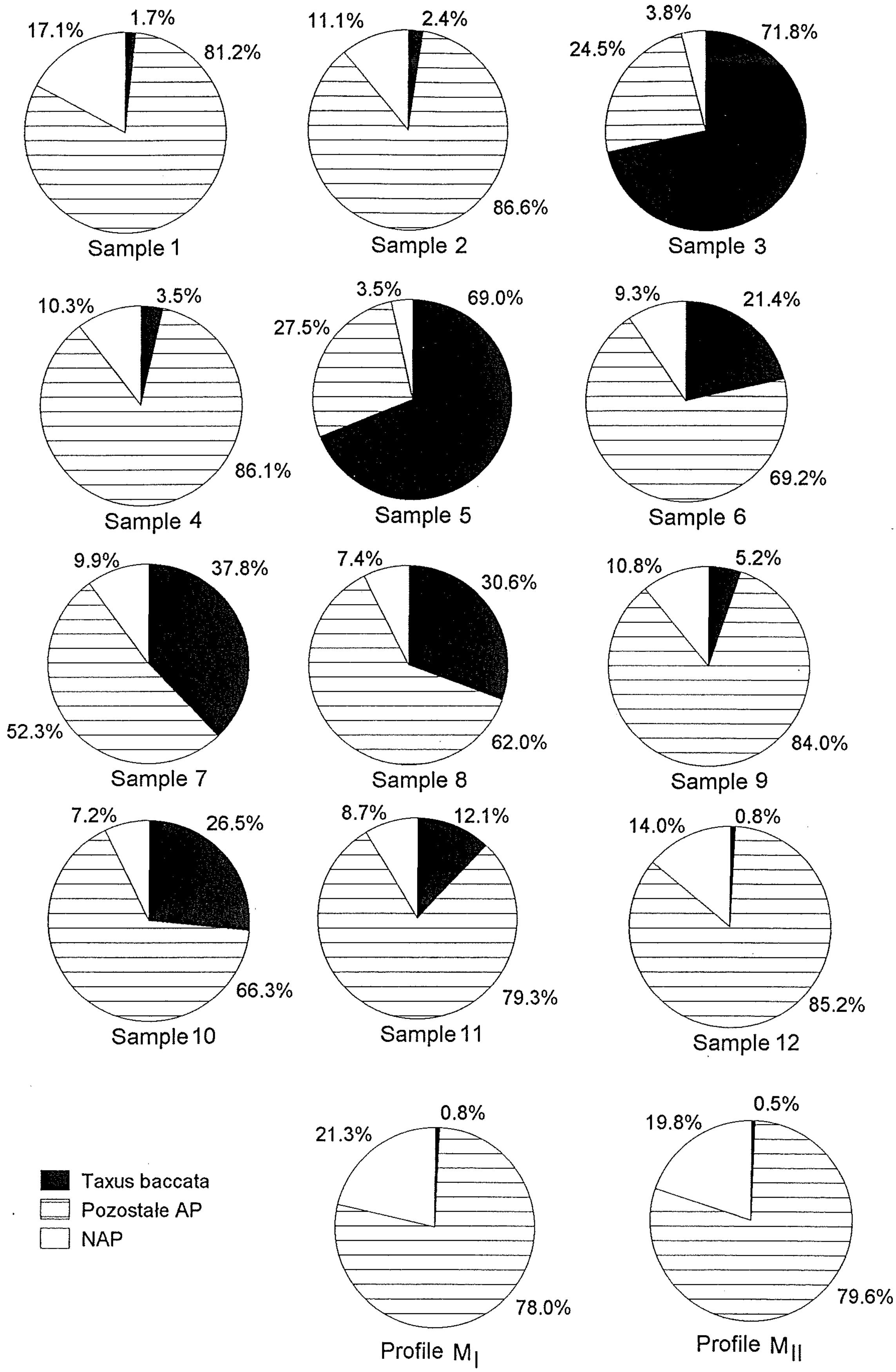


Fig.7. Pollen cyclograms from Wierzchlas (AP+NAP=100%) – (samples location – fig. 2)

Transformation of wetlands and lakes at the zone of influence of Koronowski Reservoir.

Koronowski Reservoir appeared as a result of the dam building across the Brda River in Koronowo (the earth dam) and hydro-electric power plant in Samociążek south of Koronowo and was filled in 1960. Groundwater level in the surrounding of Koronowski Reservoir raised in the period 1960-1970. These events followed the rise of water level of the reservoir. After the reservoir had been filled, water infiltrated into the sandr. Before the dam was built, Brda River had drained sandr deposits. Reservoir has drained the new stabilized level of groundwater since 1970, which is influenced especially by natural factor as precipitation (see. Fig. 66a) and development of spring snowmelts. Taking into consideration these facts and high ground permeability on sandr (Fig. 66b), groundwater level is characterized by seasonal and annual fluctuations.

Changes of the hydrogeological conditions occur whenever any reservoir come into being, but changes of the hydrographical network surrounding reservoir need favorable morphological and lithological conditions and no drainage system. Such conditions often exist in the vicinity of man-made lakes lying on permeability deposits on lowlands. The changes are the more considerable the higher is damming in the reservoir.

Koronowski Reservoir is situated at the area with favorable conditions to the hydrographical network changes.

- Brda valley is deeply incised in permeable sandr deposits. It caused, due to strong drain, low groundwater level in the adjacent area and a small number of wetlands and lakes;
- In group of lowland dams there was a high damming of water here (about 20 m);
- There is a large number of hollows on the sandr;
- The sandr area surrounding reservoir has considerable extent.

Main transformation of the hydrographical network has occurred in 10 years period (1960-70).

6 types of transformations occurred on this area. 4 of them are connected with wetlands (printed below in bold fonts):

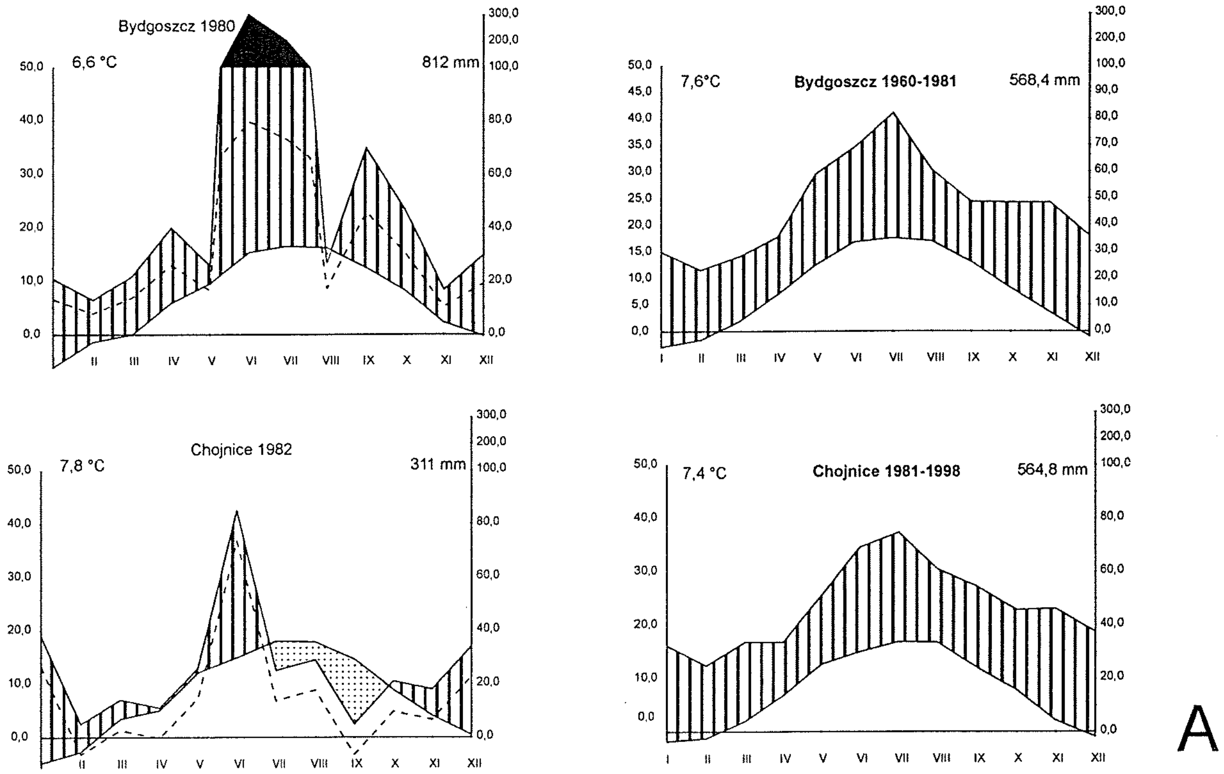
1. Occurring of a number of new water bodies,
2. **Occurring of a number of new wetlands (process of paludification),**
3. **Occurring of a number of new intermittent wetlands (process of intermittent paludification),**
4. Raising of level of existing water bodies,
5. **Raising of water level in existing wetlands (process of renaturalization),**
6. **Flooding of existing wetlands and replacing them by new water bodies.**

On the current reservoir influence area, before the reservoir had been built (except wetlands and lakes presently flooded by reservoir water) 115 wetlands existed covering area 227 ha and 36 ha of open water surface in it. On the whole area 142 new wetlands and lakes came into being, which exist on mineral ground, without organic deposits (Fig. 67). Area of wetlands raised from 227 ha to 464 ha (in 1996) i.e. twice as many (204%). Area of surface of water of surrounding reservoir raised from 36 ha to 231 ha i.e. over 6 times as many (636%). So large increase of surface water and wetlands area near reservoir predicted none of the projects of the reservoir.

Considering wetlands (with flow through) and surface of reservoir, excluded from research, but laying in extent of reservoir influence, one can calculate lake and wetland density index. It amounts to 11.2% with relation to 3.15% before the dam was built.

The most interesting are changes, which occurred in Strzyżyny double channel. Several bigger eutrophic lakes lie in the western channel. Water level in these lakes rose around 0.5-2 m, mostly in its southern part. In the eastern channel several dystrophic lakes overgrowing with floating *Sphagnum*-mat are distributed. Before the reservoir was created, floating mat had been covering nearly all the surface of the lakes. In some lakes, rise in ground water level (Fig. 68) resulted in partial separation of the mat from lake shores, because they raised (as an emersion community) together with water level (Fig. 69a). In that way, the floating mat could have been fragmented due to wind and wave activity (Fig 69b). In other lakes, floating mat was completely separated from lake shores forming a uniform floating island in the middle part of a lake. In the case of lakes incompletely overgrown by floating mat, a peculiar structure of floating *Sphagnum*-ring was formed (Fig.70).

Grzegorz Kowalewski



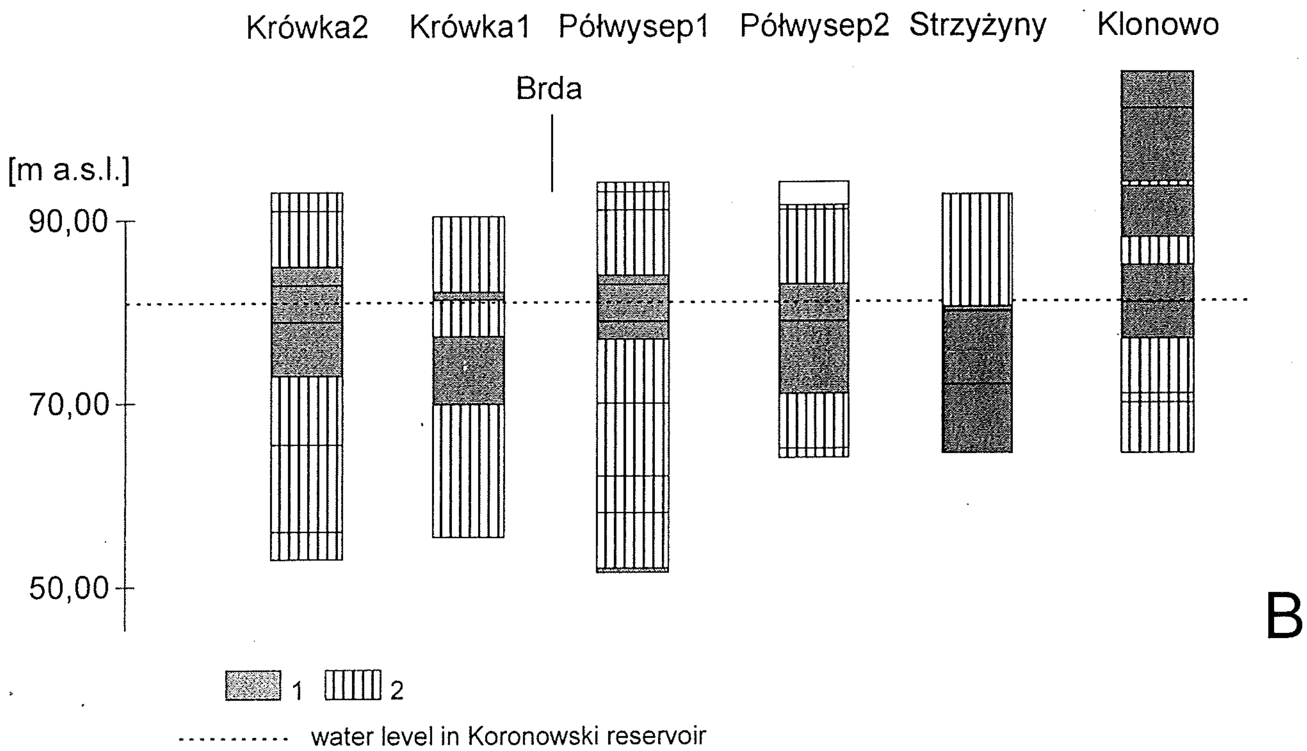
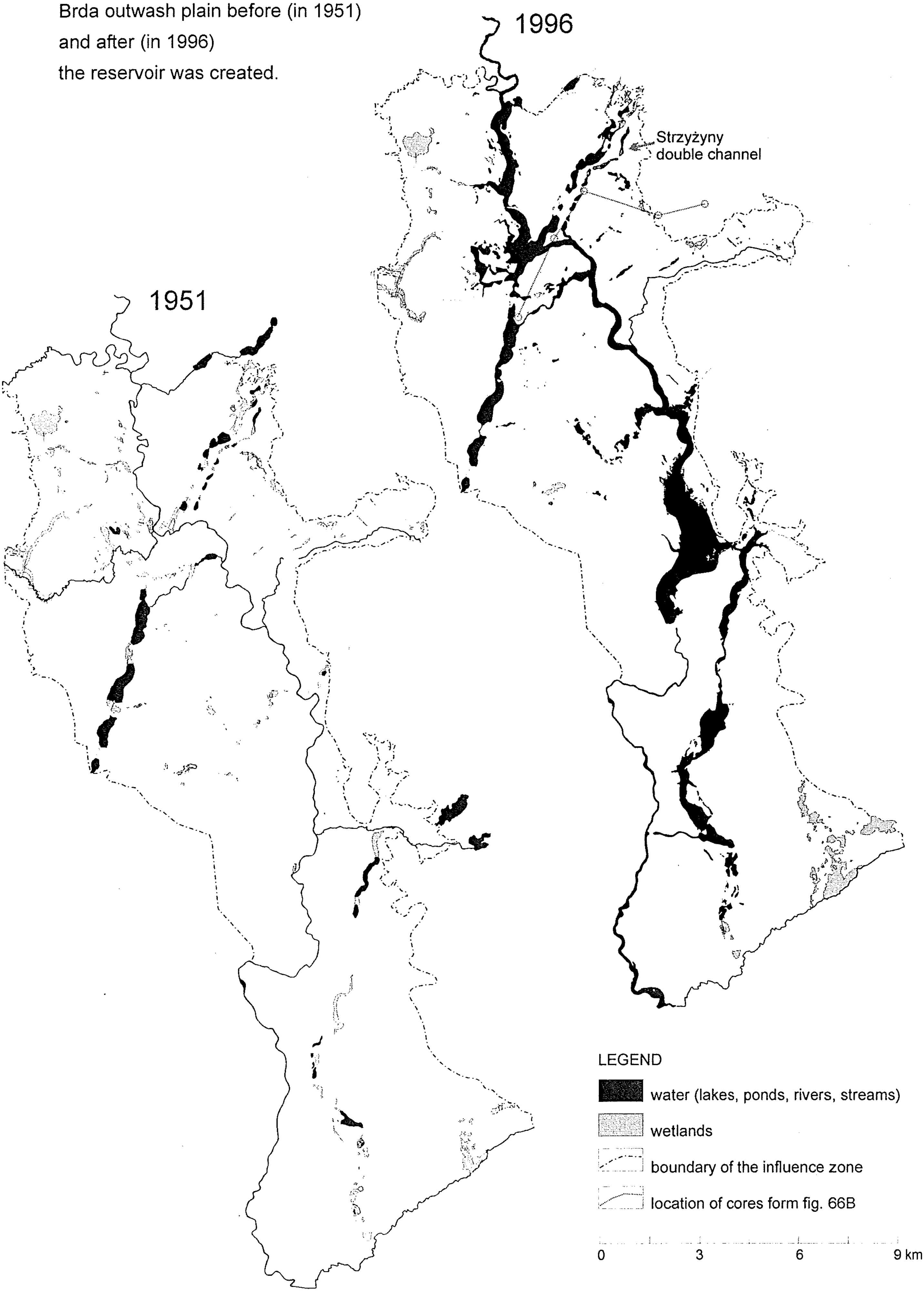


Fig. 66.

A Climatic diagrams for the wetest, driest and average month in the meteorological stations Bydgoszcz and Chojnice in the years 1960-1998;

B. Geological structure Brda outwash plain: 1 - impermeable deposits, 2 - permeable deposits. Locality of cores see fig. 67

Fig. 67. Wetlands and waters on the Brda outwash plain before (in 1951) and after (in 1996) the reservoir was created.



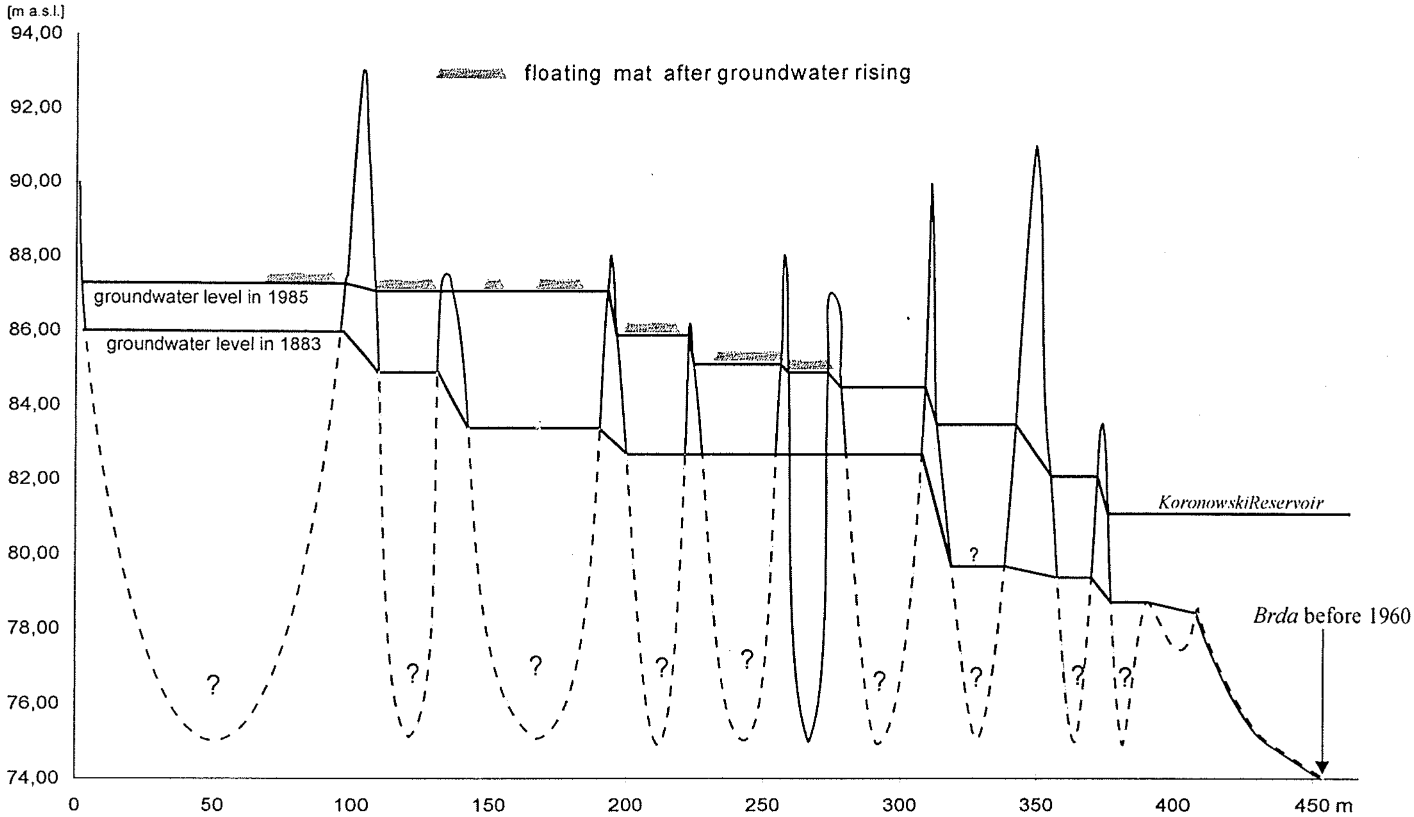


Fig. 68. Hydrogeological and topografical profile of groudwater rising in east Strzyżyny channel. Location of profile see fig. 69.

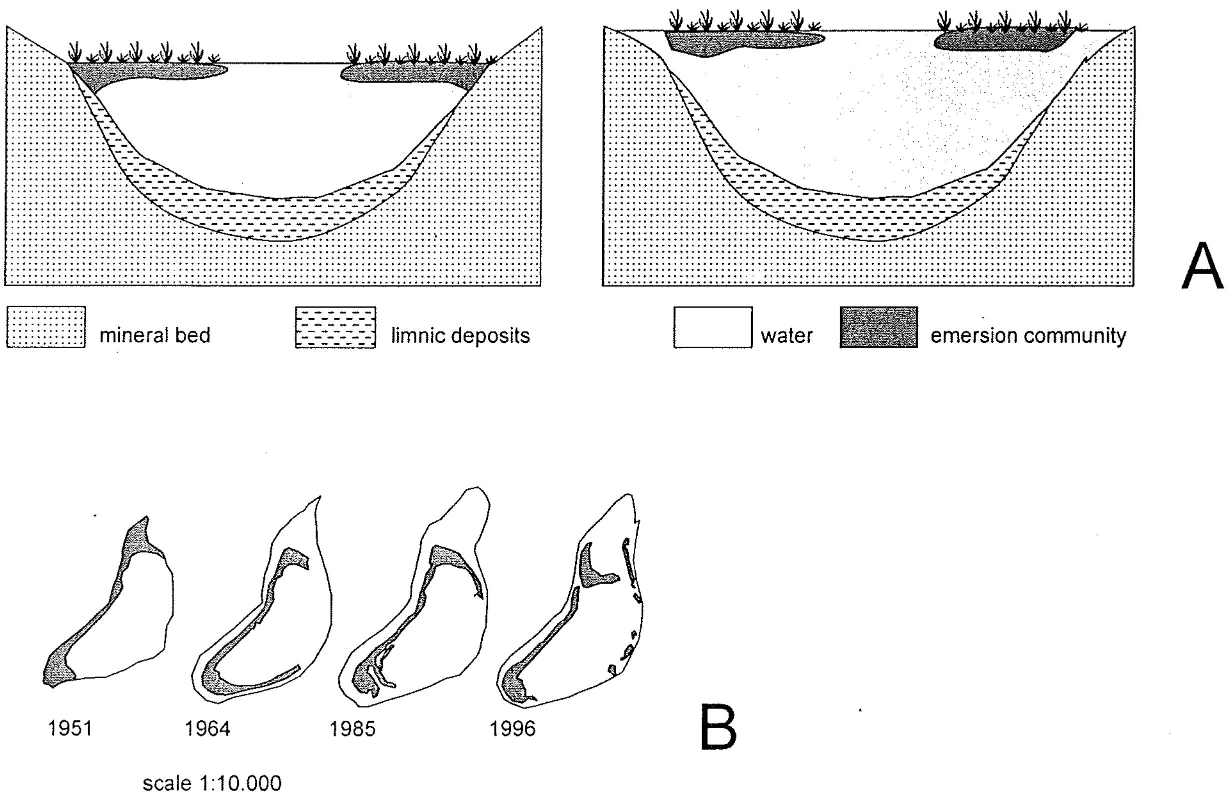
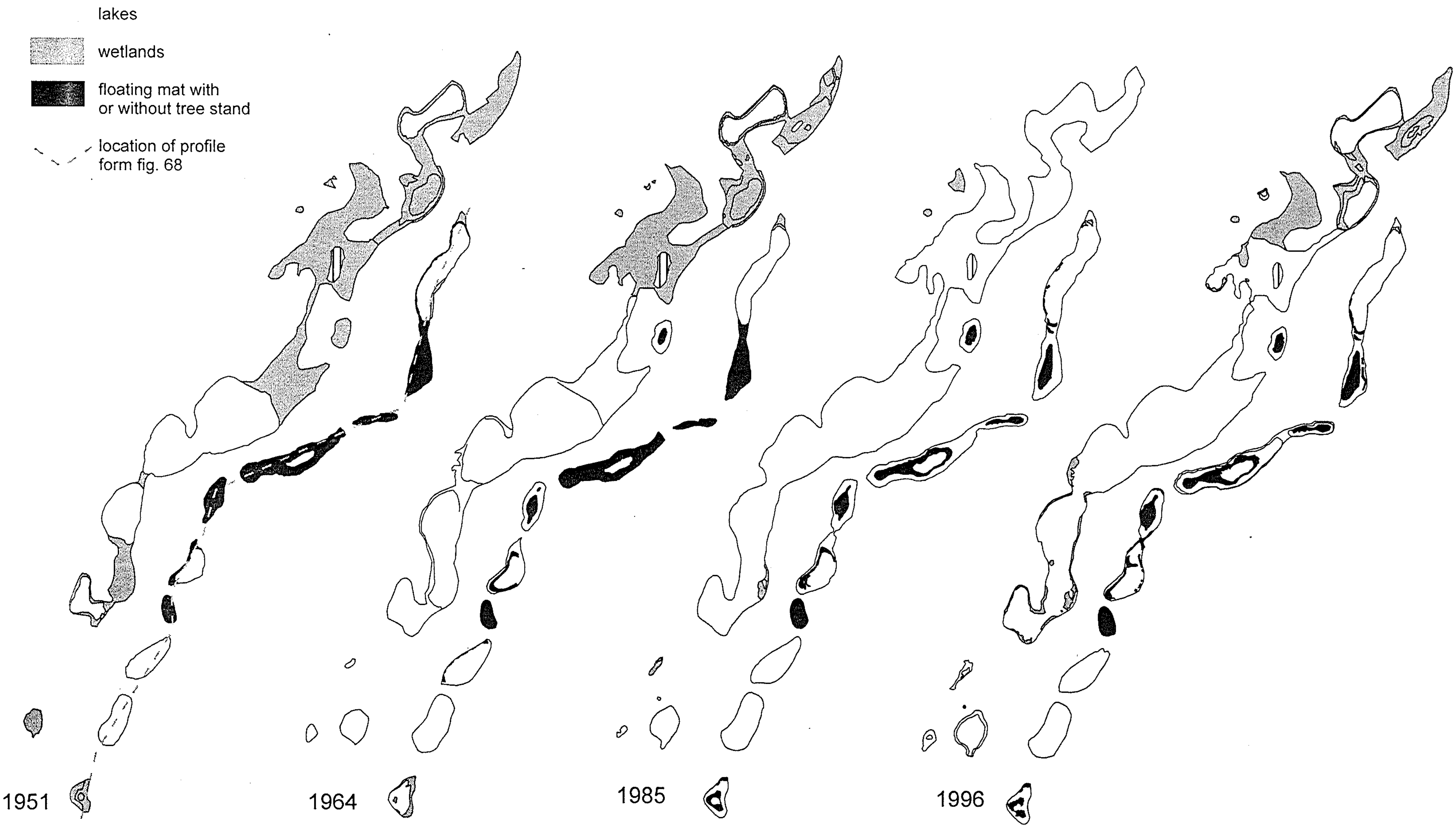


Fig. 70. A - Scheme of raising of floating mat; B - moving of floating mat on the lake surface

Fig. 70. Simplified map of transformation of wetlands and lakes in double Sytrzyżyny channel



Development of cultural landscape in Central Great Poland

Toruń-Eberswalde ice-marginal valley near Nakło

The Toruń-Eberswalde ice-marginal valley (pradolina, Urstromtal) represents the largest ancient river valley in Europe formed in Vistulian (Fig. 71).

The origin of the Toruń-Eberswale ice-margin valley according to Kozarski (1961): *„The study of the terraces of the Noteć ice-marginal valley near Nakło (Fig. 72, 73) lets us believe that in its geomorphic development rhytmically repeated periods can be distinguished, when lateral erosion and accumulation, and periods of the predominance of vertical cuttng, prevaill. Those periods were the result of climatic oscillations of that part of the last glacial when all terraces of the ice-marginal valley were formed, i.e. between the Pomerainan Stage (the upper terrace) and the Younger Dryas (the flood plain). Periods with predominance of lateral erosion and accumulation took place during stages: during the Oldest Dryas (middle terrace), Older Dryas (lower terrace) and Younger Dryas (flood plain). Verical cutting prevailed during interstadials: the first during the Masurian Interstadial, the second during Bölling, the third during Alleröd"*

Table 2, acc. to Kozarski 1961

Period	Prevalent geomorphic processes and deposits	Terrace(genetic type)
Holocene	accumulation, peats muds	
Younger Dryas	lateral erision and accumulation gravels, sands, gyttja, peats	Flood plain, accumulative
Alleröd	vertical cutting; dissection of the lower terrace (II)	
Older Dryas	lateral erosion and accumulation sands, gravels	Lower (II) partly: erosive, accumul.
Bölling	vertical cutting, dissection of the middle terrace (III)	
Oldest Dryas	lateral erosion and accumulation sands, gravels	Middle (III) partly: erosive, accumul.
Masurian Interstad.	Vertical cutting, issection of the upper terrace (IV)	
Pomeranian Stage	lateral erosion and accumulation sands, gravels	Upper (IV) partly: erosive, accumul.

In the central part of Nakło town are distributed Eem-Interglacial lake sediments (Fig. 74) investigated by B. Noryśkiewicz (1978). Simpified pollen diagram is shown on Fig. 75. The Eemian and Vistulian palynostratygraphy in Great Poland (based on materials mainly from Konin area is on Fig. 76.

Kazimierz Tobolski

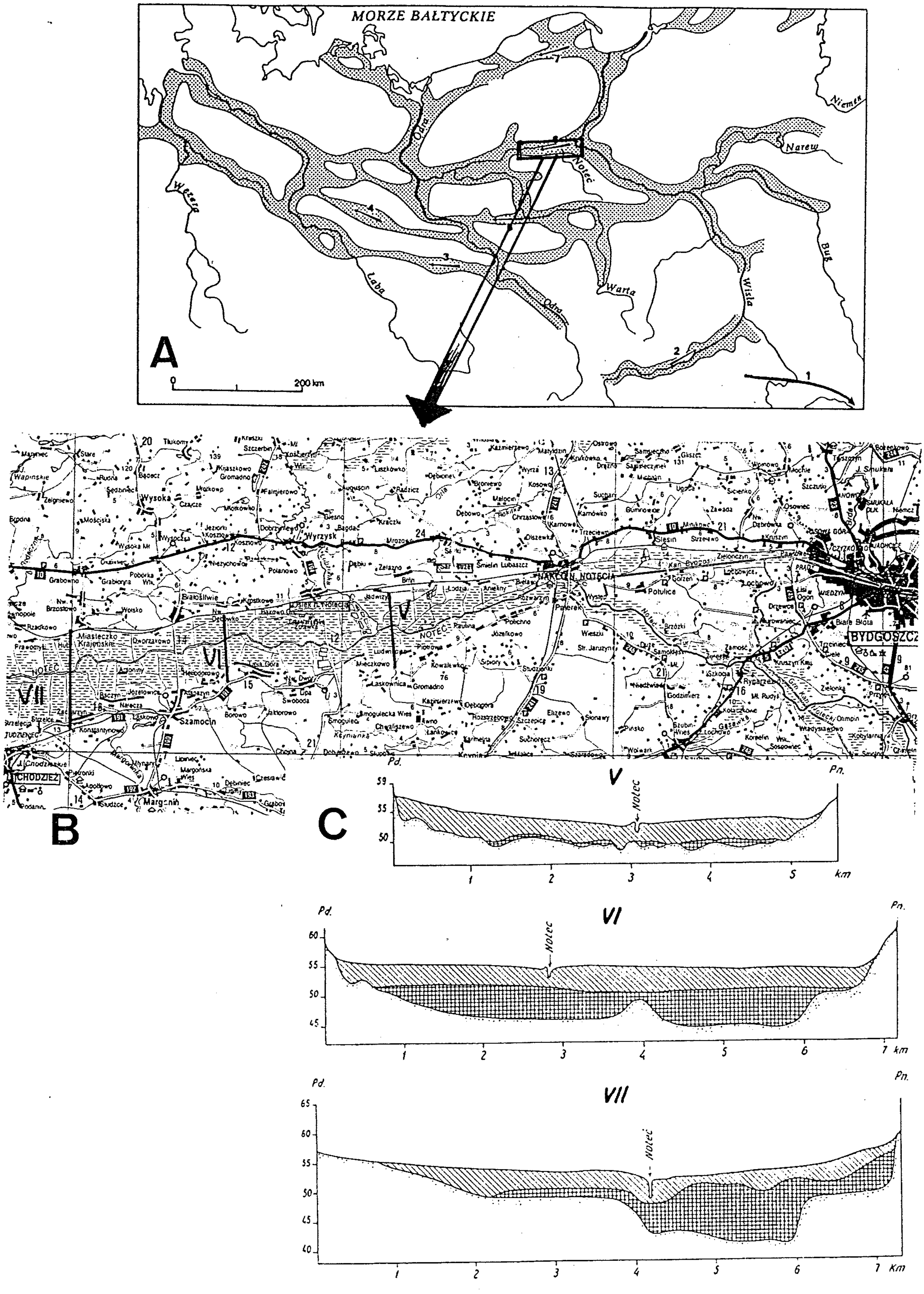


Fig. 71. Noteć ice-marginal valley – part of the Central-European ice-marginal system (A), the ancient flood-plain terrace near Nakło (B), filled with peat (upper layer) and gyttja (lower layer) – C.

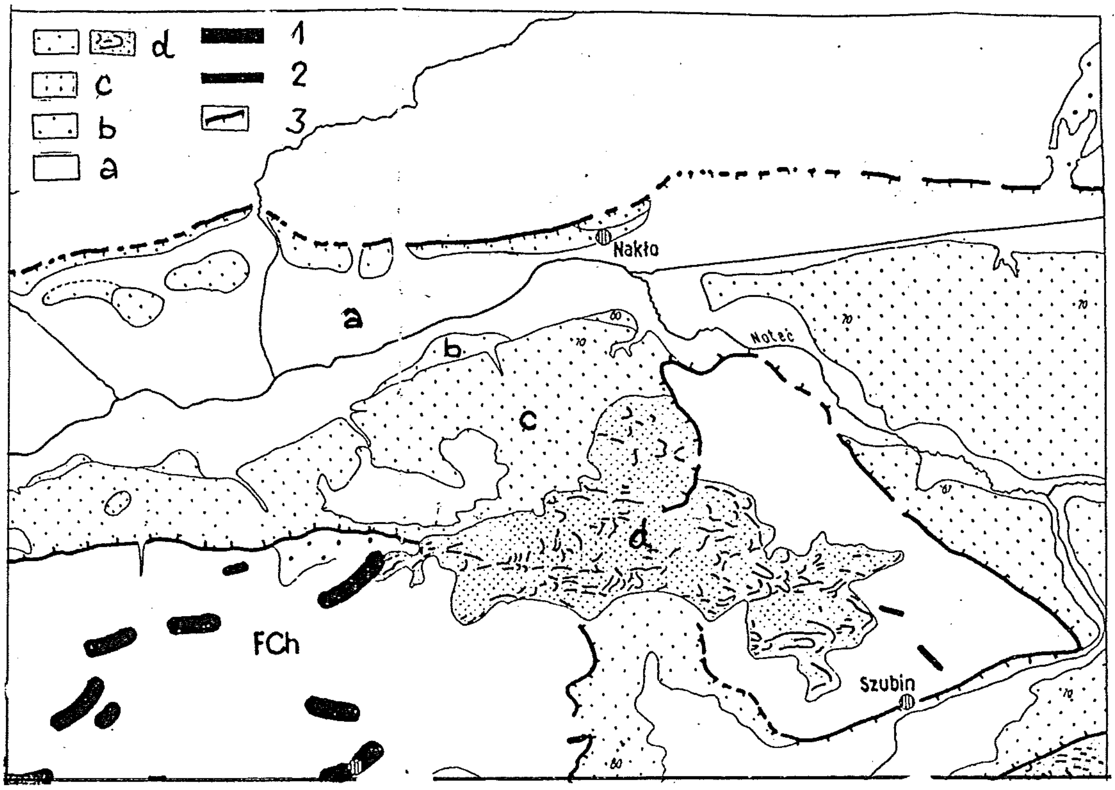


Fig. 72. Terraces in the Noteć ice-marginal valley near Nakło (acc. to Kozarski 1961, simpified), d - middle terrace with dunes, c - transitonal terrace, b - lower terrace, a - flood plain, 1 - end moraines of phases (FCh – Faza Chodzieska) 2 - end moraines of oscillations, 3 - erosional scarps.

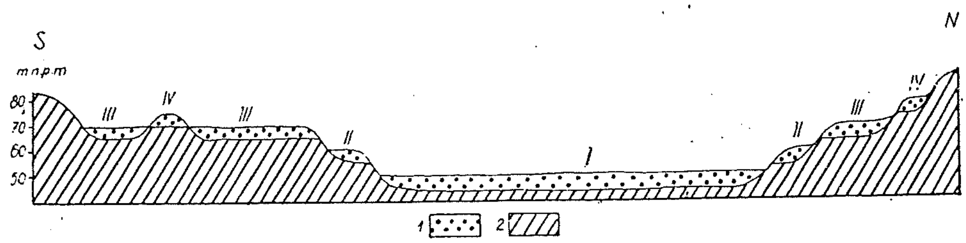
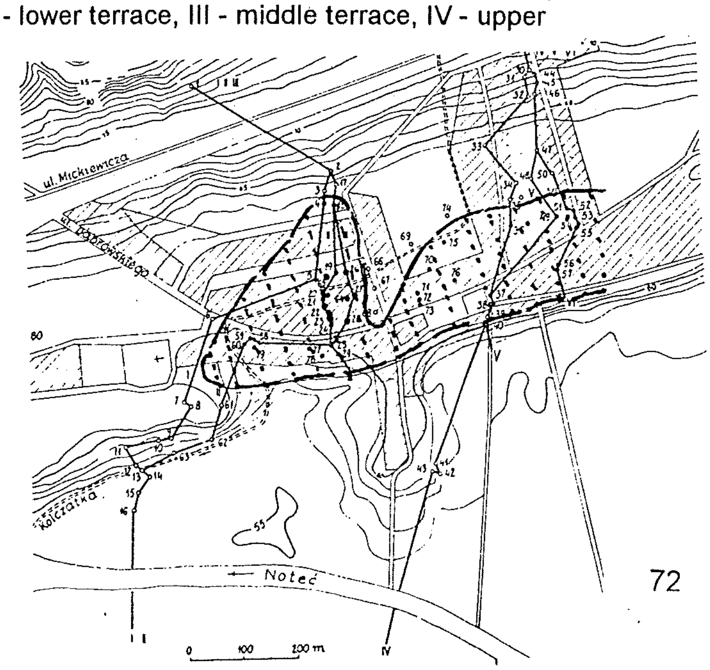


Fig. 73. Scheme of terraces of the Wyrzysk-Noteć part of the Noteć ice-marginal valley (Kozarski 1961): 1 - accumulative covers, 2 - substratum; I - flood plain, II - lower terrace, III - middle terrace, IV - upper terrace.

Fig. 74. Distribution of eemian deposits in Nakło

(Noryśkiewicz 1978, simplified).



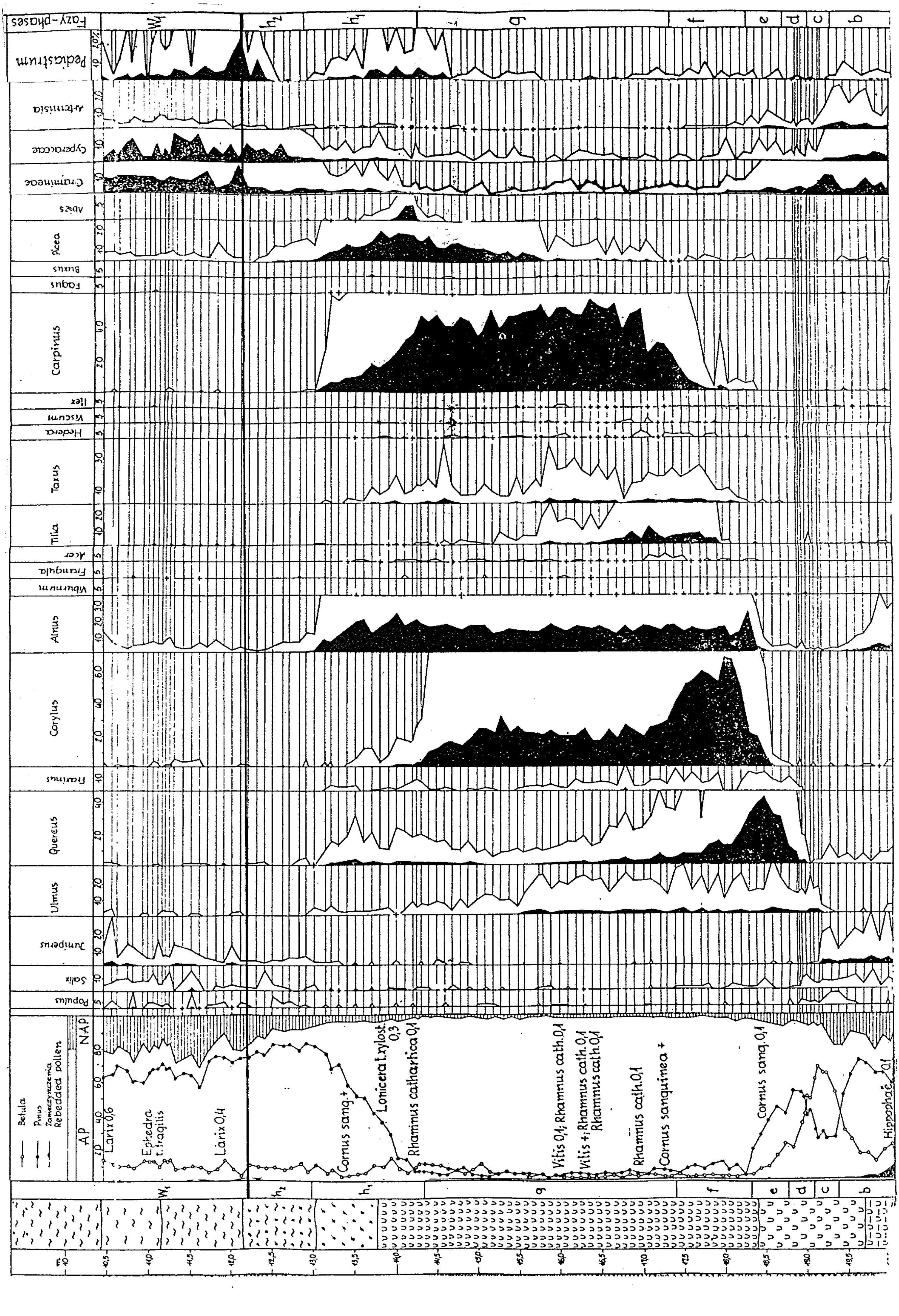


Fig. 75. Simplified pollen diagram of Eem interglacial and Early Vistulan at Nakło (Noryśkiewicz 1978).

BIOSTRATIGRAPHY A	B	C	D	PLANT COVER	PLANT INDICATORES	CLIMATE		CORRELATION			
		NAP III		moss tundra	SCORPIDIUM TURGESCENS	middle arctic (VII-6-8°C)	OC	VISTULIAN	late	MALINIEC II 25000 BP (Tobolski 1984)	
		4 NAP II		dwarf shrub tundra	ARMERIA SP EMPETRUM CF. HERMAPHRODITUM	low arctic (VII-9-10°C)	OC		middle	EBERSDORF (Stadial)	
	V-III	3 BETULA NANA - EMPETRUM		shrub tundra	BETULA NANA					Oerel (Interstad)	MALINIEC I (Tobolski 1984)
		2 BETULA ALBA - ARTEMISIA			BETULA "ALBA" BETULA NANA	subarctic (VII- 10-11°C)	OC				
		1 BETULA NANA - NAP									
		SALIX-EQUSETUM	b / a	tundra		low arctic	CO			Schalkholz (Stadial)	VS 3
	V-II	2 PINUS		pine forest	PINUS SYLVESTRIS	middle boreal (VII-14°C)	CO		early	Odderade (Interstad)	RUDUNKI
		1 PINUS-BETULA		pine-birch forest	BETULA "ALBA"						
		NAP I		steppe meadow						Rederstall (Stadial)	VS 2
	V-I	4 PINUS		pine forest						Brörup (Interstad)	AMERSFOORT
		3 BETULA-NAP				boreal	CO				
		2 BETULA-LARIX		birch-pine forest	BETULA HUMILIS LARIX SP	boreal	CO				
		1 NAP-BETULA		steppe with shrubs							
		ARTEMISIA-NAP		steppe	RUMEX MARITIMUS EPHEDRA, POTAMOG PRAELONGUS	subarctic	CO			Herning (Stadial)	VS 1
Eemian succession	E-III	7 PINUS		pine forest		boreal (VII-15-16°C)	CO	EEMIAN	late	Eem-Warmzeit	Eemian
		6 PICEA-ABIES		spruce-pine forest with fire			OC/CO				
	E-II	5 CARPINUS		deciduous forests	CARPINUS BETULUS				middle		
		4 CORYLUS			BRASENIA PURPUR CYPERUS GLOMERAT DULICHIUM SPATHAC	temperate (VII-20-21°C)	OC				
		3 QUERCUS									
	E-I	2 PINUS-BETULA		birch-pine forests	BETULA PENDULA				early		
		1 BETULA		birch forest with	BETULA "ALBA" B HUM SELAGINELLA SEL	boreal (VII-14-15°C)	CO			Behre, Lade 1986	Jastrzębska-Mamełko 1985

Fig. 76. A stratigraphic-correlation table of the Eemian Interglacial and the Vistulian in the Konin area. A - interglacial pollen succession, B - pollen period, C - pollen zone (R PAZ), D - pollen subzone (Tobolski1991).

The state of palynological research on the Wielkopolska-Kujawy Lowland

Palynological research on the Wielkopolska-Kujawy Lowland has been started since 1926 It was initiated by Prof. Wodziczko from the Institute of General Botany of the Poznań University. The fist results were published in the years 1928, 1929, and 130. The synthesis by Wodziczko (1936) recapitulating the decade of palynological research in Wielkopolska, contained 32 localities with 57 examined cores. Up till now there are at least 150 investigated localities and some of them have two or more cores analysed. Fig. 77 contains so called „early" localities without NAP. The „more recent" are presented in Fig. 78 with one suplement.

Some sites are included among the primary reference sites of the International Geological Correlation Programme - IGCP 158B (Fig. 79). Fourteen regional pollen asseblage zones (R PAZ) were distinguished (Tobolski, Okuniewska-Nowaczyk 1989) for about 2/3 of the area P-r, containing Gniezno Lake District and Kujawy Lowland:

	Late-Glacial	
Pr 1	to 12 800 B.P.	Cyperaceae-Poaceae paz
Pr 2	12 800-12 500 B.P.	Betula-Artemisia paz
Pr 3	12 500-12 300 B.P.	Salix-Hippophaë paz
Pr 4	12 300-11 800 B.P.	Betula-Populus paz
Pr 5	11 800-11 000 B.P.	Pinus-Populus paz
Pr 6	11 000-10 000 B.P.	Pinus-Juniperus
	Holocene	
Pr 7	10 000-9 000 B.P.	Betula paz
Pr 8	9 000-8 200 B.P.	Pinus-Betula paz
Pr 9	8 200-7 650 B.P.	Corylus-Pinus paz
Pr 10	7 650-6 400 B.P.	Alnus paz
Pr 11	6 400-5 250 B.P.	Quercetum mixtum paz
Pr 12	5 250-3 300 B.P.	Quercus paz
Pr 13	3 300-1 500 B.P.	Carpinus paz
Pr 14	1 500- 0 B.P.	NAP paz

The spread of more important trees and shrubs are illustrated in Fig. 80.

Kazimierz TOBOLSKI

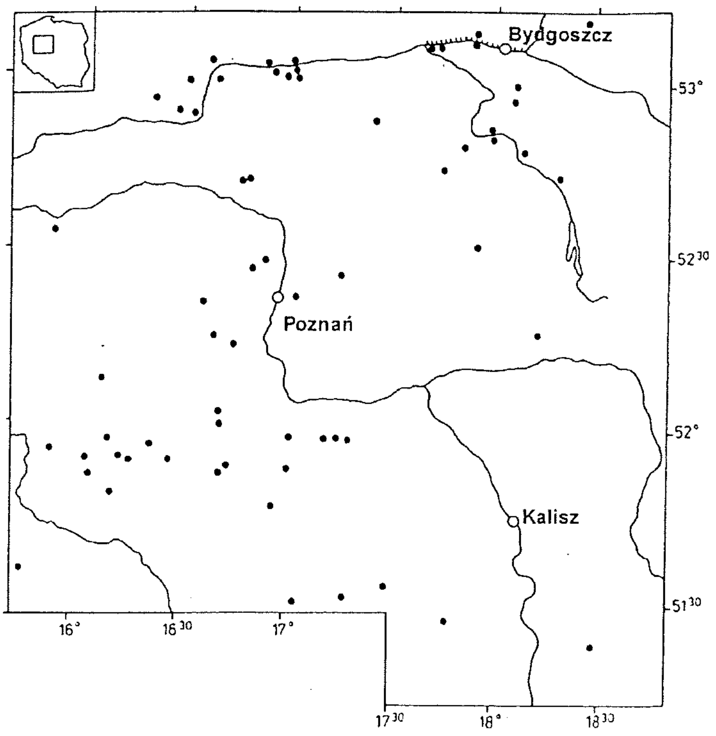


Fig. 77. Early (without NAP) palynological localities (Tobolski 1994).

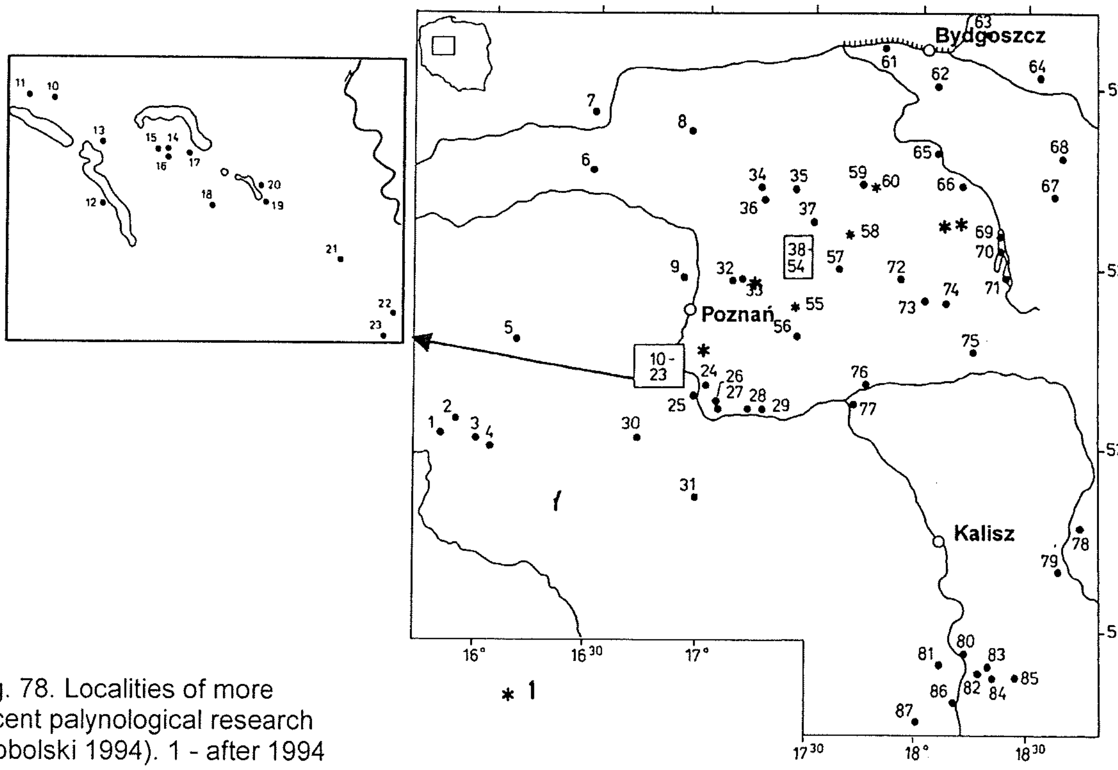


Fig. 78. Localities of more recent palynological research (Tobolski 1994). 1 - after 1994

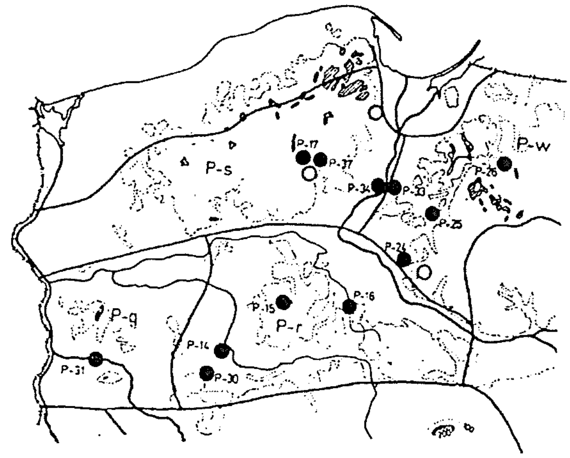


Fig. 79. Type Region P-R and reference sites

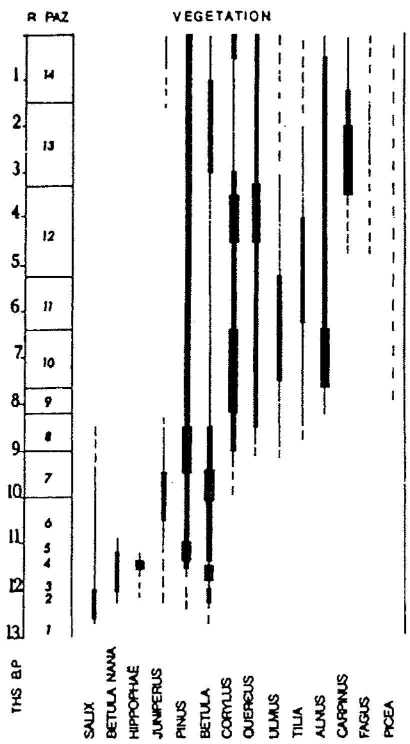


Fig. 80. Type Region P-r R PAZ and spread of trees and some shrubs (Tobolski, Okuniewska-Nowaczyk 1989).

Biskupin fortified settlement and its environment in the light of palynological studies

Biskupin is situated 75 km north-east of Poznań and 50 km south-west of Bydgoszcz, in the so-called Pałuki region, geographically lying between Great Poland and Pomerania (Fig. 81). In 1933 on a peninsula of Lake Biskupin a fortified settlement of the Lusatian Culture from the Early Iron Age (Hallstatt C), about 750-670 BC was discovered (Kostrzewski 1936, Zajączkowski 1995). Numerous traces of settlements from other archaeological epochs were also discovered in the vicinity of Biskupin (among others Rajewski 1961).

Archaeological investigations on the Biskupin peninsula were accompanied by natural studies including palaeobotanical surveys (Jaroń 1936, Tobolski 1964, Niewiarowski, Noryśkiewicz A. 1995 and Noryśkiewicz B. 1993, 1994, 1995).

Biskupin's surroundings are now mostly used as arable land (68.2%). Small patches of forest appear on the least fertile soils, for example on some kames. In total, forests occupy about 0.6% of analysed catchment. Meadows and pastures occur on wetlands, mainly on biogenic plains (10.0%). In a remaining part, there are lakes (16.2%), anthropogenic features (settlements, roads and management area) that constitute about 5.0% of the area (Table 3).

The vegetation of the Biskupin's region has been reconstructed basing on a palynological study of thirteen profiles of biogenic sediment from Lake Biskupin and its vicinity (Fig 82, 83). The palynological evidence of the vegetation of the Biskupin's region spans a period between the late Glacial Epoch (Alleröd) and the present (Fig 84, 85, 86). As early as in the Alleröd period, Lake Biskupin displayed considerable fertility. Boreal pine-birch and pine forests surrounded it (Fig. 84). Due to the cooler climate of the young Dryas, the forests became thinner, and consequently heliophilous growth developed. The landscape was predominantly park – like tundra, with scare specimens of birch and pine, and numerous specimens of juniper, which formed shrubs. During the Holocene, the history of the forests in the region of Biskupin begins a period of the domination of pine, which competed with birch (in the Preboreal period), and early multispecies deciduous forests, principally consisting of hazel, which formed shrubs (in the Boreal period). In the Atlantic there appeared multispecies deciduous forests, consisting of oak, elm, linden and ash; the undergrowth of hazel remained abundant until mid-Subboreal period. The disturbance of the composition of the deciduous forests and the concurrent appearance of charred wood in the sediment result most probably from the activities of Mesolithic man. The unchanged number of pollen grain of herbaceous plants (NAP) proves that the recorded developments in this forests stand did not cause deforestation.

During the Subboreal period the composition of the forests in the region of Biskupin changed due to the spread of hornbeam and the decreasing share of linden, elm and ash. Hornbeam, although devastated by humans, on two occasions regenerated in forests, in both cases returning to a similar percentage, which testifies to good soil conditions and to the vitality of the species. Extensive deforestation took place during the Subatlantic period, which may be inferred from the larger percentage of herbaceous plants in the diagram. The degree of the deforestation of the region of Biskupin probably reached a value close to the present one. Considerable deforestation is particularly noticeable in a profile from the profundal layer of the lake – profile 5 (Fig. 85).

The geographic environment of the region of Biskupin, and in particular the lakes and fertile soil, always provided good living conditions for the ancient communities. Based on the percentage of herbaceous plants and the appearance of synathropic plants in the diagrams, nine stages of intensive human activity may be distinguished (Fig. 84), separated by periods of forests regeneration of a length of between 200 and 500 years. Only minor evidence of agriculture has been discovered in the strata representing the first two stages (late and middle Neolithic period), which proves that crop growing and animal husbandry were not a very significant activity at that time. During stages 3 (late Neolithic period) and 4 (early Bronze Age), animal agriculture was of more importance than farming. Stage 4 of settlement, beside individual grains of crop, provided the highest percentage of ribgrass, which showed that the people of the Ivno culture used extensive areas of pasture. In stage 5 of settlement (the Lusatian culture), we find not only traces of animal grazing, but also a higher percentage of crops. Stage 6 is the period of the inhabitation of Lusatian community in the settlement of the Biskupin peninsula, as evidenced by the deep depressions in the curves of the percentage of deciduous trees and by the simultaneous appearance of grain and forage. Intensive agriculture (with rye being the principal crop) and a decrease in the significance of animal grazing are characteristic of the Roman period. The final two stages (8 and 9) are illustrated by periods of anthropogenic deforestation due to intensive agriculture beginning in the early Middles Ages.

Palaeographic maps (Fig. 87) reflected only a synthesis of selected periods as follows (Niewiarowski & Noryśkiewicz 1998): 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 the 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. Potential forest communities, their range and size within used deforested areas were determined approximately in an area of 2664 ha near Biskupin.

Table 3.
Potential vegetation, hydrography and land use in the Biskupin Region during the selected periods, in percentage of whole (2664 ha) area (after Niewiarowski & Noryśkiewicz 1999).

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

The evaluation of the range of forest communities and land use in these periods is shown in Table 3. The mean values of selected taxa that are typical of particular forest communities were calculated. The calculation included the NAP total (Fig. 88) that best characterises the deforested areas in selected periods, based on profile 4 (Fig. 84) from the bay of the lake (water 4 m deep) and profile 5 (Fig. 85) from the central deepwater part (10.9 m).

The best knowns are the variations in the water level of Lake Biskupin, illustrated in fig. 89 (Niewiarowski 1995). At the time of building the settlement in Biskupin (app. 747-722 BC; Zajączkowski 1995), the water level of the lake was 1.3 m lower than the present level, but soon, app. 2500 years BP, it was higher than it is now by 0.7 m.The maximum water level of the lake, 2.0-2.5 m higher than the present level, dates to app. 2100-1900 years BP.

Bożena Noryśkiewicz

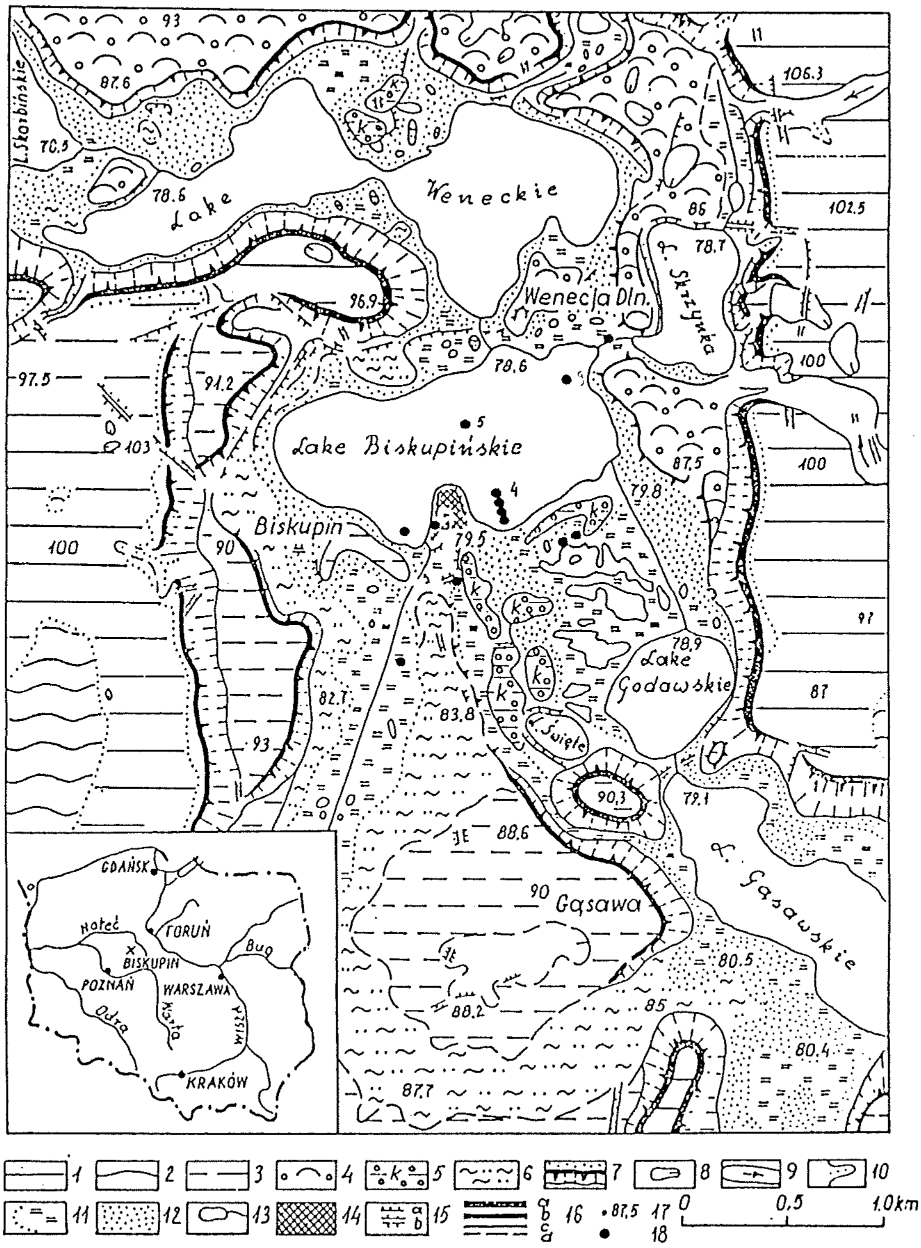


Fig 81 Biskupin Lake and its surroundings: 1 – flat moraine plateau, 2 – undulating moraine plateau, 3 – plains and morainic undulations in the bottom of subglacial channel, 4 – morainic undulations with sandy and gravelly fluvioglacial cover, 5 – kame hillocks, hills and ridges, 6 – plains built of ice dammed lake sediments, 7 – slopes and degradation zone, 8 – kettles, 9 – meltwater valleys, 10 – periglacial denudation valleys, 11 – biogenic plains, mainly peat plains, 12 – minerogenic lake terrace deposits, 13 – lakes, ponds, and streams, 14 – EarlyIron Age fortified settlement at Biskupin, 15 – anthropogenic forms (ditches, embankments etc.), 16 - height of escarpments: 10-20m, b – 5-10m, c – up to 5m, d – undistinct, 17 – altitude points, 18 – location of palynological profiles

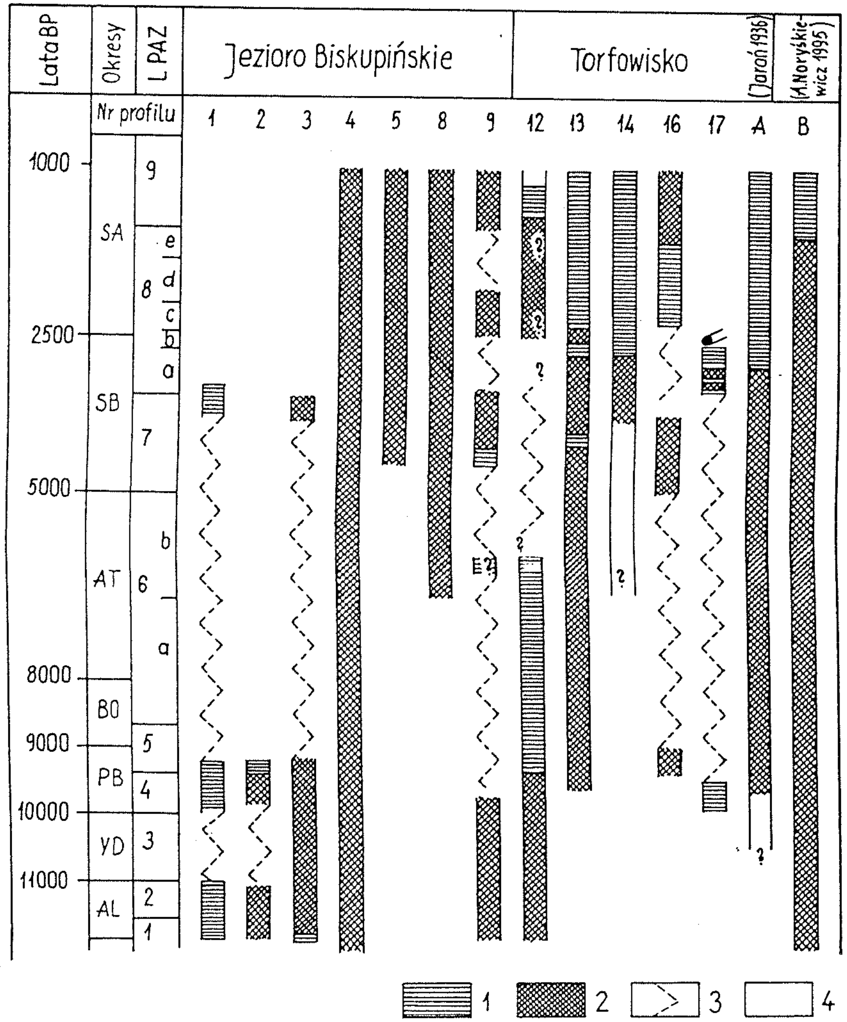


Fig 83 Profiles correlation on time scale. 1 – peat, 2 – lake sediments, 3 – hiatus, 4 – sediments were not tested

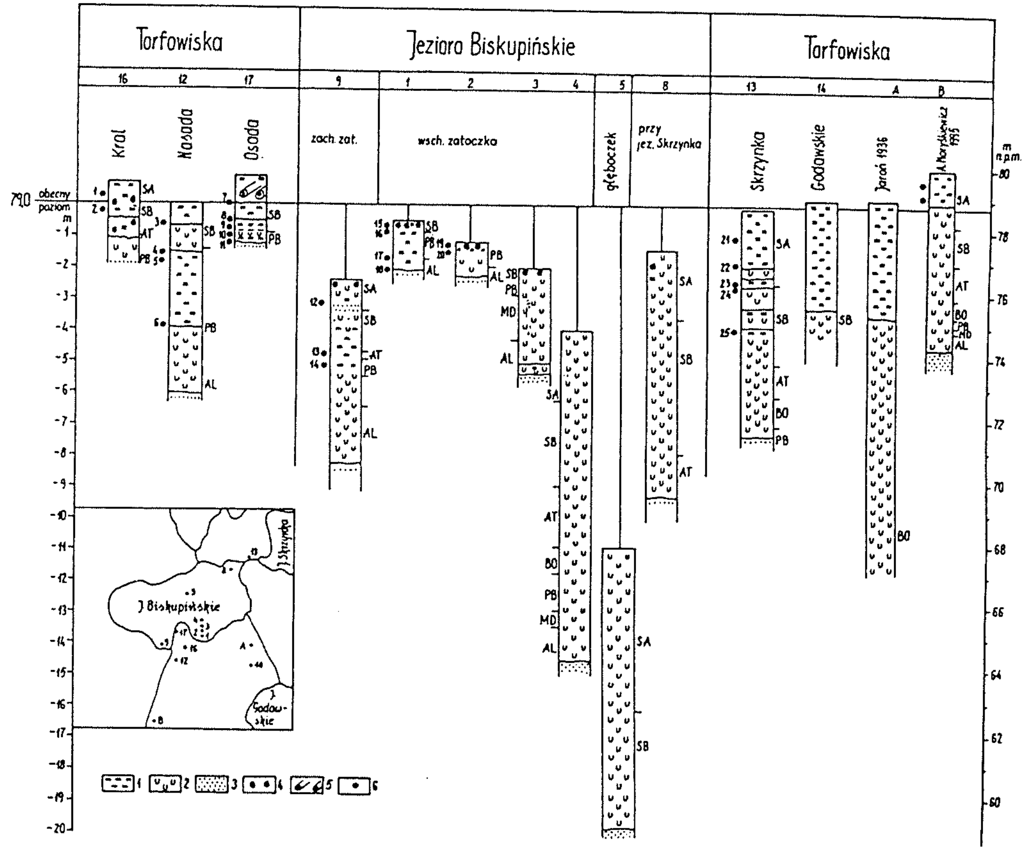


Fig 82 Location of investigated profiles from Biskupin Lake and its surroundings, 1 – peat, 2 – calcareous sediments (gyttja, marl, chalk), 3 – sands, 4 – mollusc shells, 5 – fossil wood constructions, 6 – location of samples taken for C^{14} datings. 78.8m a.s. l, - present level

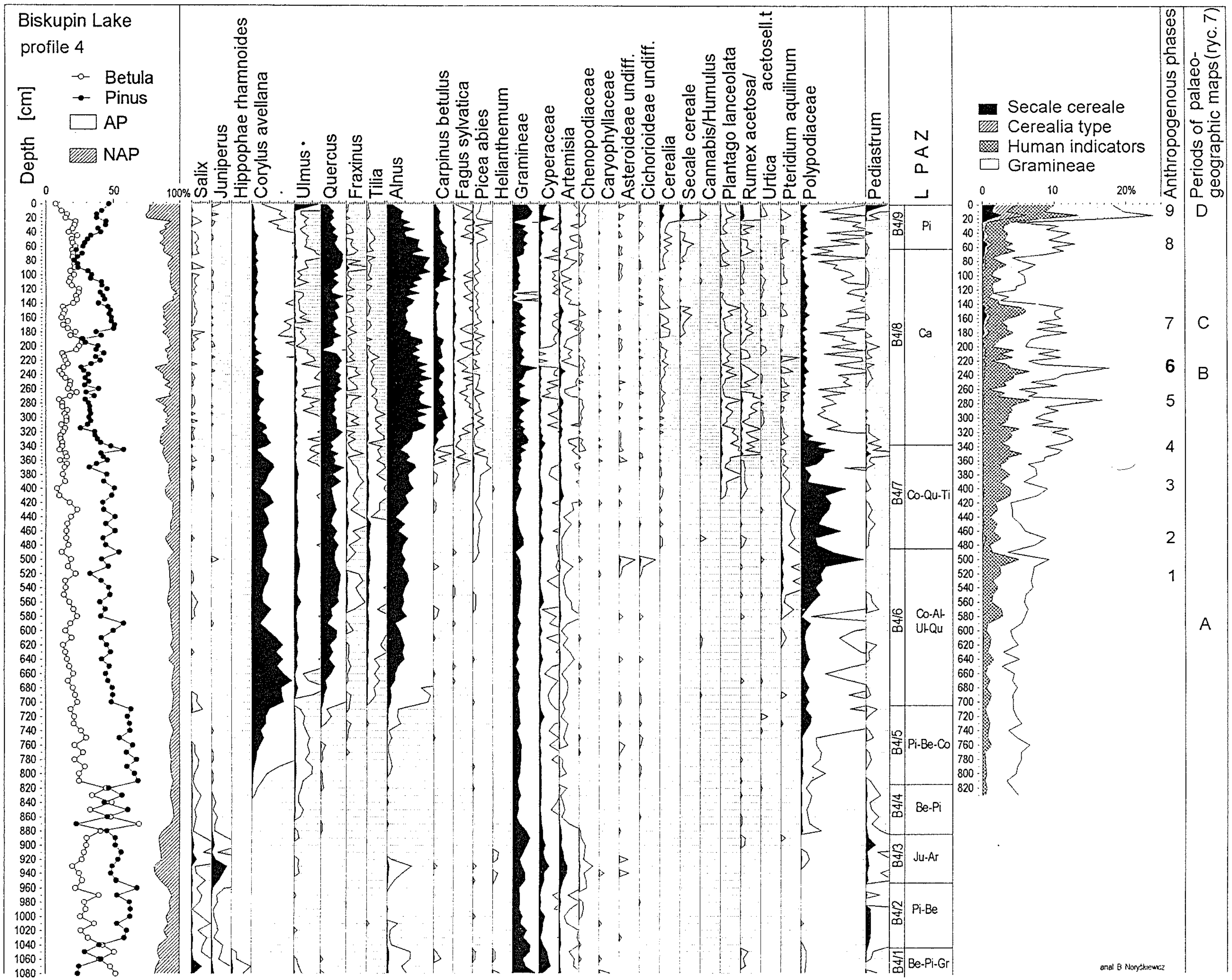


Fig 84 Biskupin Lake. Pollen diagram (profile 4) with selected pollen types and synthetic diagram of human activity (phase 6 is the period of the existence of a fortified settlement at Biskupin)

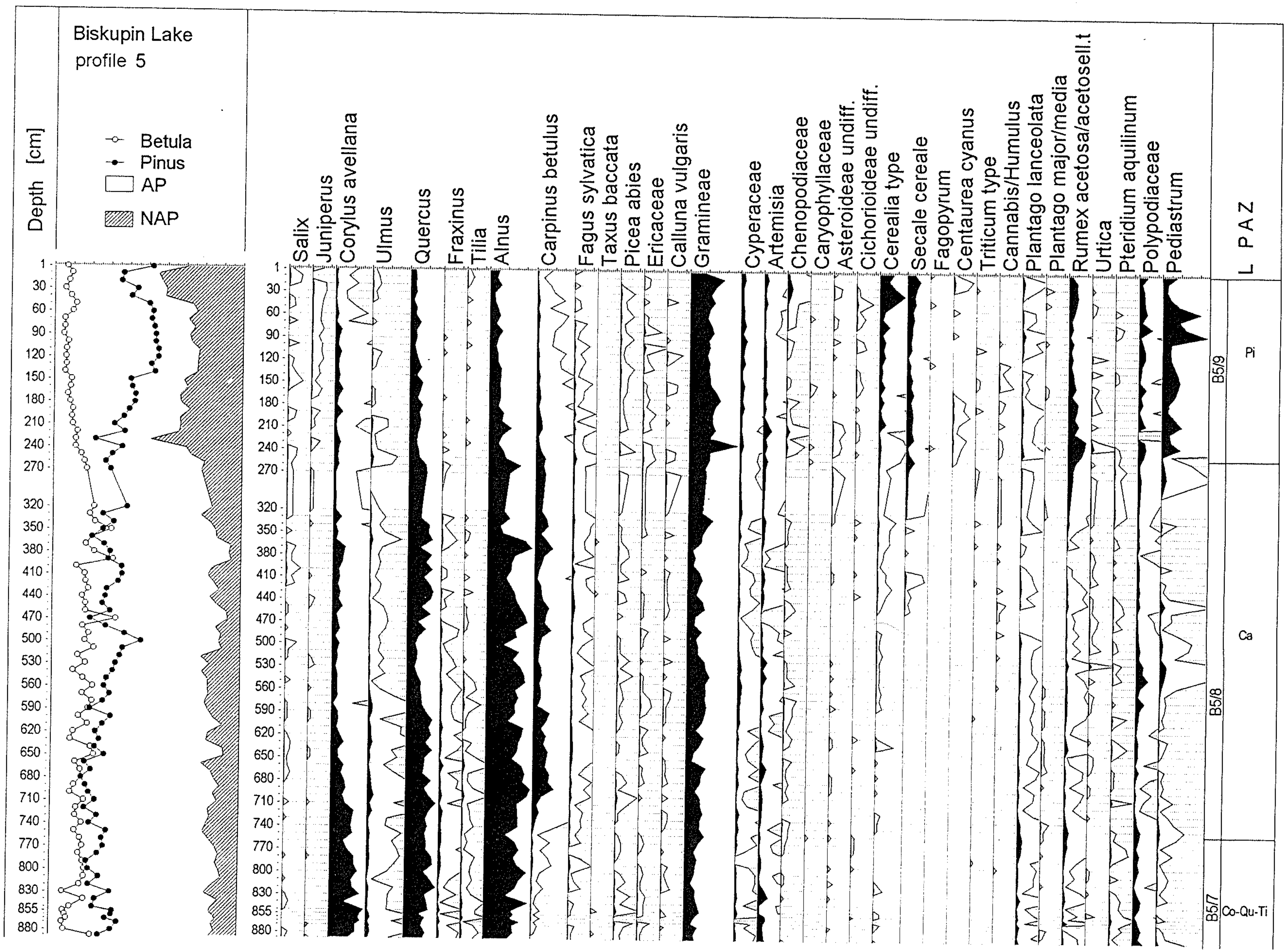


Fig85 Biskupin Lake. Pollen diagram (profile 5) with selected pollen types

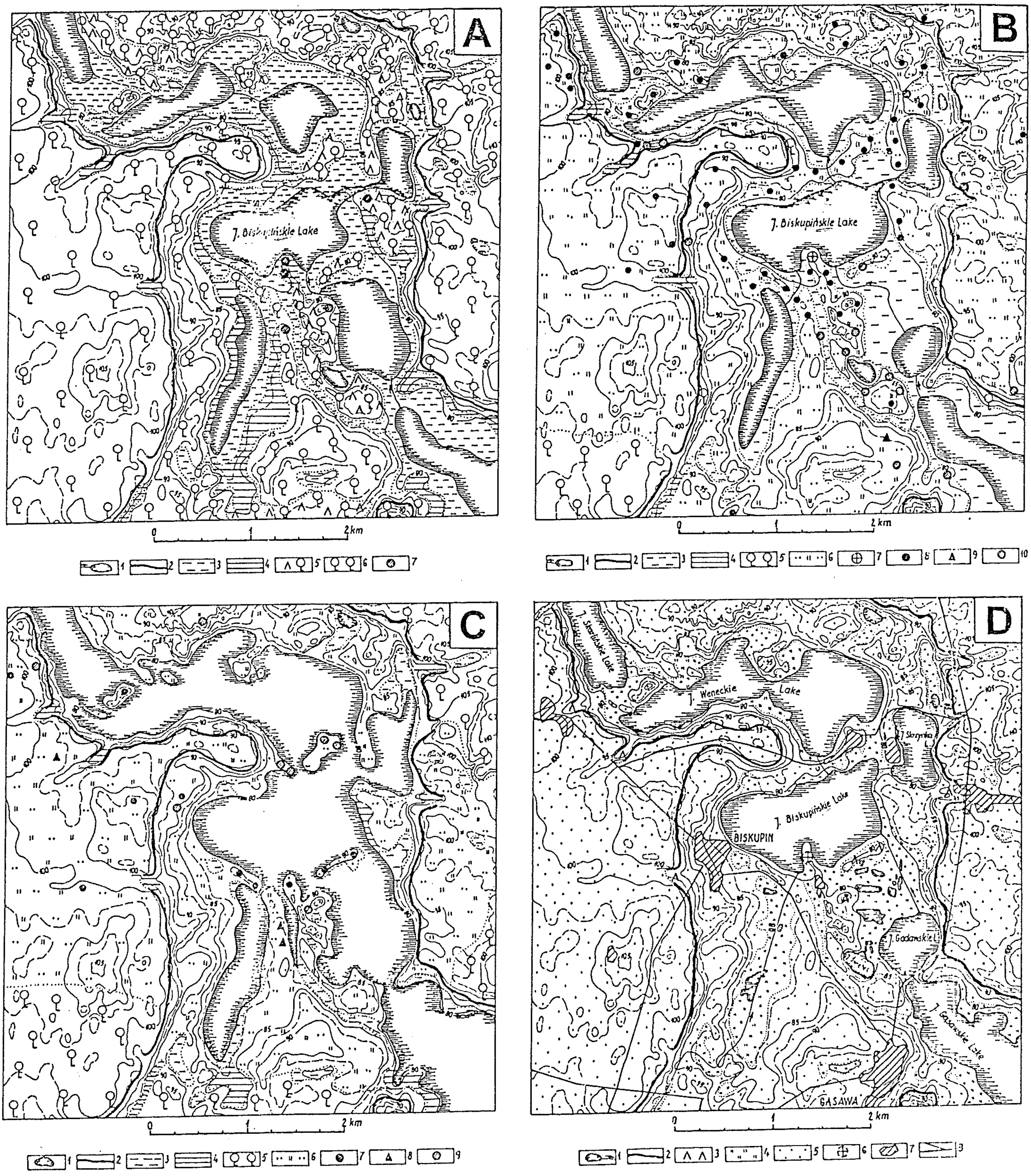


Fig 87 Potentialvegetation, hydrographyand land use inthe Biskupin region.
A – about 6.0 ka BP: 1 – lakes and streams, 2 – edge of the Żnin subglacial channel, 3 – alder forests and mire vegetation, 4 – alder-ash forests, 5 – oak-pine forests, 6 – oak-lime forests, 7 – Mesolithic sites, after Piotrowska (1995).
B – about 3.0 – 2.5 ka BP: 1 – lakes and streams, 2 – edge of the Żnin subglacial channel, 3 – alder forests and mire vegetation, 4 – alder-ash forests, 5 – oak-hornbeam forests, 6 – mostly deforested areas used as arable land, pastures and wood - pastures, 7 – Biskupin fortified settlement, 8 – settlements, 9 – cemeteries, 10 – settlement traces. Lusatian Culture settlements of 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 forests and mire vegetation, 4 – alder-ash forests, 5 – oak-hornbeam forests, 6 – mostly deforested areas used as arable land and pastures, 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 influences 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 – forests, 4 – meadows and pastures, 5 – arable land, 6 – fortified settlement of the Lusatian Culture, 6 – villages and farmsteds, 8 – main roads.

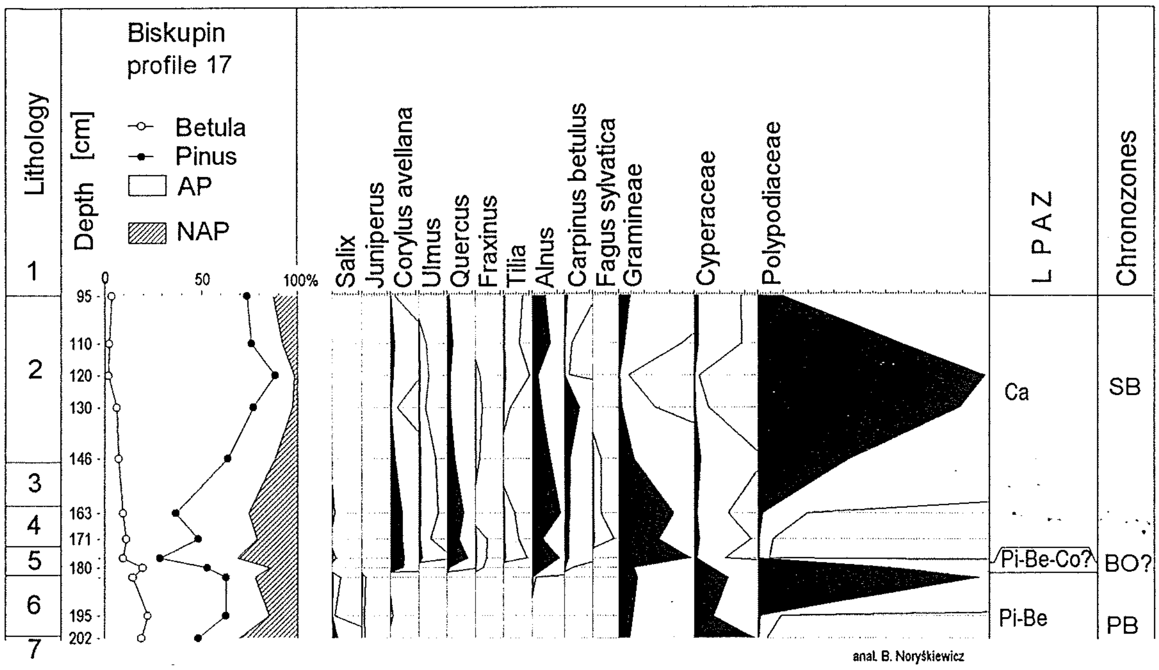


Fig 86 Biskupin Lake. Pollen diagram (profile 17) with selected pollen types. 1 - anthropogenic deposit with fossil wood constructions, 2 - peat, 3 - mollusc shells, 4 - peat, 5 - gyttja,6 - peat, 7 - silt with sand

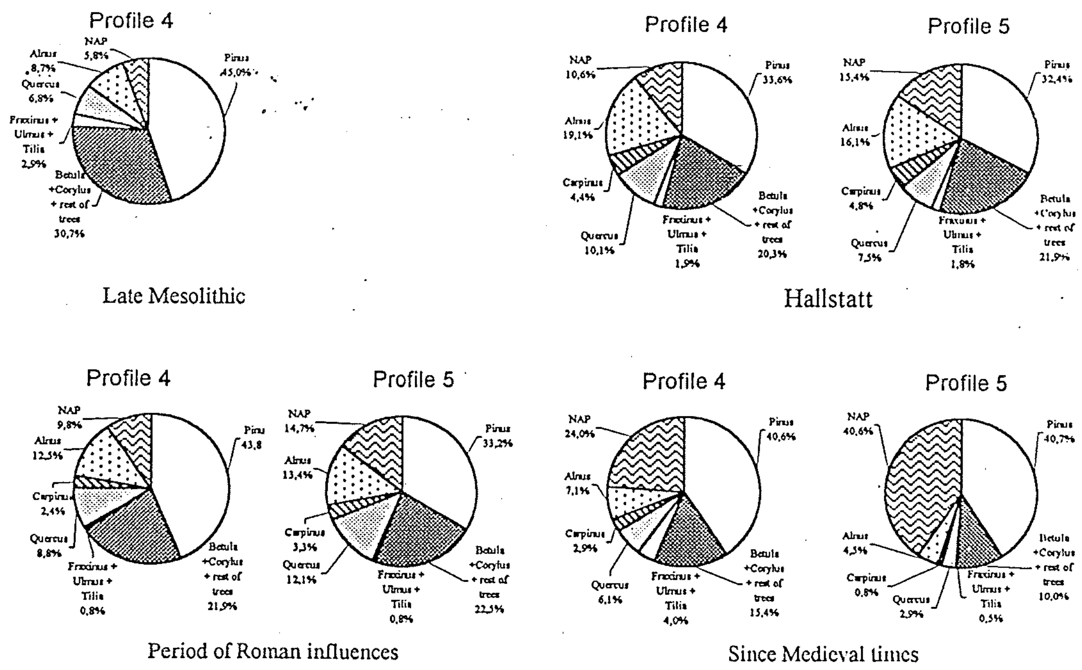


Fig88 Mean percentage values of selected pollen taxa

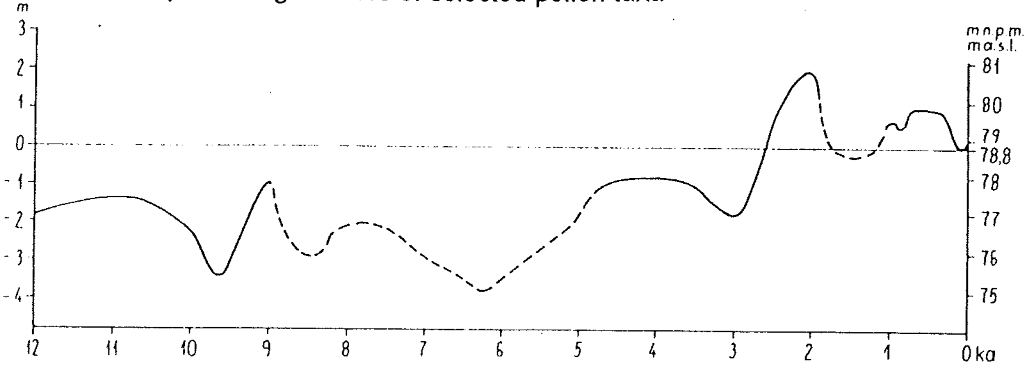


Fig 89 Established (continuous line) and presumable (broken line) lake level fluctuations of the Biskupin Lake during last 12 thousand years (78.8m a.s. l. - present level), after Niewiarowski (1995)

Głęboczek Lake - late Holocene history of vegetation in a forested area

In result of settlement processes continued since the medieval times, the region of Central Great Poland has been dominated by cultural landscape. Areas of morainic upland covered with grey-brown podzolic soils are largely deforested and exploited for agricultural purposes. Remnants of forests, with *Pinus sylvestris* as main arboreal component, are distributed mostly on poorer podzolic and brown podzolic soils developed on sands and gravel of outwash plains. Palynological data indicate that also presently forested areas situated beyond zones of more intensive habitation underwent during the late Holocene changes due to human impact.

Pollen analyses of 10.8m long sediment core from Gleboczek Lake revealed 4500 years history of forests preserved in an outwash plain located between Biskupin and Gniezno. Three main stages in the vegetation development have been delimited in the analysed pollen sequence:

- prior to around 4100 uncal. BP, dominance of pine and oak forests with significant representation of deciduous components as birch and hazel
- since 4100 uncal. BP, development of hornbeam forests
- since 14th century A.D., changes towards present-day pine dominated phytocoenosis

Prior to the spread of *Carpinus*, forest cover in the area formed pine and oak with remarkable admixture of birch and hazel. Ash, elm, lime and maple have been represented in smaller amounts, distributed locally in Fraxino-Ulmetum associations on damp soils. Part of the recorded pollen grains of deciduous components may have also represent further stands located beyond direct vicinity of the lake.

Hornbeam expansion in the region was dated to around 4100 uncal. BP. The composition of pollen spectra from Gleboczek Lake suggests that *Carpinus betulus* expended predominantly in niche occupied previously by *Corylus avellana*. Evidence of weak human activity correlated with the late Neolithic, reflected in the pollen diagram by presence of *Plantago lanceolata* and *Rumex acetosa/acetosella* type, has been recorded during the period of *Carpinus* spread. However, the fact of former regular appearance and gradual increase in amount of *Carpinus* pollen grains do not indicate that the human groups of late Neolithic had a decisive influence on the hornbeam expansion.

History of *Carpinus* showed several phases of forest destruction coincided with increase of palynological indicators of human impact. First phase of the forest clearings was recorded during Bronze Age. Extensive forest clearings occurred during early Iron Age and could be correlated with the activity of late groups of Lusatian Cycle. Pollen spectra of that phase showed decrease of most deciduous trees as hornbeam, oak, elm, lime and ash. Further clearings occurred due to activity of groups associated with Przeworsk Culture and dated broadly to the Roman-influence Period. Pollen spectra from that time documented first evidence of rye cultivation. During the settlement phase representation of hornbeam and elm decreased to minimum while oak maintaned high values. Similar pattern of environmental change during the settlement phase of Przeworsk Culture has been observed in the pollen records from other Central Great Poland sites as Swietokrzyskie and Lednica Lake. The phenomenon seems to be connected with differences in economical and settlement model between Lusatian Culture and Przeworsk Culture.

After the phase of the Przeworsk settlement, forest cover fully regenerated. Pollen data indicate break in settlement activity. Hornbeam reached in that time maximum representation 27% of AP and NAP sum, while *Quercus* 17% and *Pinus* 18%. The stage of forest regeneration has been correlated with the Migration Period. The following phase of forest clearings and spread of open communities was associated with the activity of settlers of the Early Medieval Period identified with Slavic population. First evidence of Early Medieval settlement inferred from pollen data has been estimated to around 8^{th} century A.D. Initial deforestation during that period concerned hornbeam and partly oak stands.

Present-day pine dominated phytocoenosis were formed around 14^{th} century A.D. Increase in pine representation (to 50% in pollen spectra) corresponded with intensified settlement activity reflected by increase of cultivated plants and weeds (*Secale cereale*, *Triticum* type, *Cannabis* type, *Centaurea cyanus, Rumex acetosa/acetosella* type). New open habitats appeared due to cutting out stands of deciduous trees with *Carpinus*, *Quercus*, *Ulmus, Tilia, Fraxinus* and *Betula*. Birch might have been partly eliminated from the mixed stands in pinewoods. Diversity of forest habitats in result of human activity significantly decreased. Changes within pine forests resulted in spread of light demanding and resistant to grazing *Juniperus communis*. The only deciduous trees, which partly regenerated were oaks.

Late Holocene history of human activity recorded in the pollen data from sediments of Gleboczek Lake suggests that the area remained in close cultural connections with the region of Gniezno and Lednica.

Mirosław Makohonienko

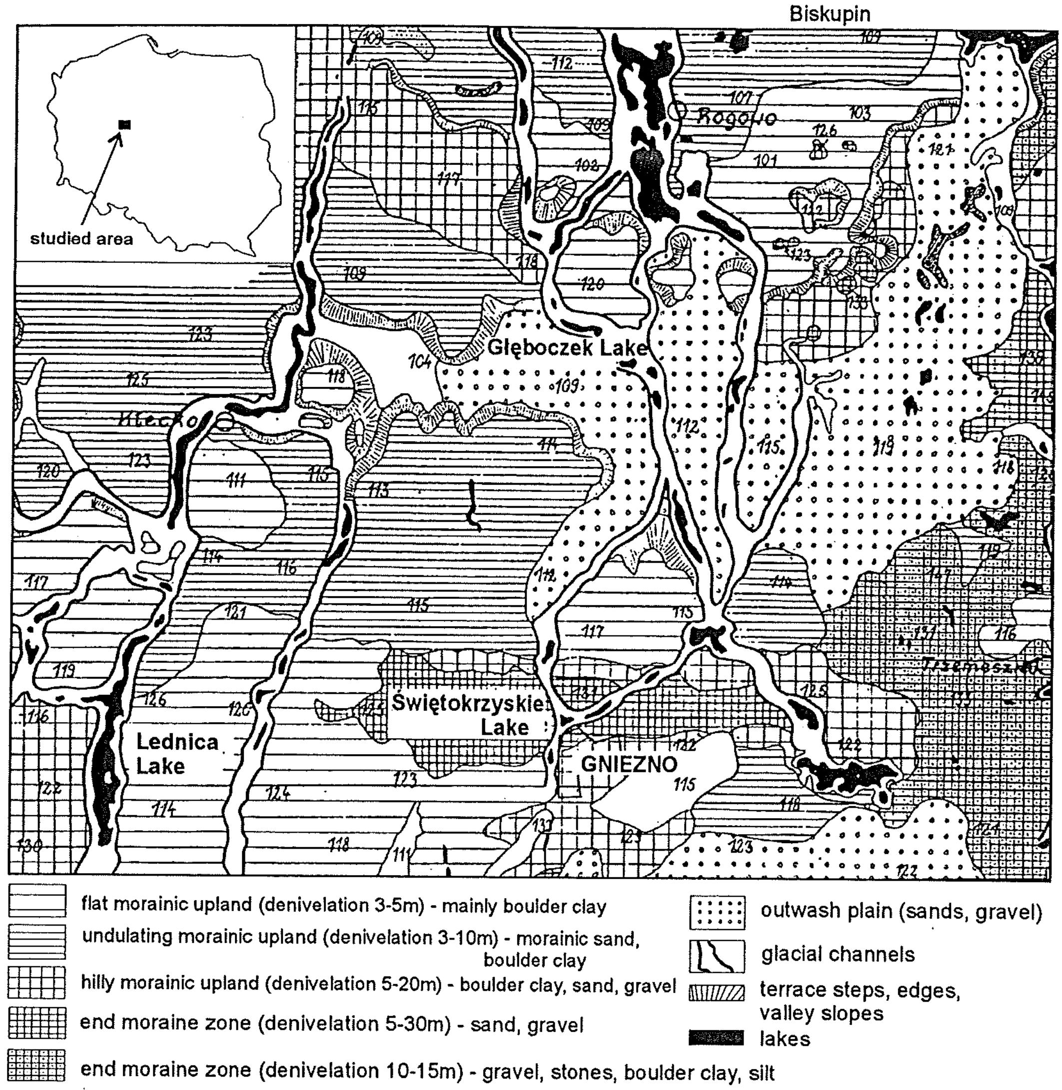


Fig. 91 Geomorphological map of Great Poland Plain in the surroundings of Gniezno. Unpublished, B.Krygowski (1953, updated1961)

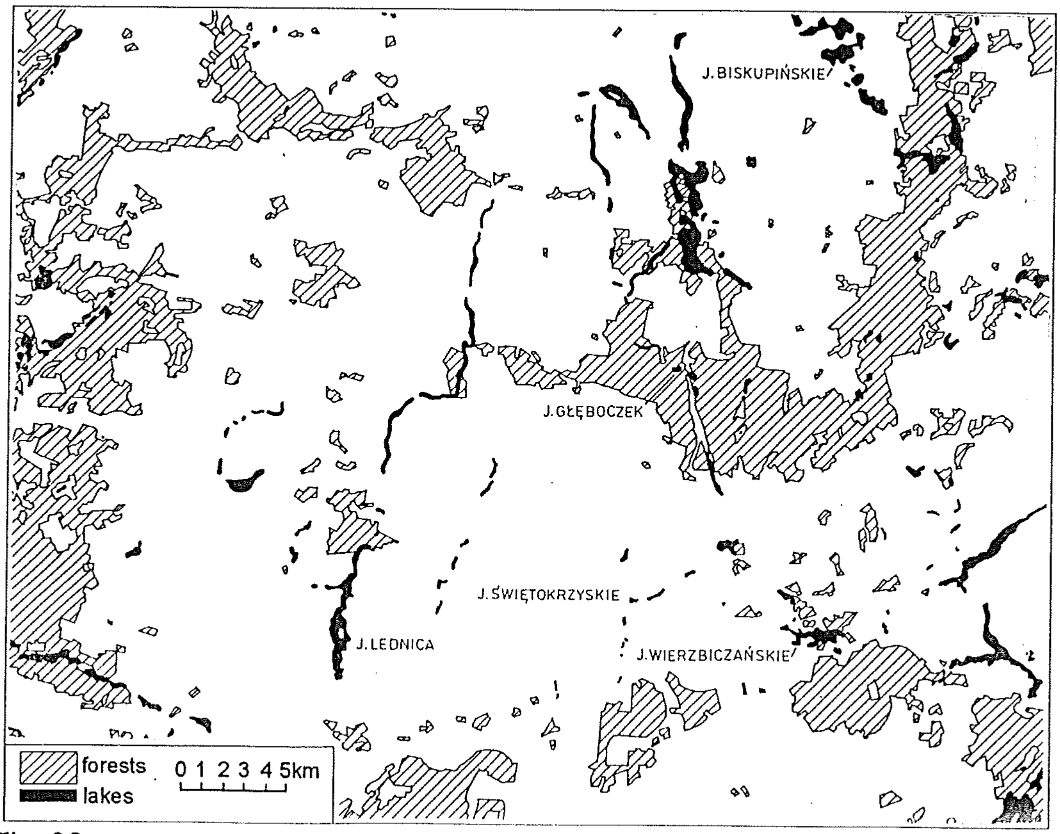


Fig. 92 Present distribution of forests in the Gniezno region.

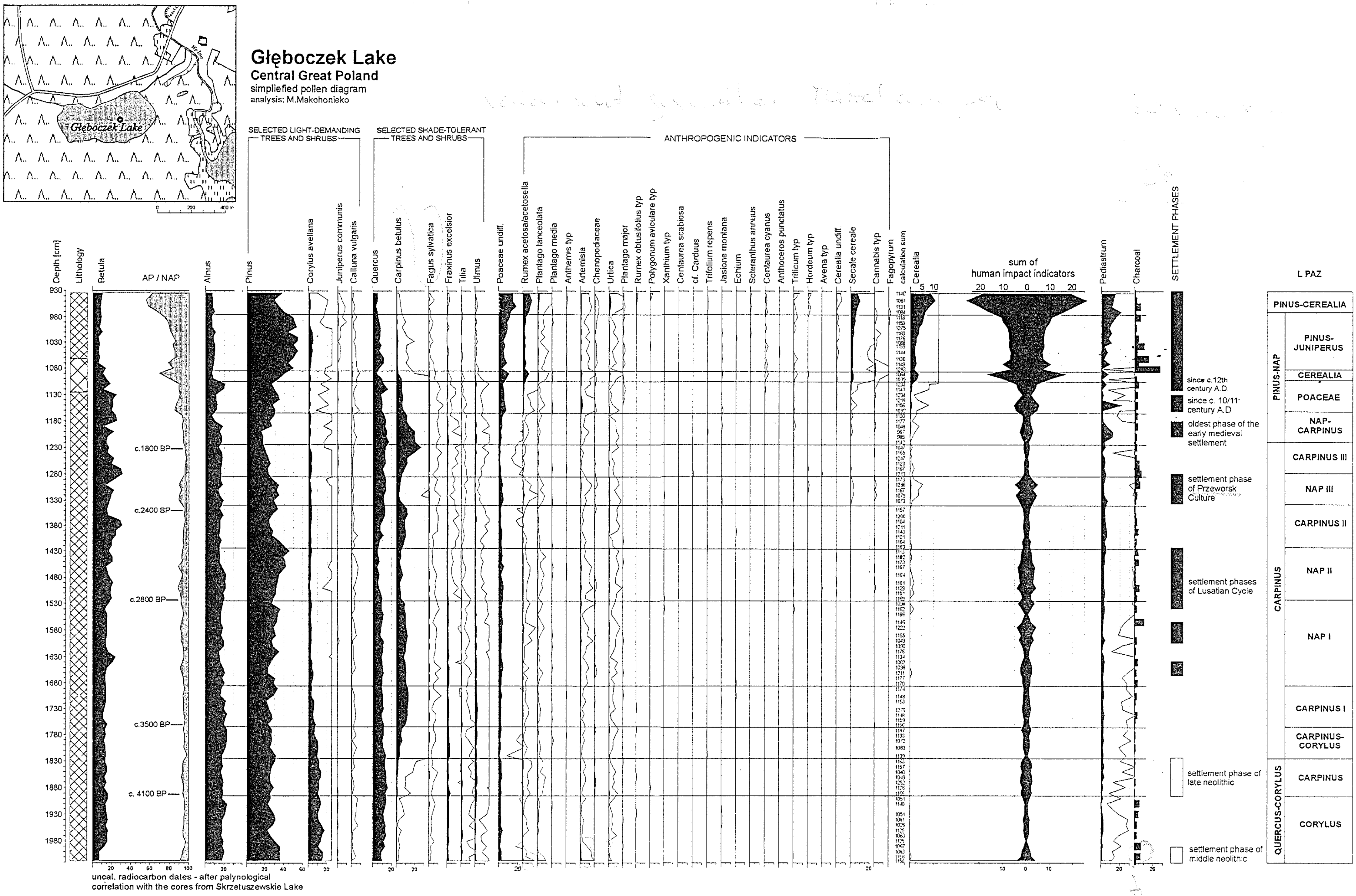


Fig. 94 Głęboczek Lake, core Gl 1/91. Simplified percentage pollen diagram, calculations based on AP+NAP=100% excluding telmatophytes and limnophytes.

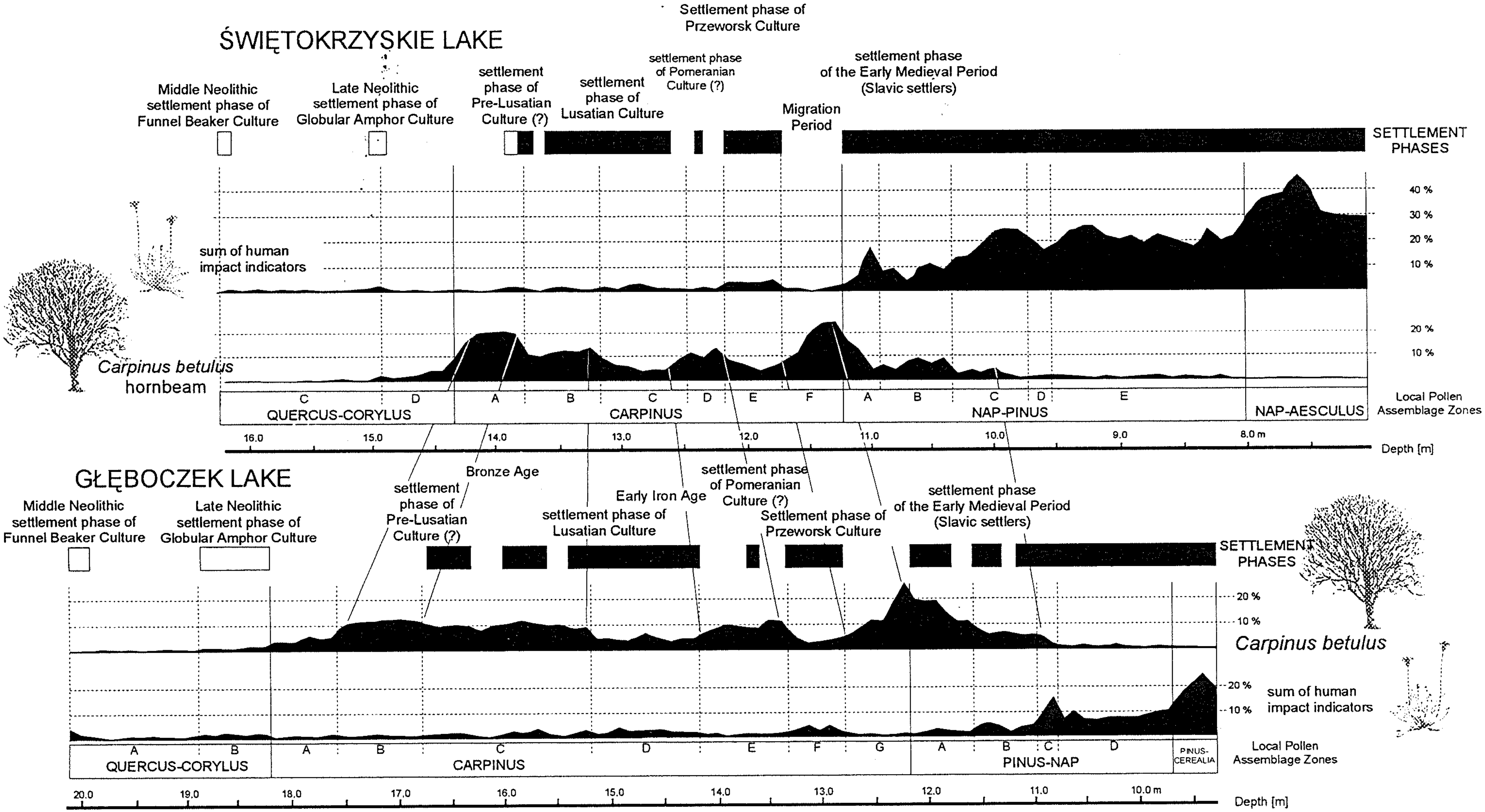


Fig. 94. Settlement phases distinguished in the pollen profiles from Swietokrzyskie (Sw 3/91) and Gleboczek (Gl 1/91) lakes and the history of hornbeam (*Carpinus betulus*) (Makohonienko 2001)

Pediastrum (Chlorophyta) in the lacustrine sediments of Central Wielkopolska

Pediastrum belongs to the best preserved and most often noted non-pollen microfossils identified during palynological procedures. It can be recognised in fossil material on species or variety level. Quantitative and qualitative variations in *Pediastrum* assemblages may reflect changes of trophic status or water-level fluctuations. Fossil records of this alga from sites of Central Wielkopolska showed correlation with phases of intensified human activity determined on the base of palynological indicators. Correlation of higher amounts of *Pediastrum* and human impact indicators in pollen diagrams suggests increased supply of nutrients to the water in result of settlement activity taking place in the catchment area of a lake. In the cores from Skrzetuszewskie Lake, the first phase of anthropogenic influence on terrestrial and lacustrine ecosystems was connected already with the settlement activity of Lusatian Culture of Early Iron Age. The next phase was correlated with the activity of Przeworsk Culture of the Roman influence period and the third one with the phase of the settlement of medieval period and modern times. The subsequent anthropogenic phases were followed by phases of settlement regression reflected in decrease of *Pediastrum* representation.

Relationships between representation of *Pediastrum* and prehistoric settlement have been observed in the case of smaller water basins as Skrzetuszewskie Lake (3.8 ha), Swietokrzyskie Lake (14.4 ha), Giecz or Baranowko but also in fossil records from such big lakes as Lednica Lake (325 ha) where visible changes in phytoplankton have been recorded since the times of Przeworsk Culture. In recent centuries, also sites located beyond more intensive habitation zones (Gleboczek Lake) showed increase of the alga, mainly represented by one species *Pediastrum boryanum*.

Mirosław Makohonienko

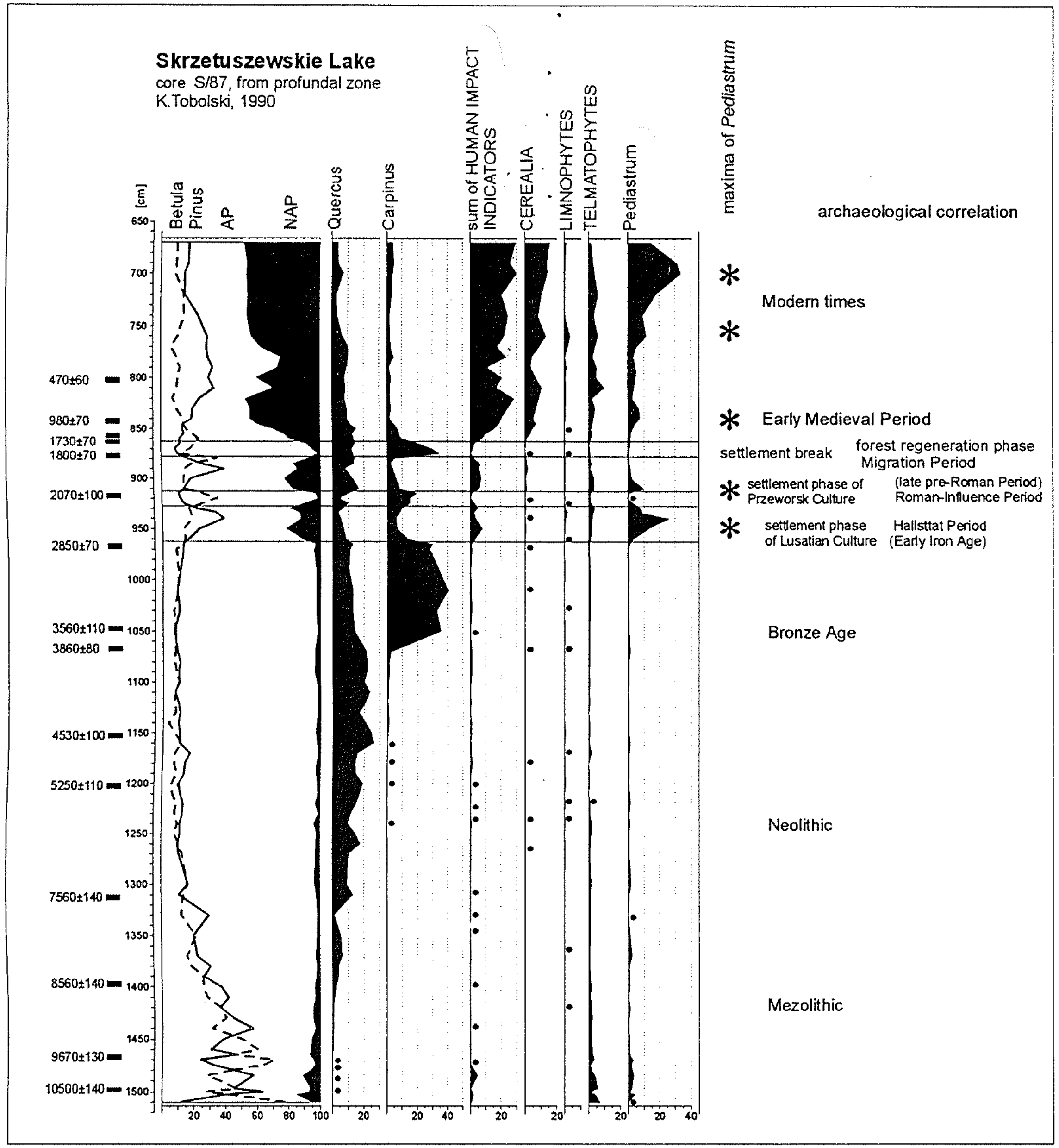


Fig. 95 Skrzetuszewskie Lake - Percentage content of the selected pollen taxa and Pediastrum in the sediment core S/87 (from profundal zone of the lake), K.Tobolski (1990).

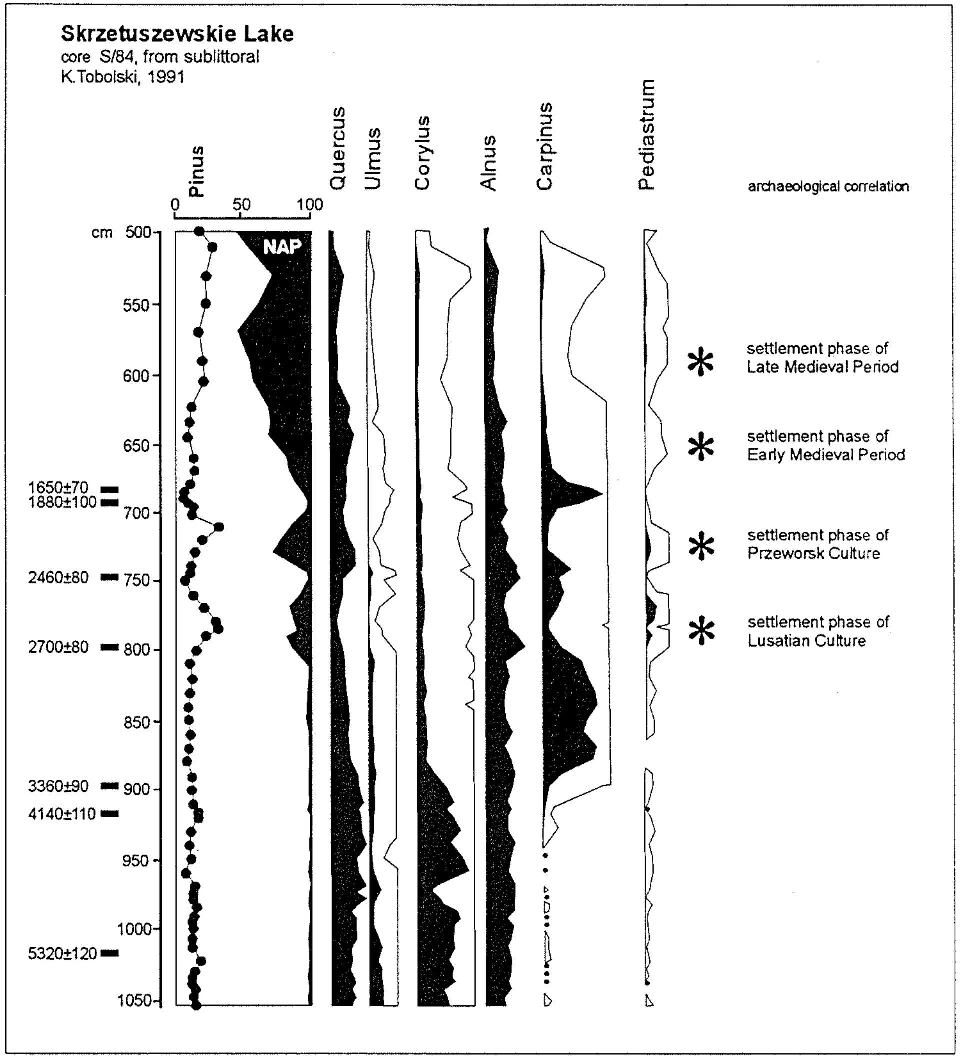


Fig. 96 Skrzetuszewskie Lake - selected pollen taxa and *Pediastrum* in the sediment core S/87 (from sublittoral zone of the lake), K.Tobolski (1991).

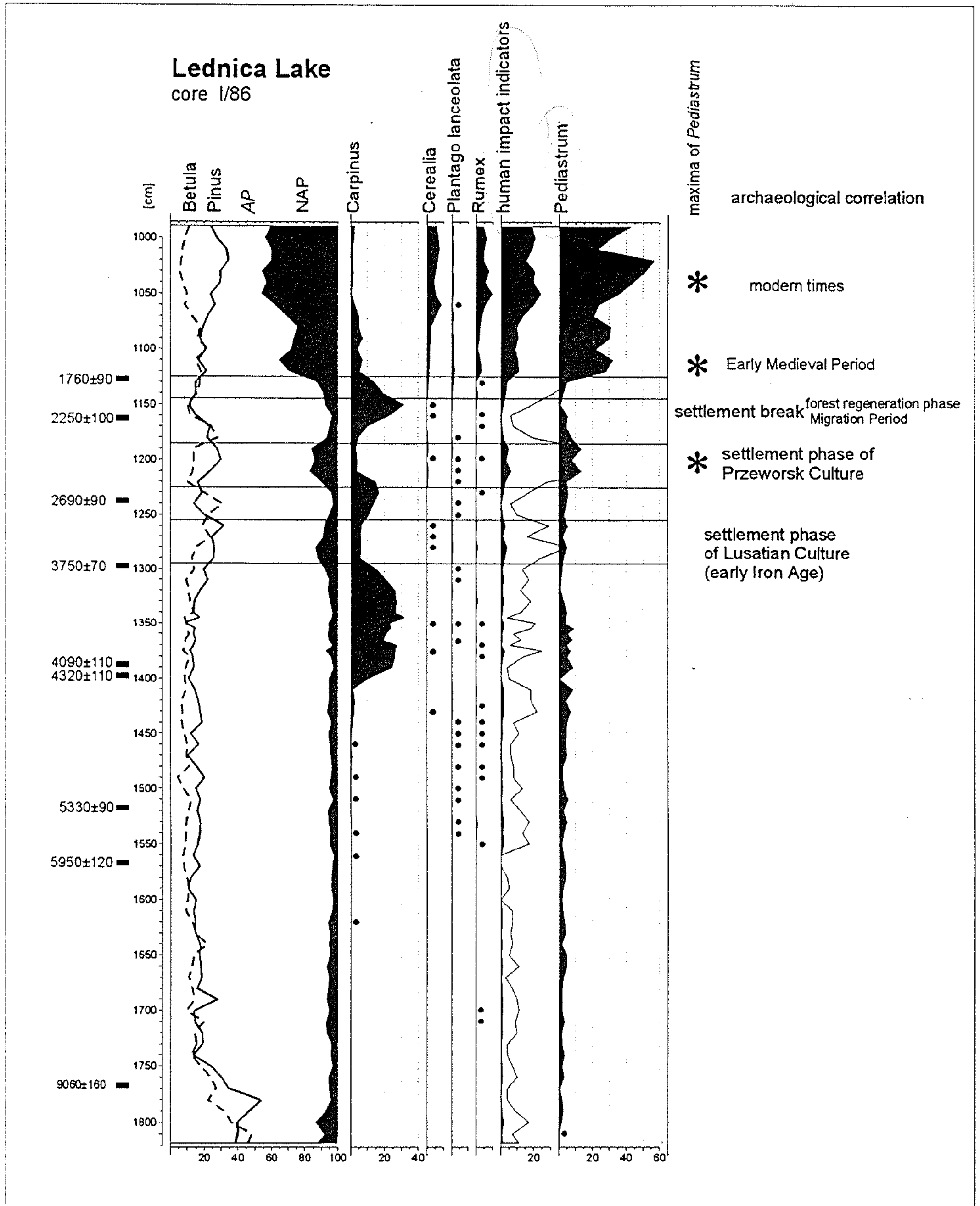


Fig. 97. Lednica Lake - percentage representation of the selected pollen taxa and Pediastrum in the sediment core I/86, M.Makohonienko (1991).

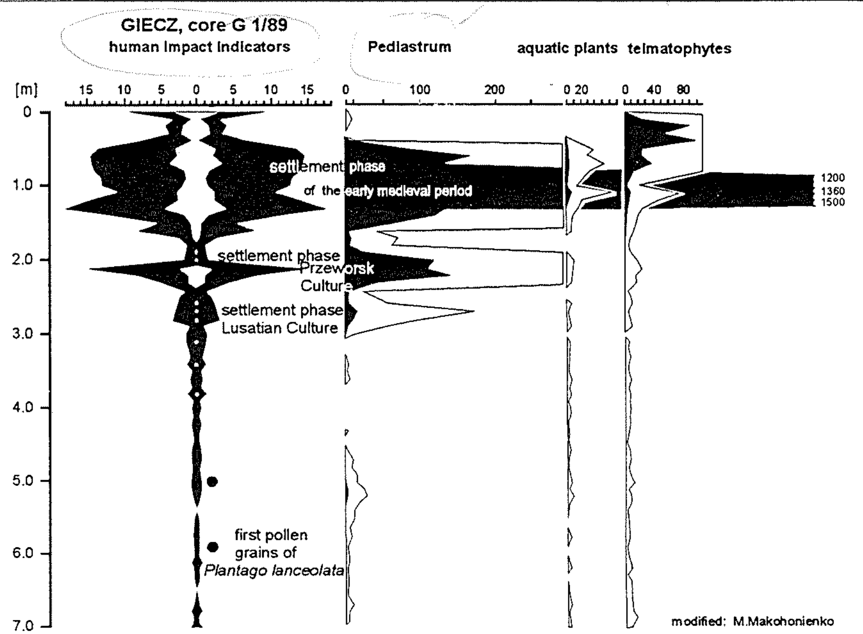


Fig. 98A. Giecz - profile G1/89, Percentage content of human impact indicators and Pediastrum, K.Milecka (1991).

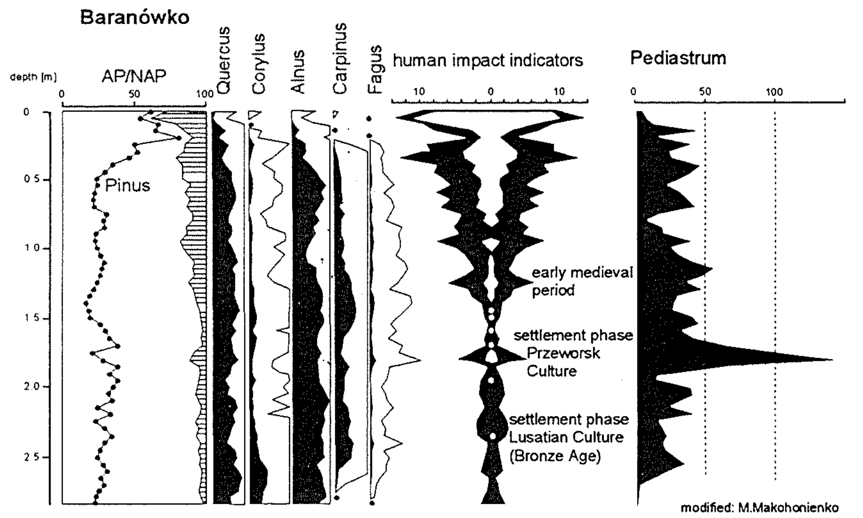


Fig. 98B. Baranówko - core Bar/81, selected pollen taxa and Pediastrum, A.Stach (1987)

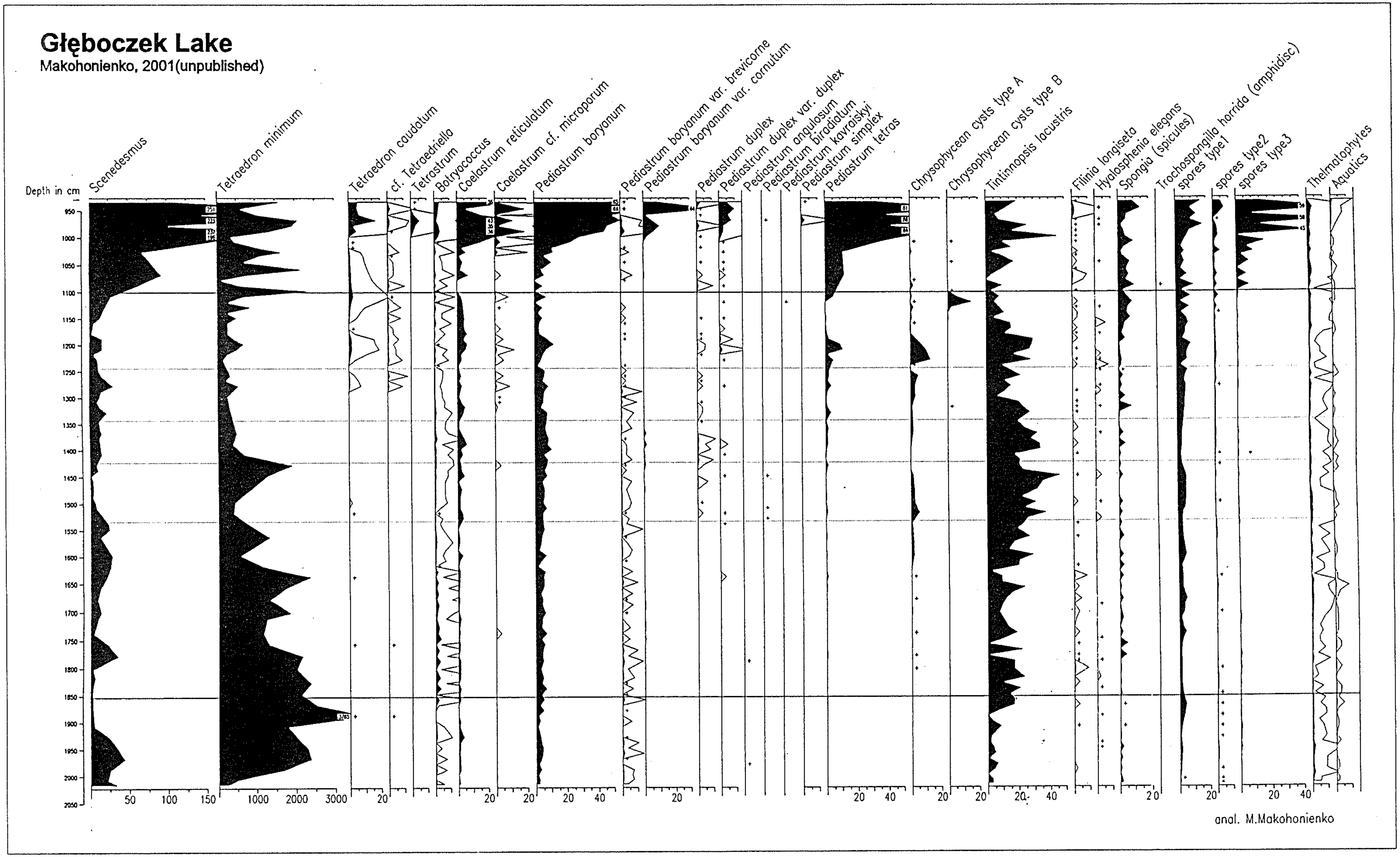


Fig. 99 Percentage diagram of non-pollen microfossils from the sediments of Głęboczek Lake (calculations acc. to pollen sum AP+NAP=100%).

The Lednica Landscape Park

The Lednica Landscape Park (5200 ha) is dominated by cultivated land and lake (Fig. 100). Lake Lednica itself, located centrally and stretching for 7 km, forms the longitudinal axis of the Park. The northern part of the area is occupied by forests, those surrounding Lake Kamionek being interesting floristically, as they contain fragments of oak and hornbeam forests and also alder.

The region of Lake Lednica is particularly interesting as a site for palaeoecological and palaeolimnic investigations (Fig. 101), the status of which is denoted by the abundance of archaeological artefacts found both in the land surrounding the lake and in the lake sediments.

Lake Lednica

Lake Lednica (Fig. 102) is a eutrophic lake filled by carbonate bottom sediments of varying thickness and petrographic composition. Thick layers of some 14 m have formed in places, whereas elsewhere, mainly at greater depths, layers of only 0.5 m have been recorded. The thickest layers, usually occurring in the deepest places, do not contain the oldest sediments, however, for the oldest material of all has been found at the northern extremity of the lake and in the area now elevated above the water level near the village of Imiołki. The bottommost sediments, at depths of 12 m beneath 10 m of gyttja, are about 3000 years younger than the sediments in the northern part of the lake and around Imiołki.

A sediment core taken from the bay in the vicinity of the island Ostrów Lednicki revealed Holocene history of forest development and human induced deforestations in the Lednica area. Palynological results were consistent with the profile V/86 (Litt and Tobolski, 1991) from Lednica Lake and profiles from Skrzetuszewskie Lake (Tobolski 1990, 1991). The core Wal/87, drilled from the northern part of the Lake, at the water depth 665 cm, showed sedimentary hiatus dated since around 3000 BP until recent times (Fig. 103-107).

The main features of the Holocene history of the forests surrounding lakes Lednica and Skrzetuszewskie may be illustrated by means of the simplified pollen diagrams in Fig. (108). The most conspicuous trait is that the forests were completely dominated by deciduous trees, which is particularly striking by comparison with the surroundings of Lake Gopło (Fig. 109). The boreal forests occurring in the vicinity of this lake (and even farther away) evidently gave way to mixed forests consisting of oak, elm, lime and ash with a rich underbrush of hazel. The deciduous character of the forests is further emphasized by peculiar hornbeam stands which existed in the area from 3500 B.P. to around 1600 B.P., as indicated by the highest percentage of pollen grains of *Carpinus betulus* of anywhere in the region, reaching a maximum of 59% (in Lake Kamionek).

Human activity subsequently led to various stages of deforestation, which were then followed by forest regeneration (Fig. 110). The current deforestation stage commenced around 1700 years ago, and a process similar to that taking place at present has been going on now for at least 1500 years.

Kazimierz Tobolski, Mirosław Makohonienko

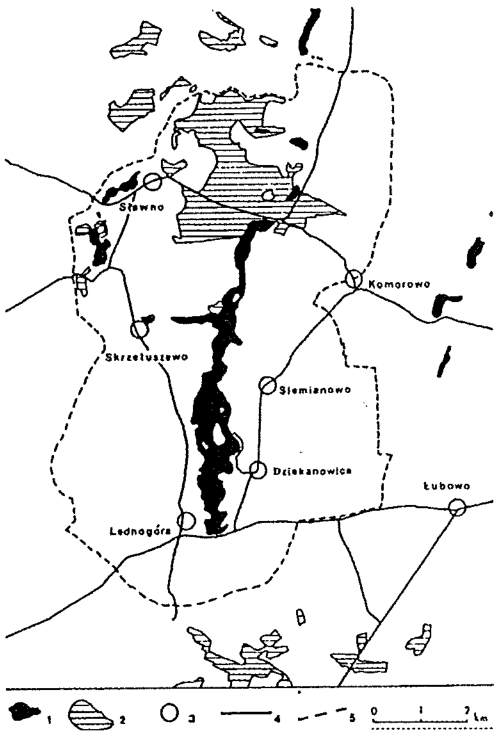


Fig. 100. Lednica Lanscape Park. 1 - lakes, 2 - forested areas, 3 - larger villages, 4 - roads, 5 - boundary of the Park.

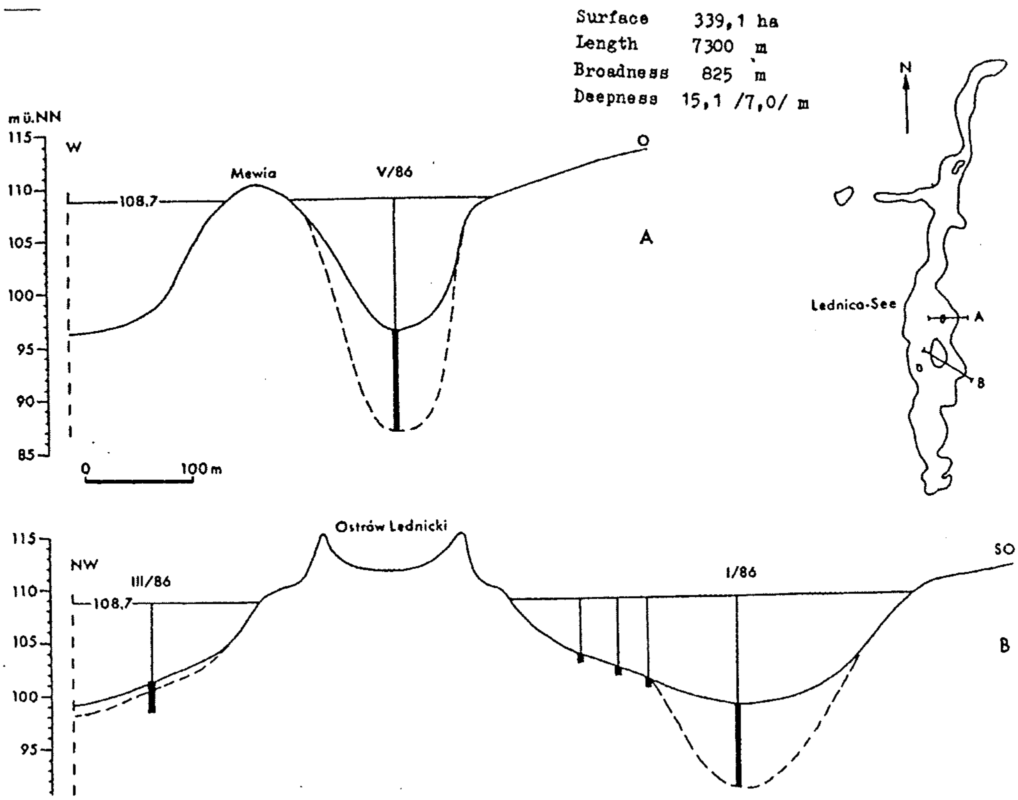


Fig. 102. Lednica Lake. The bottom sediments in two cross-sections

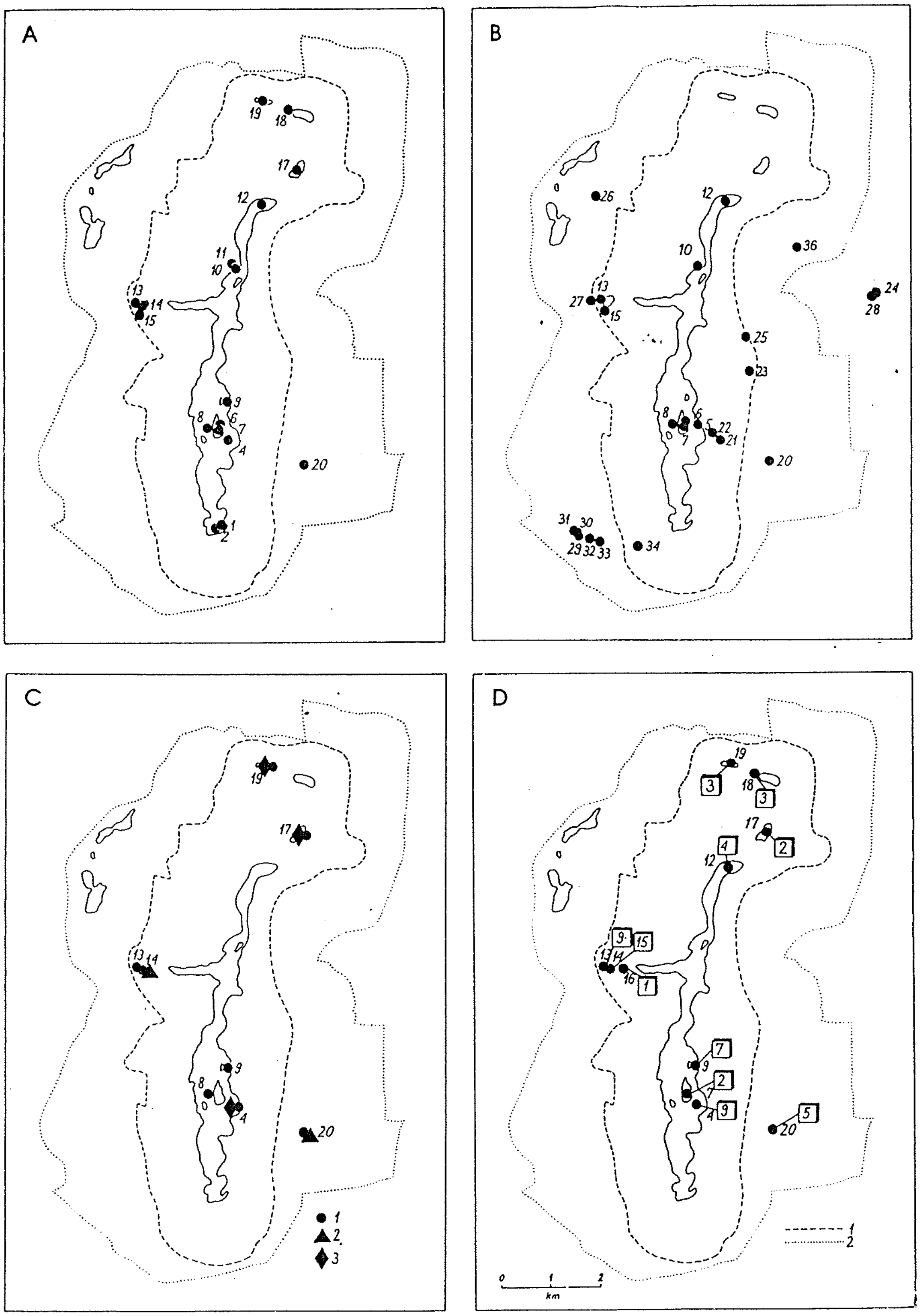


Fig. 101. Lednica Lake. More important palinological investigated sites

Lage der wichtigsten paläobotanischen und vergleichbaren Untersuchungspunkte im Lednicer Landschaftspark (Forschungsstand bis 15. Juni 1990). *A* – Plätze palynologischer Untersuchungen, *B* – Plätze mit Untersuchungen pflanzlicher Großreste, *C* – Plätze mit Untersuchungen fossiler Diatomeen und ausgewählter fossiler Faunengruppen bzw. mit physikalisch-chemischen Untersuchungen: 1 – Plätze mit Diatomeenuntersuchungen, 2 – Plätze mit Cladoceren- und Insektenuntersuchungen, 3 – Lage der Bohrkerne, die auf stabile Isotopen (C, O) untersucht wurden, *D* – Objekte, die durch die ^{14}C–Methode datiert wurden (in den Quadraten ist die Anzahl der Daten angegeben), 1 – Grenze des Lednicer Landschaftsparks, 2 – Grenze der Schutzzone des Parks. Ein Verzeichnis dr Plätze, die in der Abbildung berücksichtigt wurden, ist dr Tabelle 1 zu entnehmen

LEDNICA LAKE, core I/86

an. M. Makohonienko, 1991

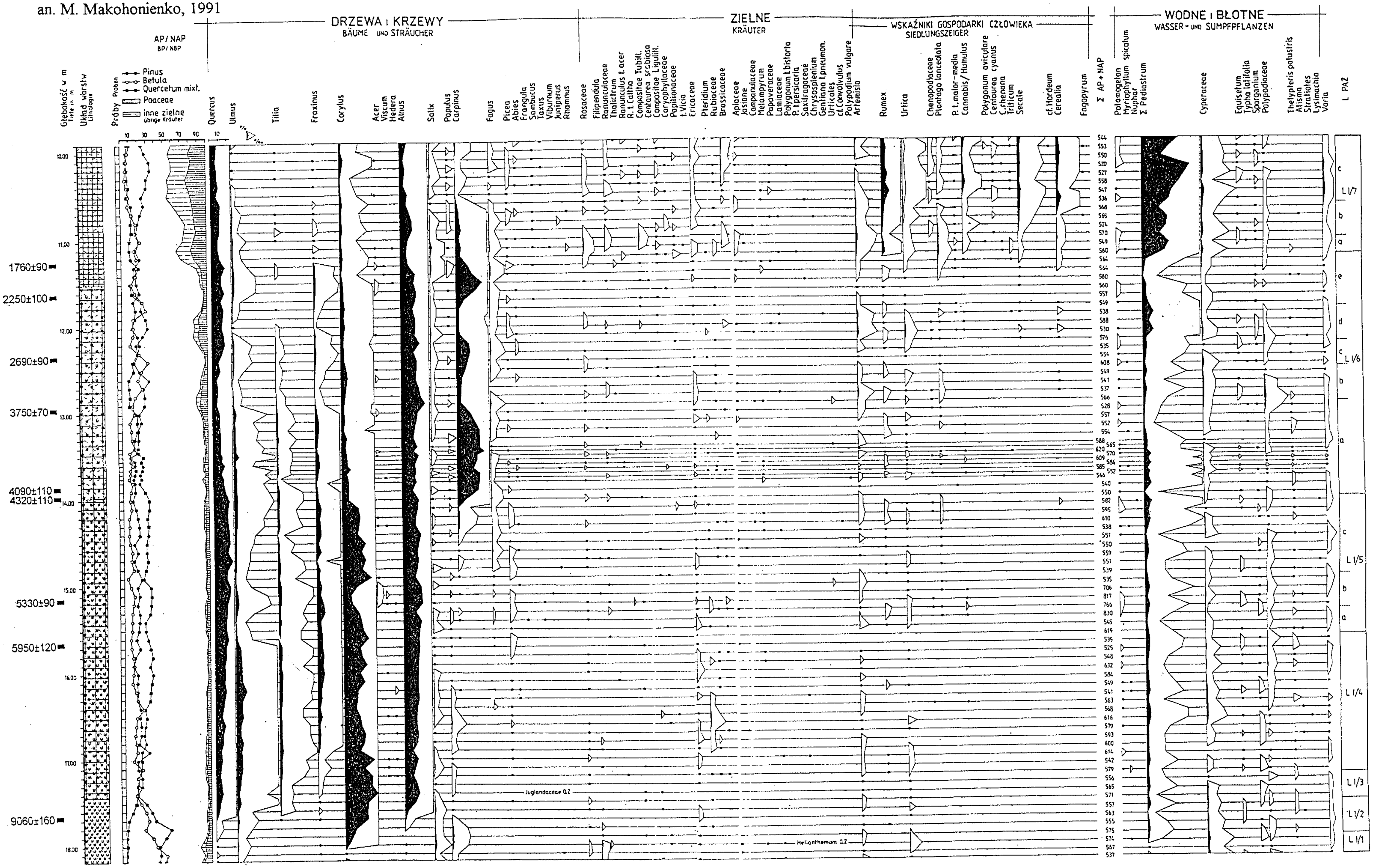


Fig. 103. Lednica Lake, core I/86, percentage pollen diagram, calculation based on AP+NAP=100%)excluding limnophytes and telmatophytes.

anal. M.Makohonienko (1991)

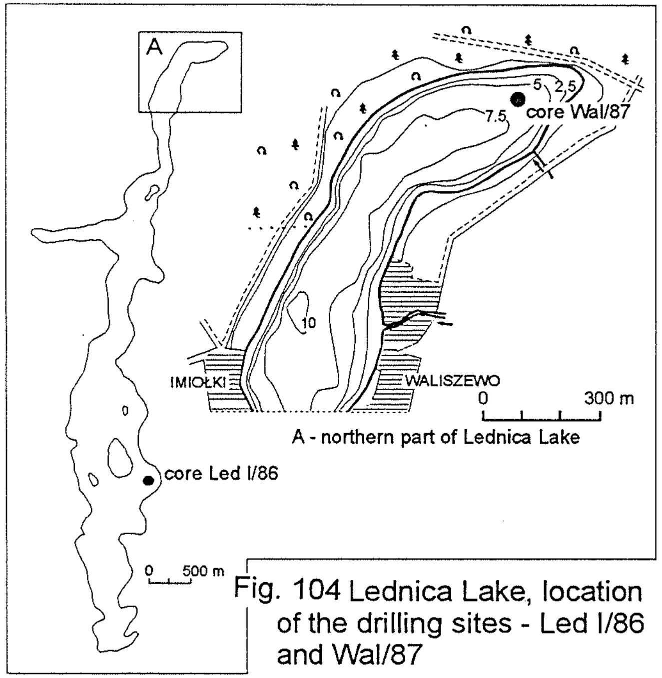


Fig. 104 Lednica Lake, location of the drilling sites - Led I/86 and Wal/87

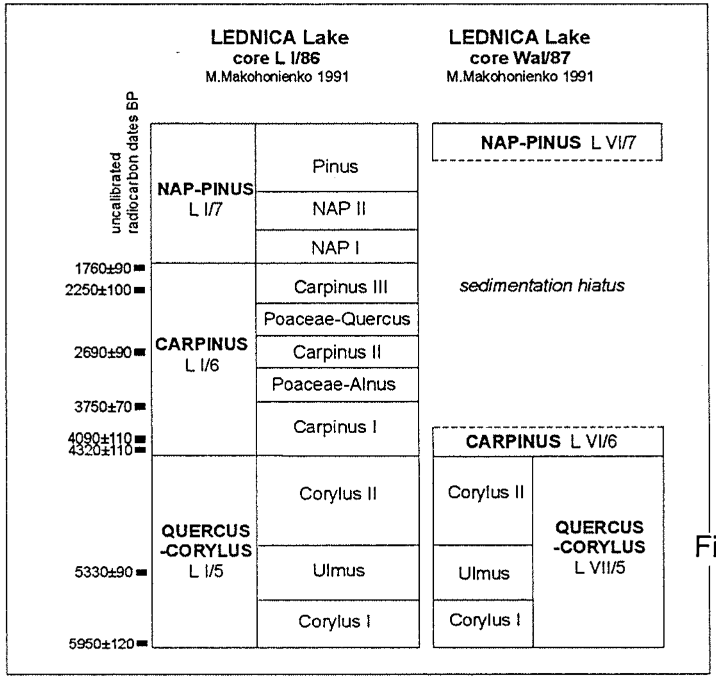


Fig. 105. Correalation of the Local Pollen Assemblage Zones of the two cores from Lednica Lake

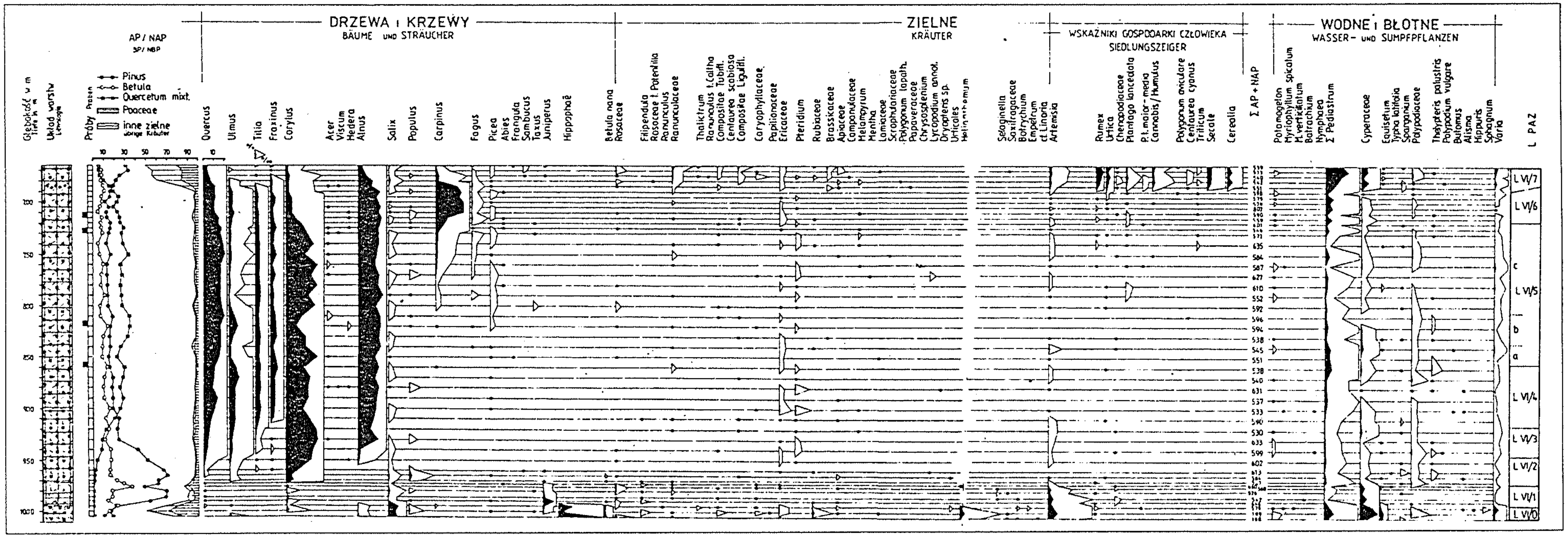
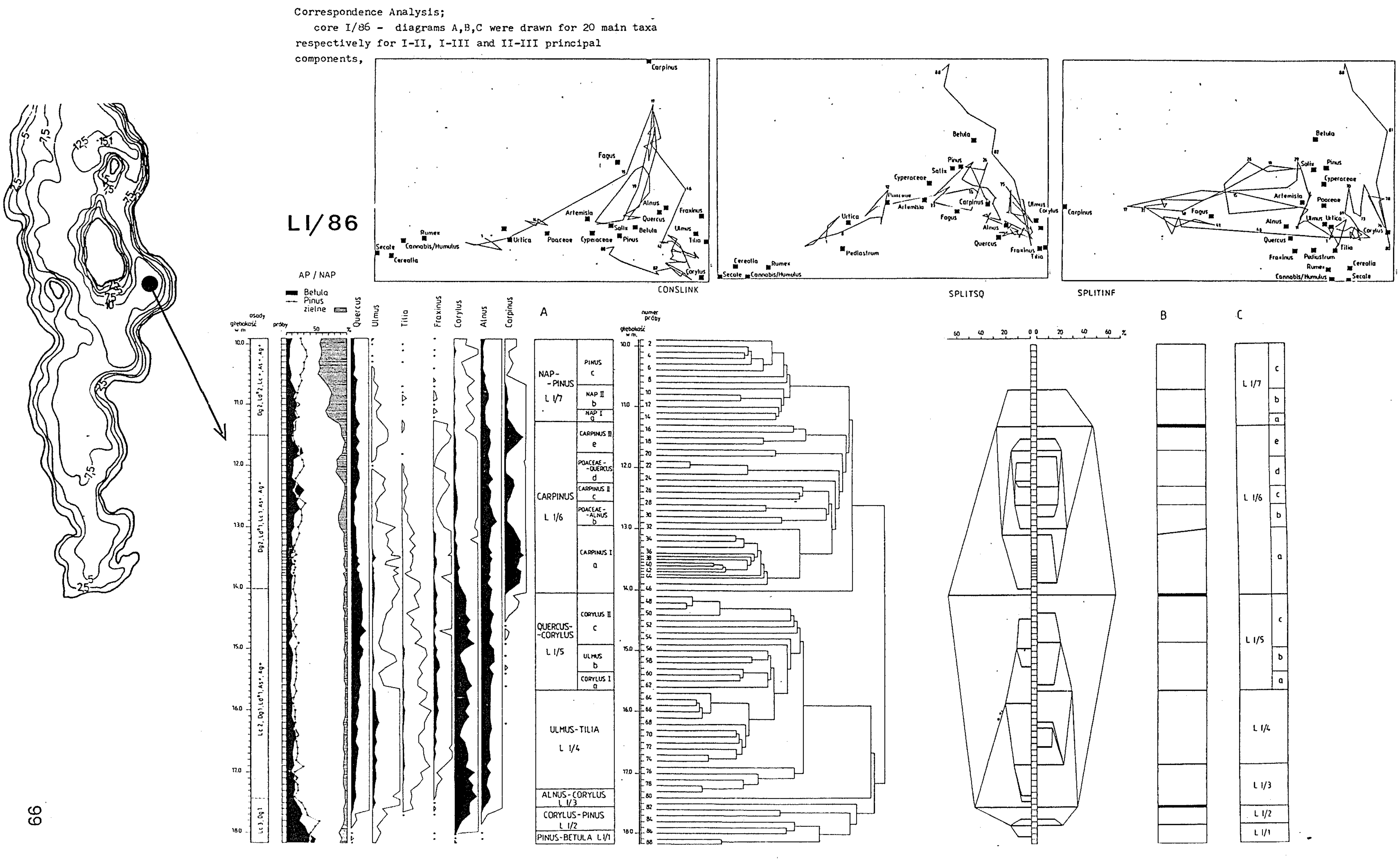


Fig. 106. Lednica Lake, core Wal/87, percentage pollen diagram anal. M.Makohonienko (1991)

Fig. 107. Lednica Lake, core I/86. Numerical and correspondence analysis



Lake Skrzetuszewskie

Lake Skrzetuszewskie is a eutrophic lake situated in a depression which is an extension of the latitudinal gully that crosses the Lake Lednica gully. It is a small basin 250+ m long and 150 m wide, with a maximum depth of 6 m and an area of approx. 3 ha. The lake contains a discontinuous belt of aquatic plants and rushes and is separated from Lake Lednica by a third-degree watershed.

This lake is a rare case for Great Poland of a basin filled with non-carbonate detritus gyttja which has been accumulating continuously for about 10,000 years. Our knowledge of the Lake Skrzetuszewskie sediments is based on two cores of combined length 16.4 m taken from the lake bottom and on a transect of the fossil littoral on the south-west shore (Fig. 111). These sediments have been examined palynologically and for macroscopic plant remains, diatoms and *Cladocera*. Numerous samples have been radiocarbon-dated.

The surroundings of the lake were occupied by birch-pine forests at the beginning of the Holocene (Fig. 112), and the proportions of herbaceous plants decrease significantly in the pollen spectra for that time, but after the phase of pine forest accompanied by more competitive newcomers at the end of the Boreal period, deciduous forests with elm, oak, lime, ash and hazel began to predominate in the vegetation cover of the area. Thus the Quercetum mixtum curve rose to 33% during the Atlantic. The amount of pine in the pollen spectra for that period is always less than 20%, and even below 15% in some cases, pointing to rare occurrences at most in the vicinity of Lake Lednica.In the later part of the Sub-boreal period the existing tree stands were rapidly reshaped, yielding to complete dominance by hornbeam, which reaches 32% in the pollen spectra.The forests underwent two regeneration phases under severe anthropogenic pressure before finally giving way to the expansion of settlement which began in Early Mediaeval times.

The pollen results provide clear evidence of human interference in the transformation of the primary vegetation (Fig. 108). This is marked initially by the occasional occurrence of taxa such as Plantago lanceolata or single grains of cereal pollen, but without any obvious traces of deforestation. It is only in the early Iron Age, or more probably at the end of the Bronze Age, that the area of dense deciduous forests decreased significantly and these were replaced by open communities, the representatives of which account for up to 13.6% of the pollen sum. Greater anthropogenic changes in the landscape are recorded in pollen spectra that should be ascribable to the Roman period and early mediaeval times. After an initial decrease in forest elements in Early Mediaeval times, accompanied by a simultaneous sharp growth in indicators of human impact connected with the erection of a stronghold on Lednica Island and the development of settlement in the vicinity of the lake, the pollen diagrams point to a recession in economic activity, attributable on the basis of the historiography of the region to the raid carried out by the Czech Prince Brzetysław in the 10th century, followed by the "heathen reaction".

The effects of human impact in the area are denoted in Fig. 113 (based on core S/87) by the curve showing the state of deforestation and the amounts of cereal and weed sporomorphs present in the samples. The diagram also contains curves showing fluctuations in water level and changes in trophic status against a background of the biostratigraphic, chronostratigraphic and archaeological divisions.

Kazimierz Tobolski

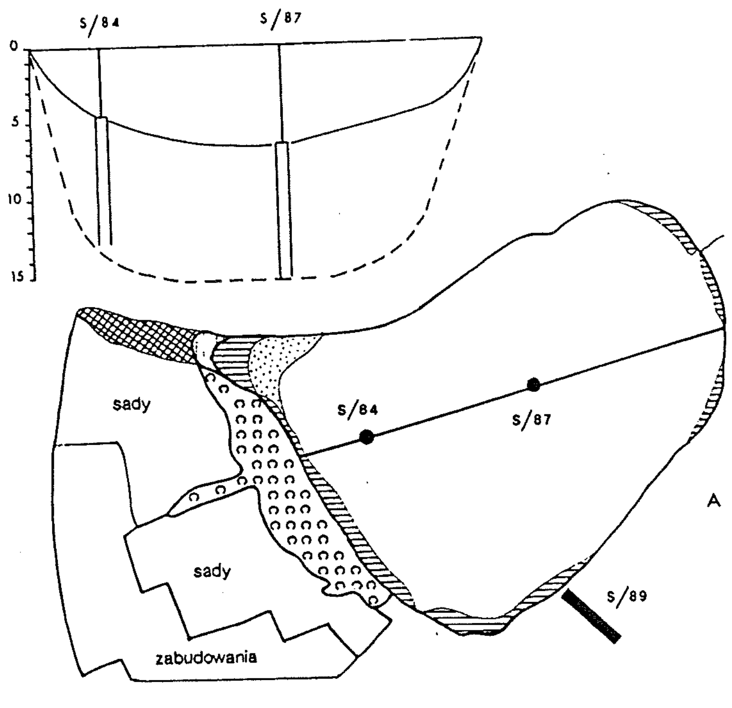


Fig. 111. Skrzetuszewskie Lake. Palinological investigations.

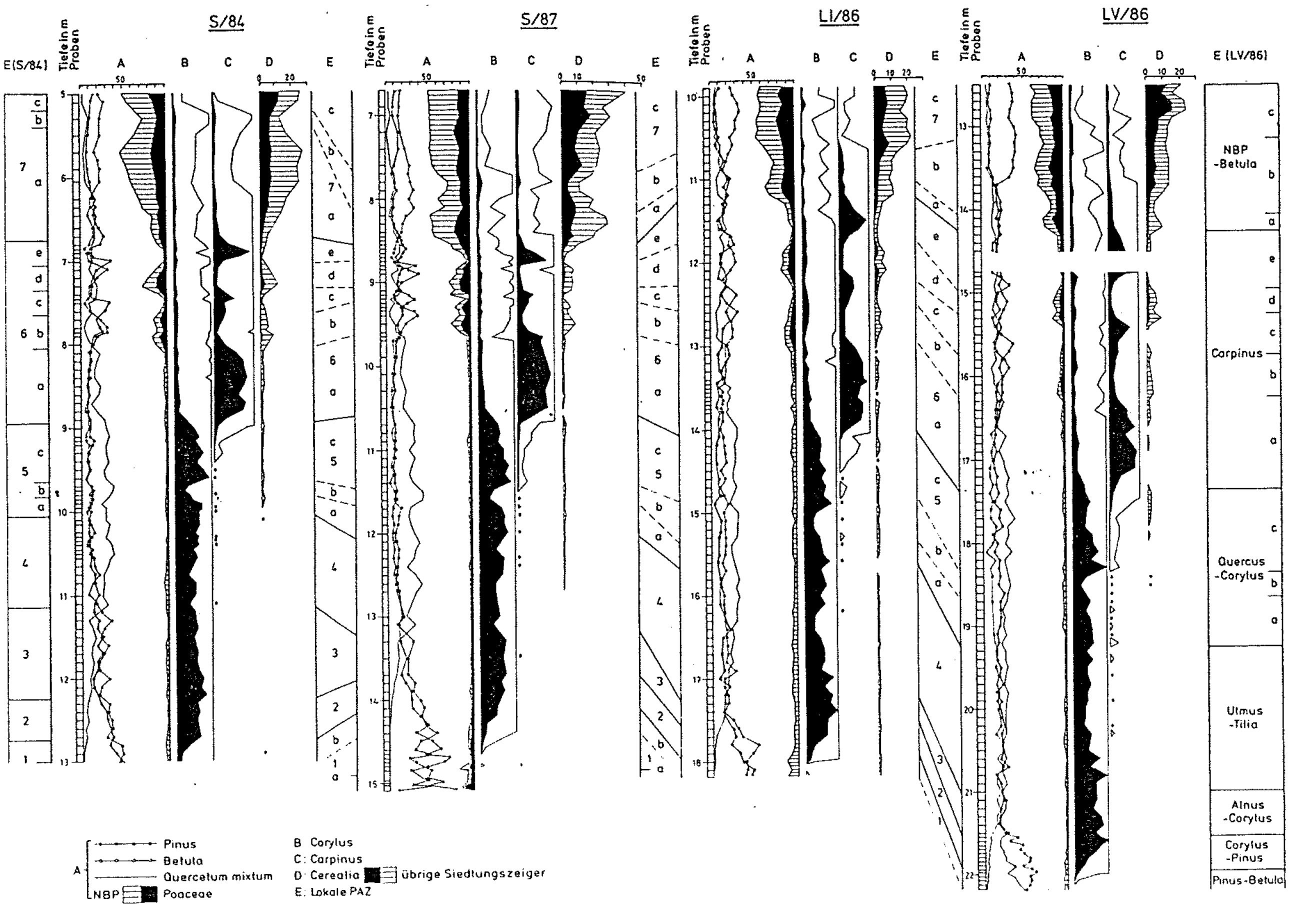


Fig. 108. Selected polen-curves from Skrzetuszewskie Lake (S-84, S-87) and Lednica Lake (LI/86, LV/86) to illustrate the similarities in local plant cover and the main changes in the vegetation.

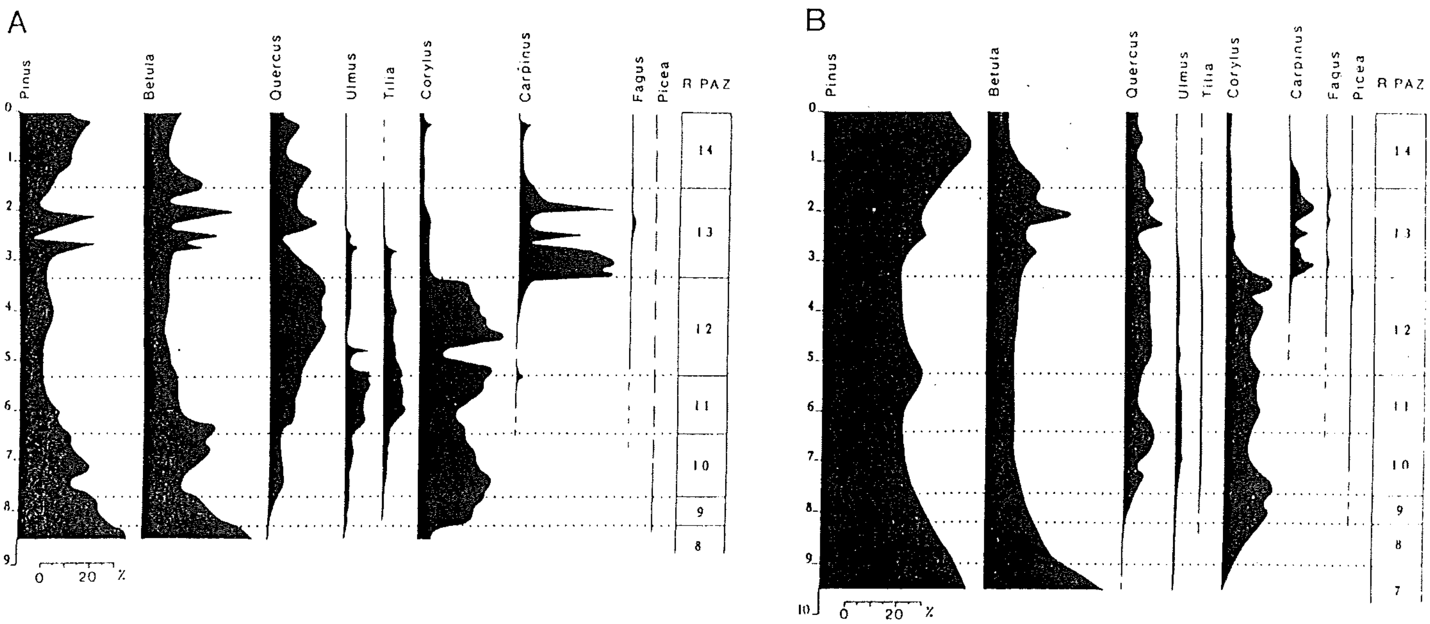


Fig. 109. Simpified pollen diagram from Skrzetuszewskie Lake (A) and Gopło Lake (B), Kujawy Lowland.

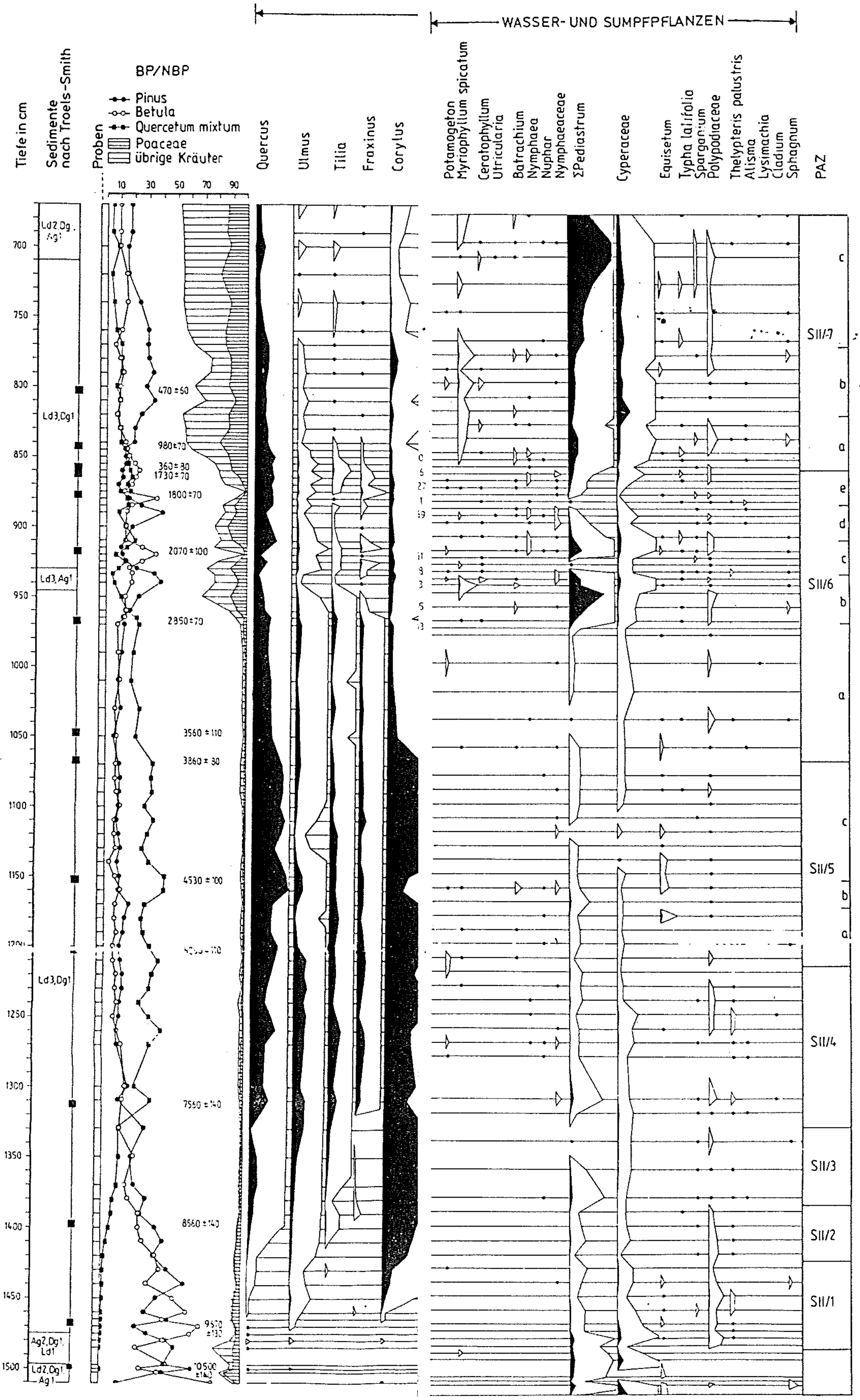


Fig. 112. Skrzetuszewskie Lake, c
Pollen diagram.

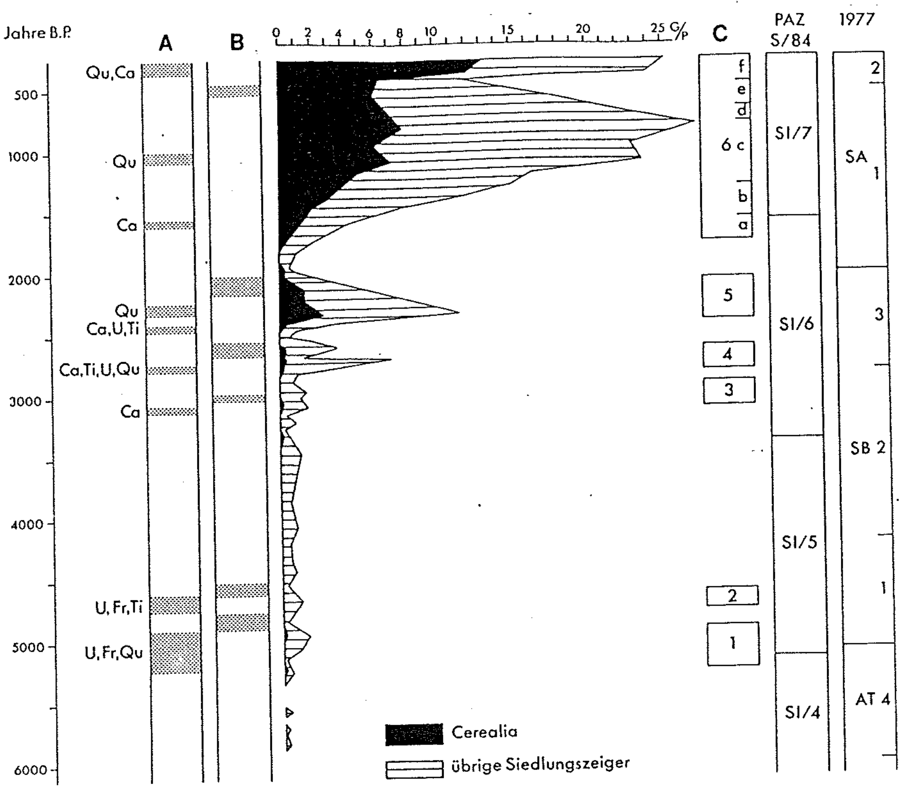


Fig. 110. Human impact detected in Skrzetuszewskie Lake (S-84). A - deforestation, B - regeneration stages, C - periods of human activity

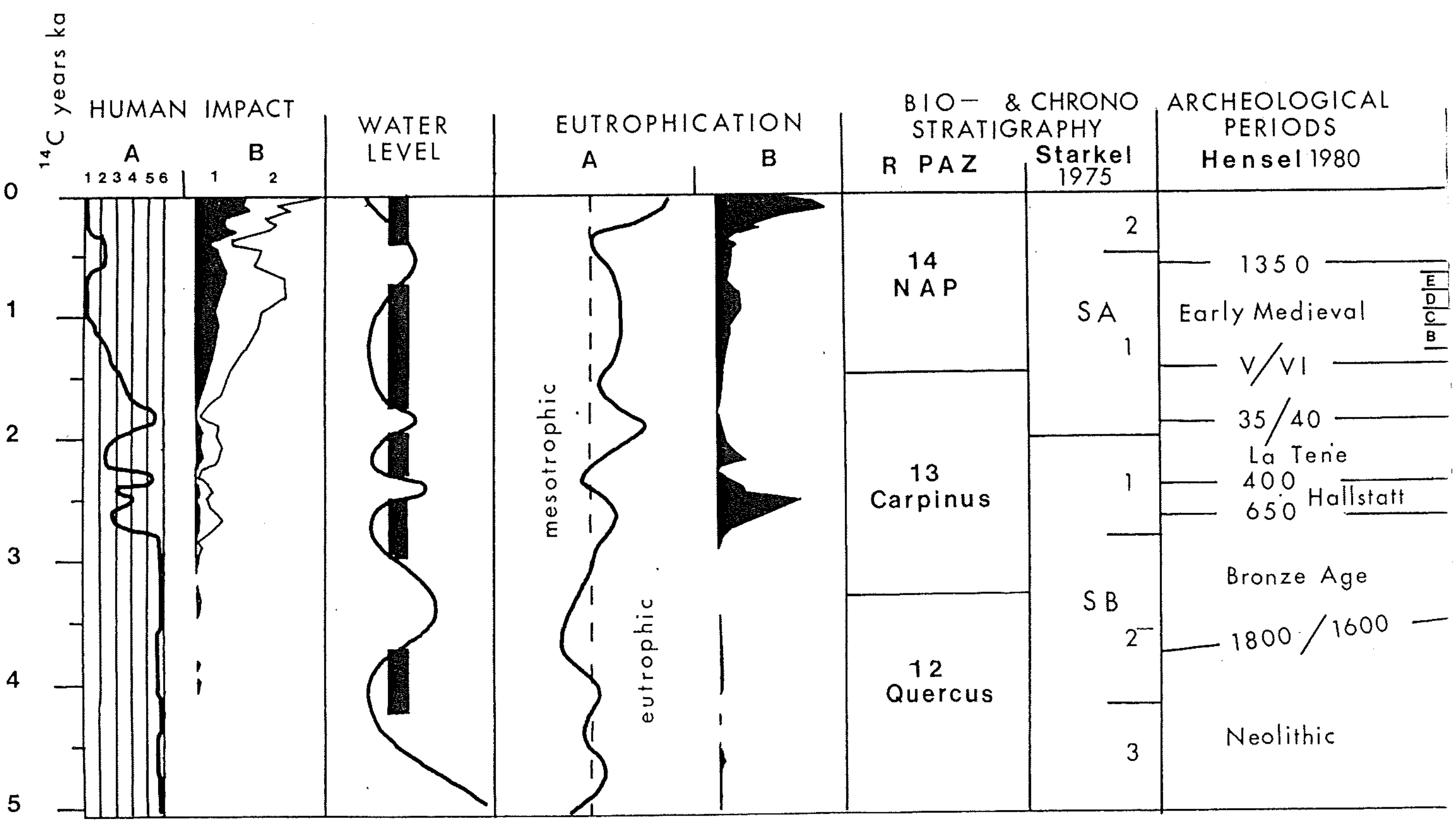


Fig. 113. Some phenomena occuring in the surrounding of the Skrzetuszewskie Lake. A) stages of deforestation: 1- complete, 2 - considerable, 3 - moderate, 4 - limited, 5 - slight, 6 - none; B) human indicators: 1 - cereals, 2 - weeds. Water level changes based on *Diatomae* and *Cladocera*, Eutrophication: A - based on *Cladocera*, B - *Pediastrum* (%).

Ostrów Lednicki Island

Lednica Island has traces of human presence going back to Neolithic times, i.e. about 5000 years. Intensive settlement began in the 9th century, as manifested in the form of a fortified stronghold, the site of which is marked by remains of the palatium at present. The most spectacular changes took place on the island in the second part of the 10th century, however, in connection with the birth of the Polish nation. It was at that time that embankments were built around the great stronghold, which have survived up to the present time together with the palatium, chapel and church. And it was at that time, too, that the island was connected to the mainland by two bridges of length 170 m and 420 m.

The palatium, built in the south-western part of the stronghold, is a rectangular building 31.6 m long and 14.23 m wide. It is joined in the east to the chapel, which is built on the plan of a Greek cross and closed off with a small apse. The total length of the building is 42.75 m.

The whole island settlement was destroyed in 1038 and 1039 in the course of an invasion by the Czech Prince Brzetysław.

In the last years the geology of the Ostrów Lednicki island was studied by Tomasz Schubetr and is presented in his doctor thesis. Fig. 114-117 are illustrating some selected results.

Kazimierz Tobolski, Tomasz Schubert

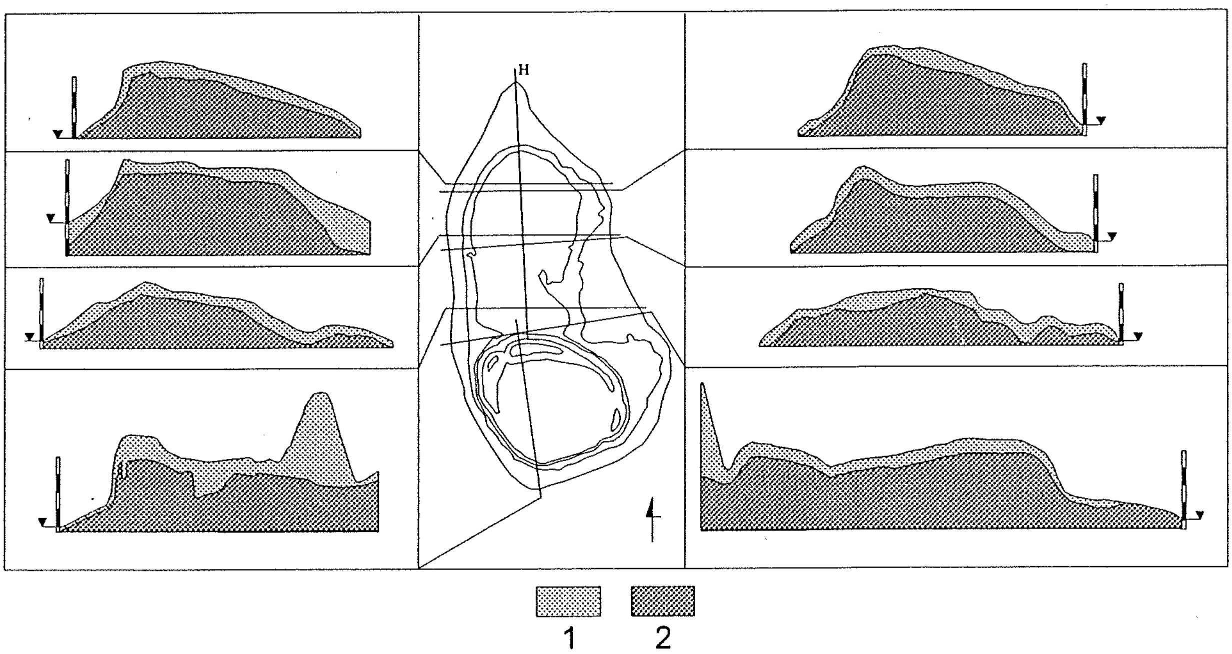


Fig. 114. Surface configuration of the Ostrów Lednicki island and distribution of cultural layer (Schubert & Kowalewski 1998). 1 – cultural layer, 2 – natural sediment substrate of the island.

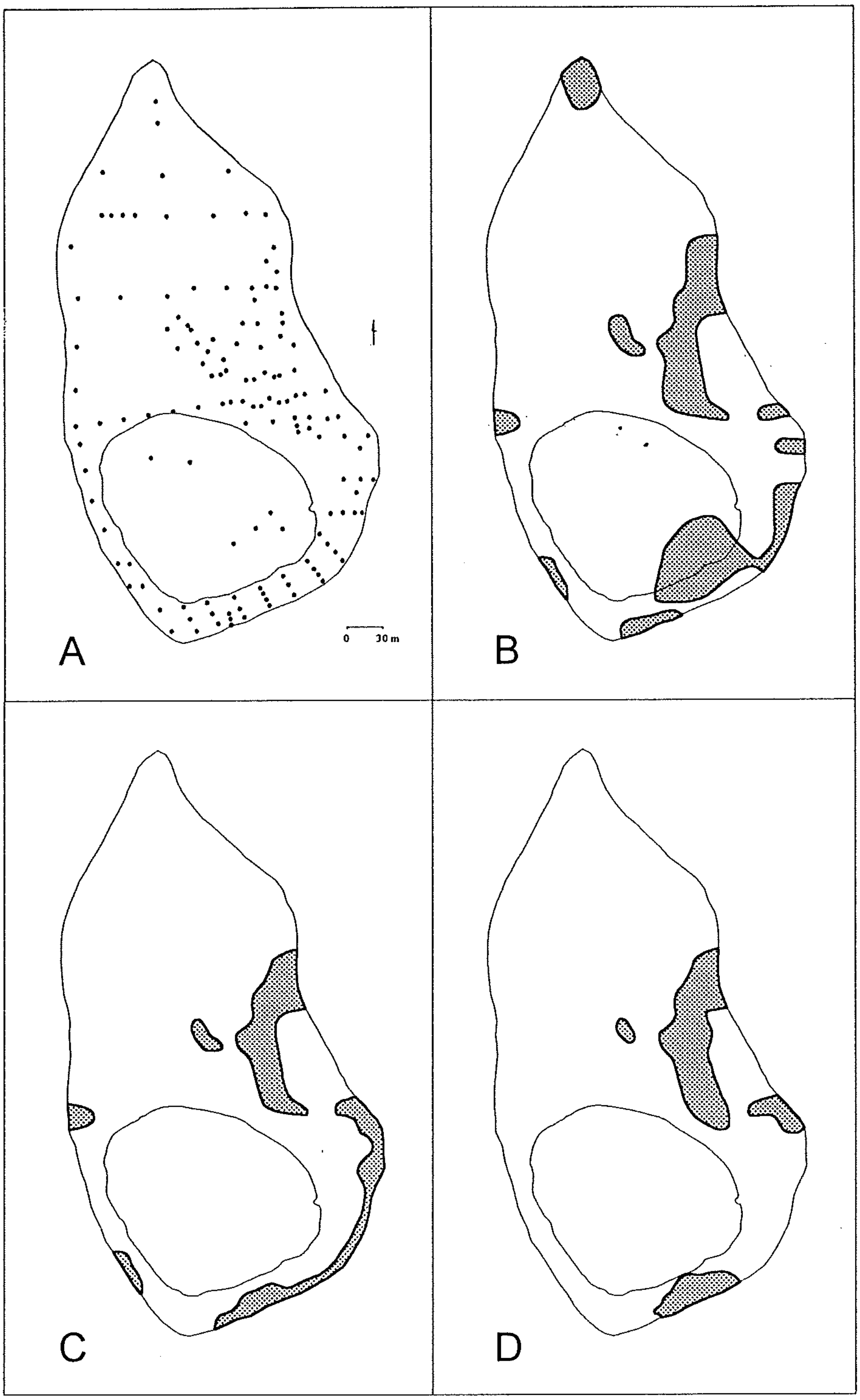


Fig. 115. The distribution of lacustrine and peat deposits on Ostrów Lednicki indicate presence of a small water pool in the central part of the island and former bays along the shore. A – location of drilling points, B – distribution of peat deposits, C – distribution of gyttja, D – distribution of clay sediments.

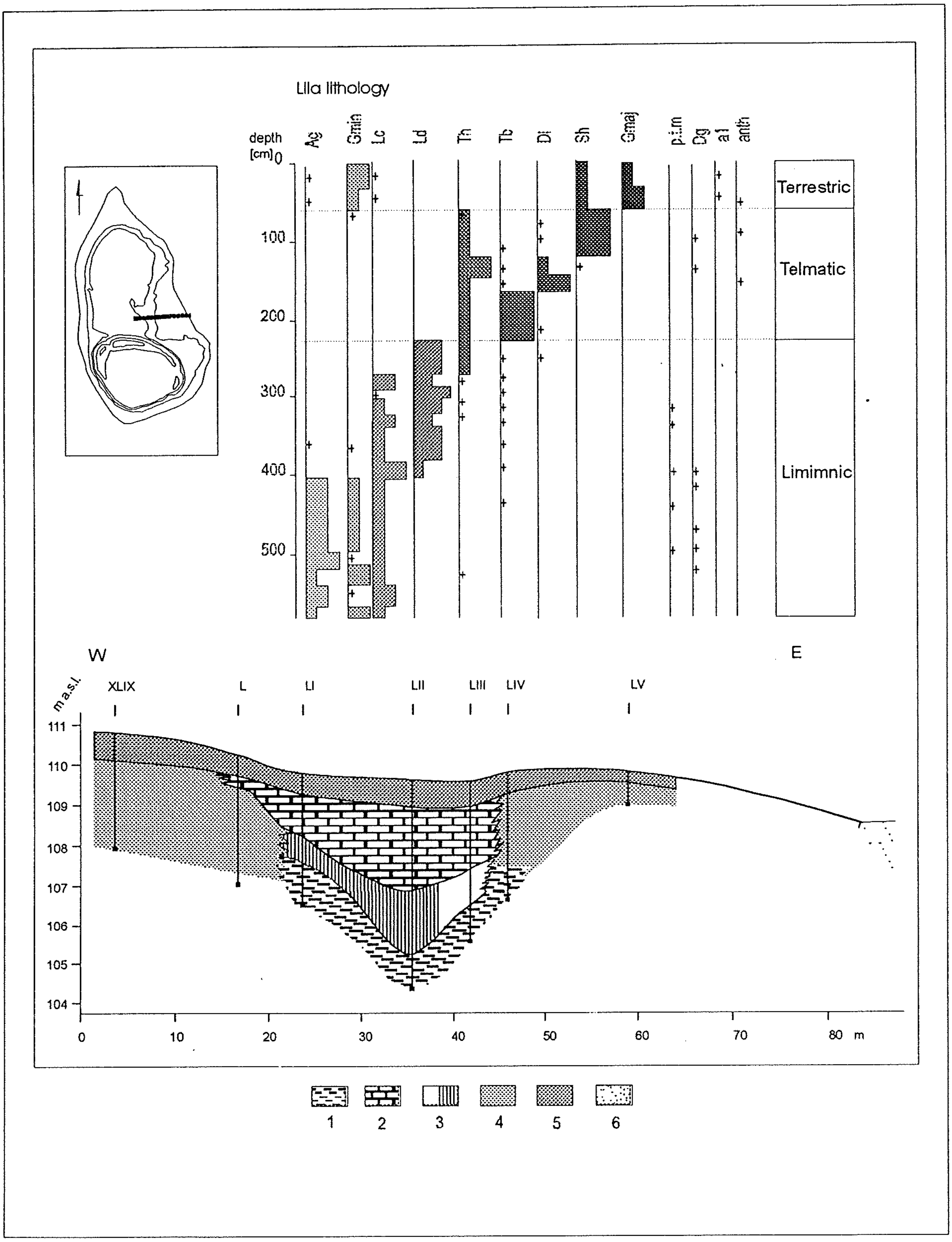


Fig. 116. Simplified geological transect XLIX-LX and lithology of the core LIIa. 1 – limnic clay, 2 – peat, 3 - gyttja, 4 – minerogenic substrate of the island, 5 – mineral-organic deposits with artefacts, 6- sand.

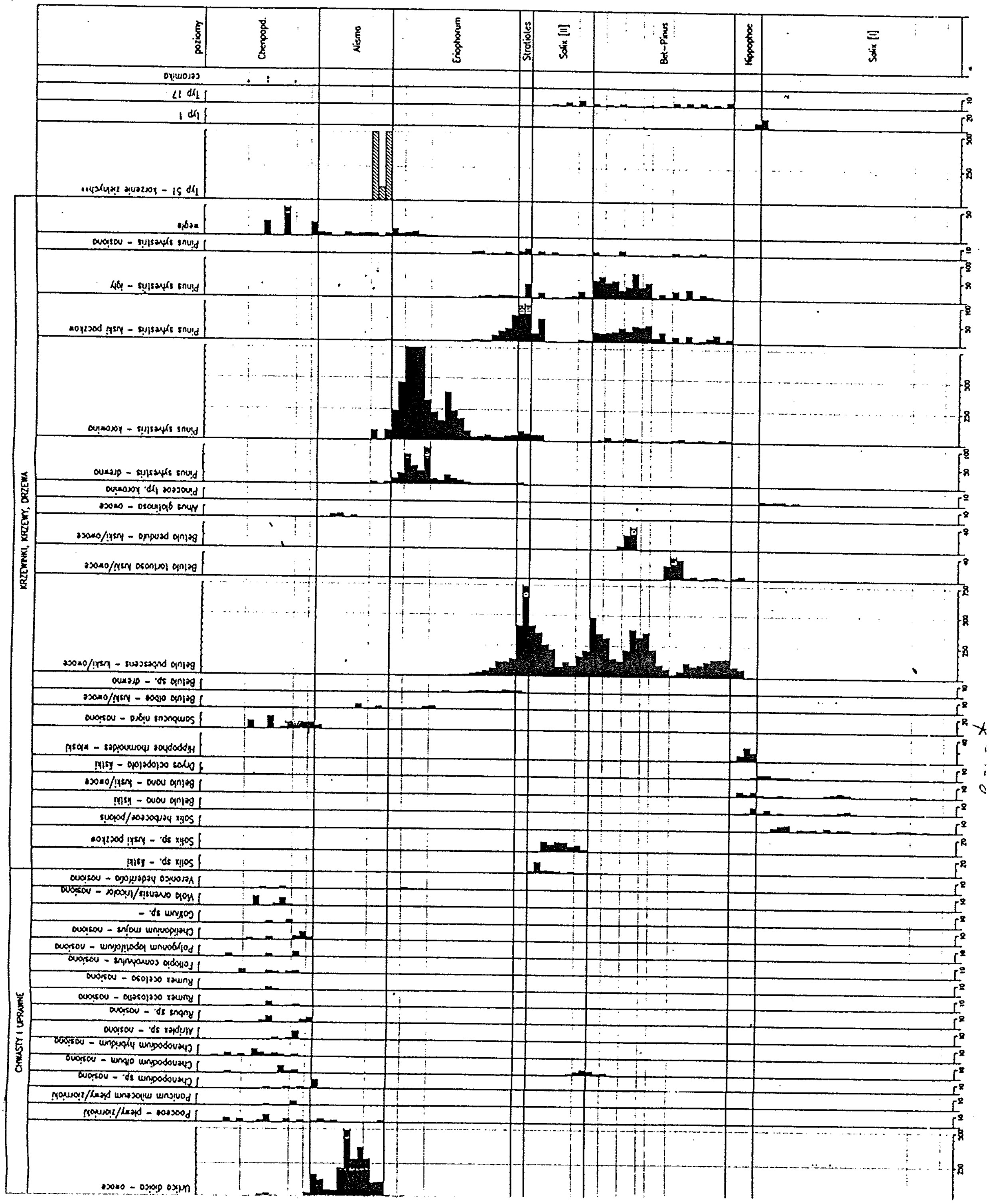


Fig. 117. Simplified plant macrofossil diagram of the core LIIa from Lednica Island.

A palynological analysis of construction of the Early Medieval fortified settlement at Ostrów Lednicki

A microscopic analyses was conducted on the remains of the wooden-earthen rampart of one of the most important centers of the then newly emergent Polish state at Ostrów Lednicki in Central Great Poland (Wielkopolska). The fortified settlement, dated from the second half of the 10th century to the first half of the 12th century, is located on the island of Lednica Lake. Analyses were conducted on the three cores of sediments representative of separate parts of the rampart. Among the analysed portions of the rampart, significant differences in the qualitative and quantitative content of sporomorphs were determined, indicating that the building materials of wood and soil came from different locations and, thus, in all likelihood, from variously exploited habitats. The level of this differentiation together with the quantity of raw materials used suggests the exploitation of resources beyond the island itself. Samples from profile I reflect a mosaic of habitats with a share of wooded areas forested with oak, hornbeam, hazel together with an open habitat with anthropogenic characteristic. Profile III, exhibiting the lowest sporomorph concentration, probably indicates the exploitation of sandy areas or severely transformed ones, denuded of their forest cover.

In assuming the probability of obtaining building materials for the construction of the rampart along the shortest line of transport, it is likely that profile I describes, to a large degree, habitats exploited in the western region of the lake's basin. The picture identified in the spectra of the eastern portion of the rampart may correspond to the exploited areas in the vicinity of the eastern shore. The data obtained in the pollen spectra, particularly the repeated high values of *Secale cereale*, allow these differentiated habitats to be connected with the early medieval period. It should be noted that there was a high content of *Anthoceros punctatus* (maximum 11.9%), indicating open habitats, in all probability, those having been previously plowed over.

Mirosław Makohonienko

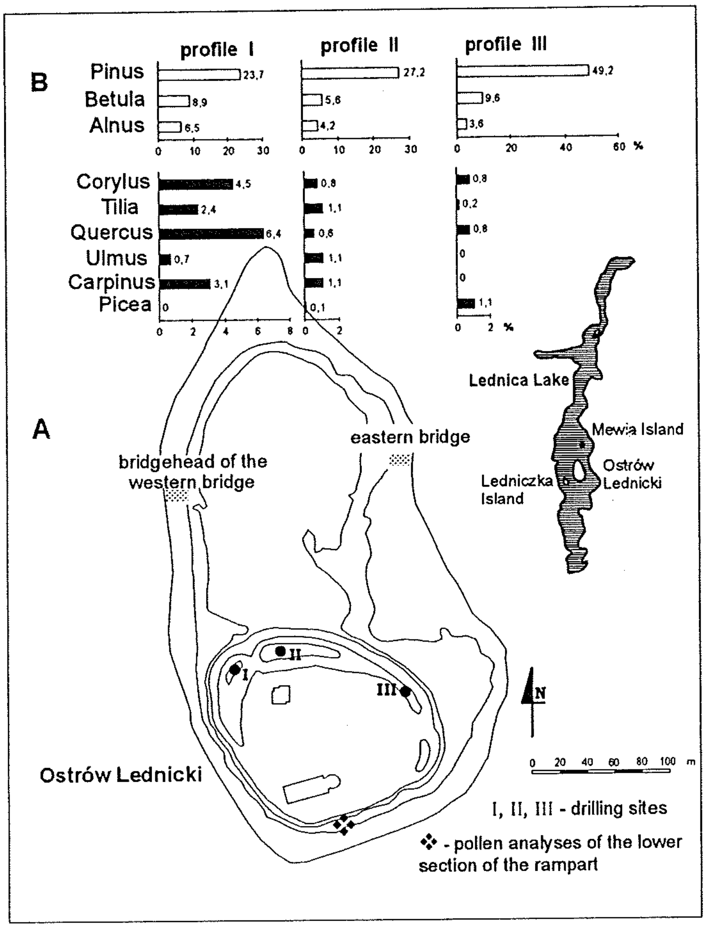


Fig. 118. Pollen analysis of the wooden-earthern rampart of the early medieval stronghold at Ostrów Lednicki. A - location of drilling sites, B - mean values ofr the selected tree taxa in the three analysed cores (Makohonienko 1998)

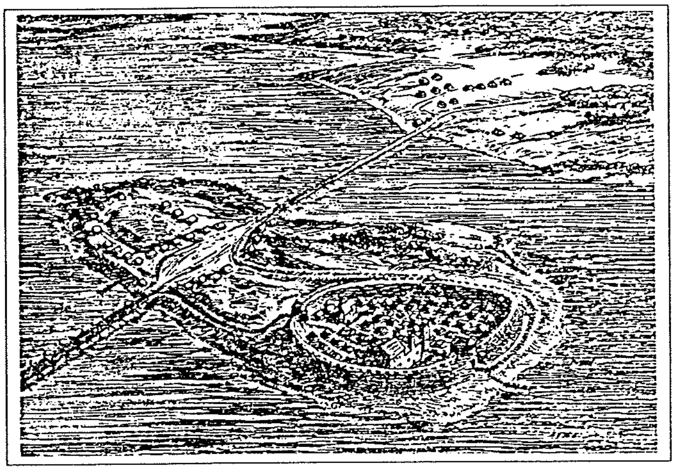
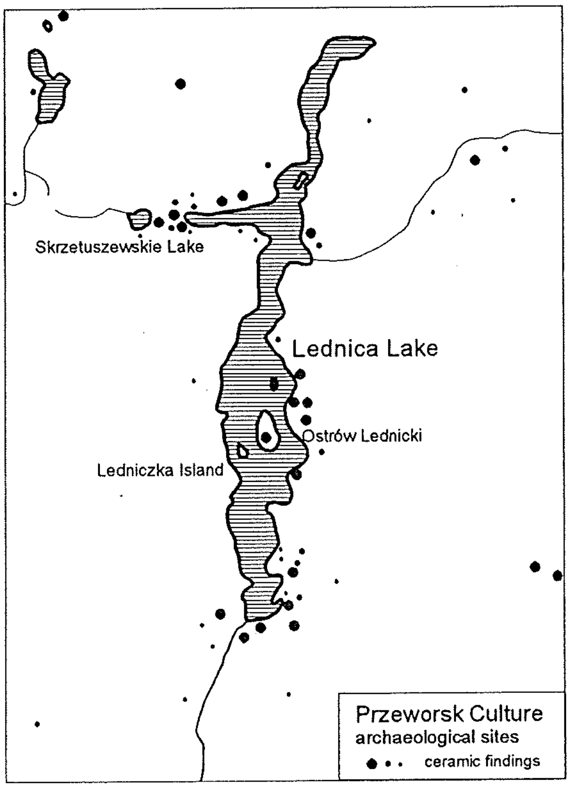


Fig. 119. Reconstruction of the early medieval settlement complex at Ostrów Lednicki



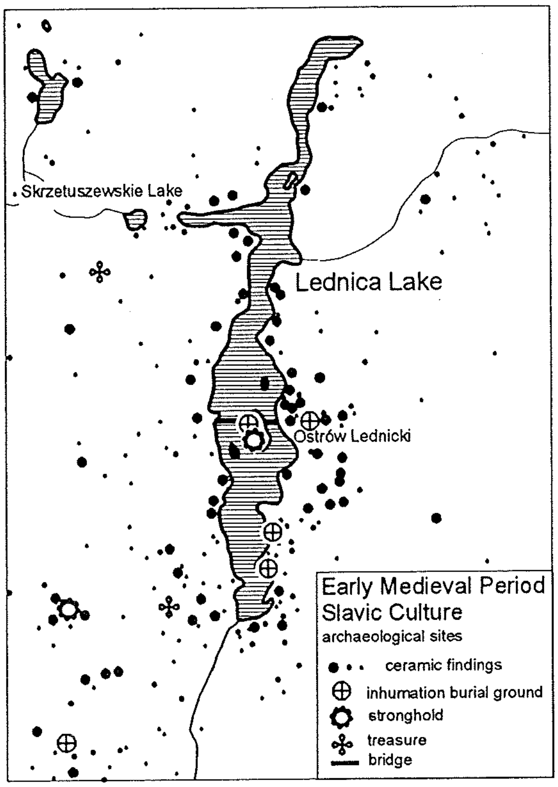


Fig. 120. A comparison of archaeological findings based on data from th "archaeological photograph of Poland" (AZP) in the immediate vicinity of Lake Lednica for the Przeworsk Culture and early medieval period (Makohonienko 1989).

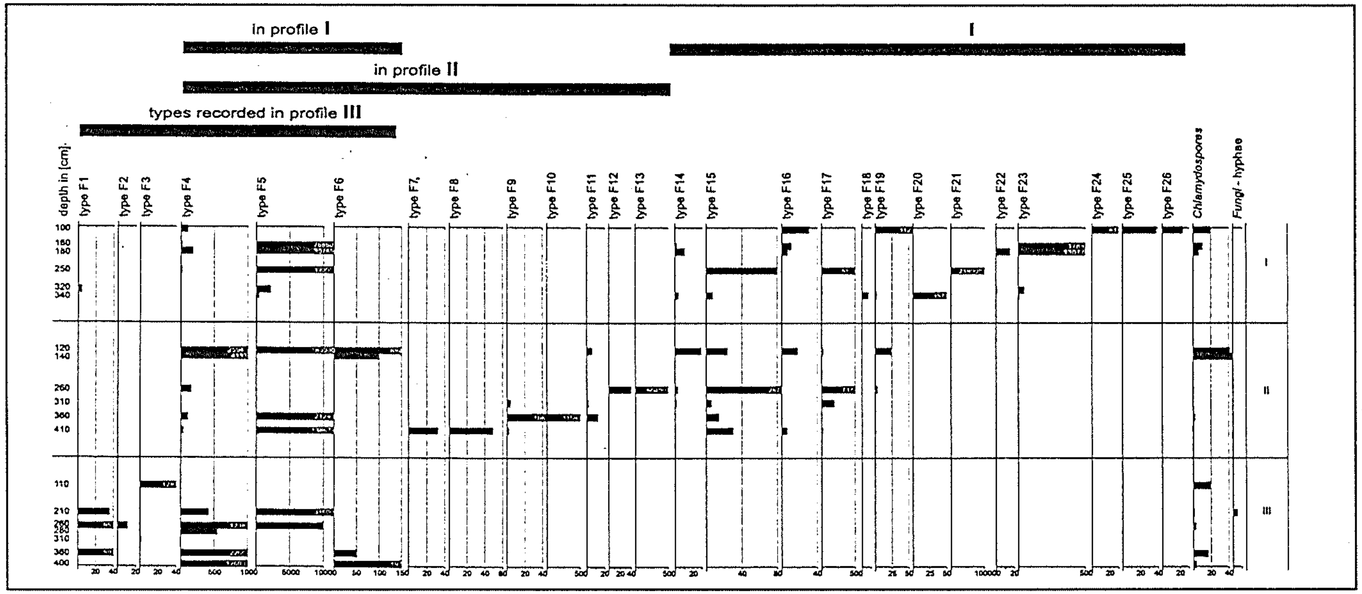
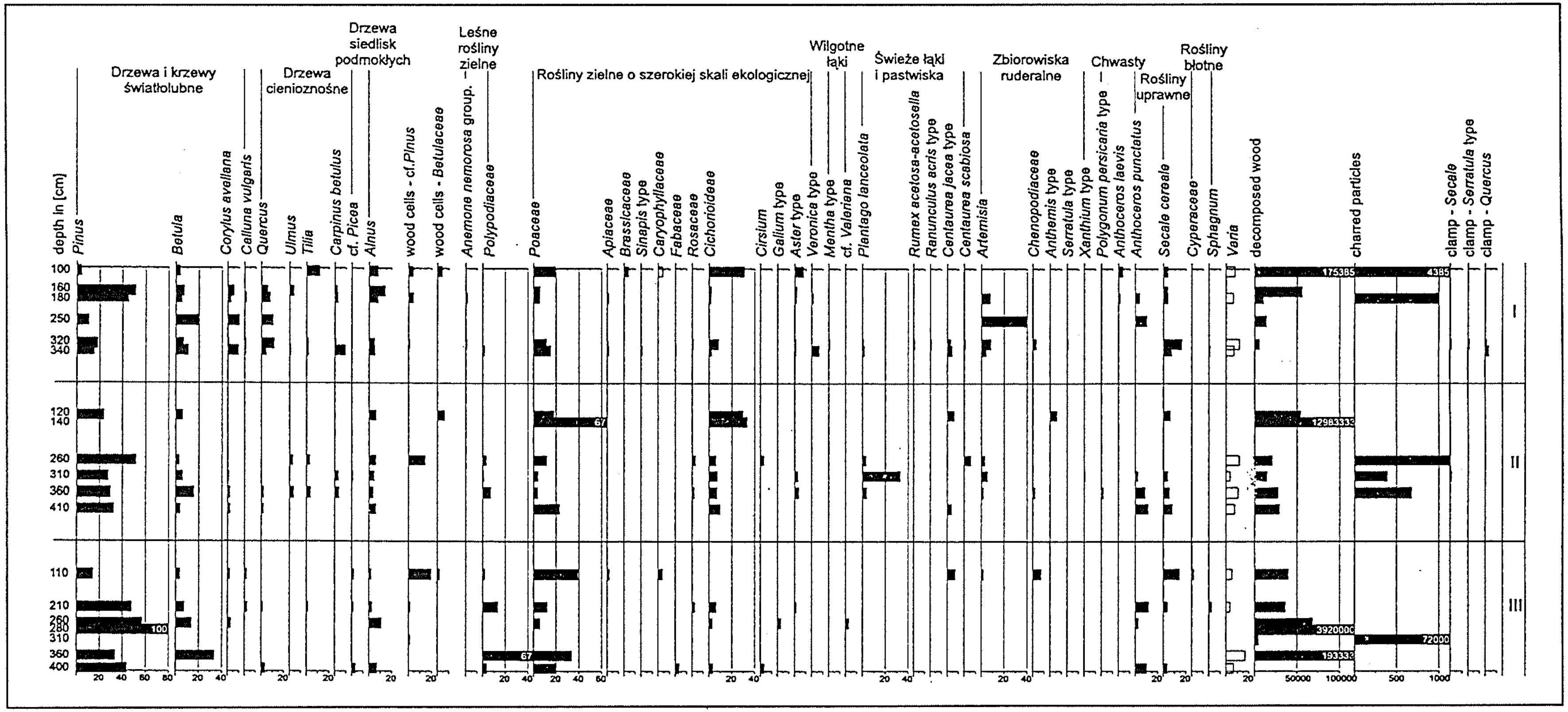


Fig. 121 Remains of Fungi in the three cores from the rampart construction of Lednica stronghold (Makohonienko 1998).

Fig. 122 Percentage pollen diagram of the three cores (I, II, III) taken from the remains of wooden-earthern rampart construction from Ostrów Lednicki. (Makohonienko 1998)



Palynology of the early Medieval archaeological site in Dziekanowice

Materials from the two categories of archaeological features from the early medieval site at Dziekanowice on Lednica Lake have undergone pollen analysis. The materials come from the settlement features, dated to the second half of the 10^{th} century to the first half of the 11^{th} century, and from the fills of inhumation graves located at the same site and being dated to the time between the second half of 11^{th} and the first half of 12^{th} century.

The analysed materials were characterised by a very low frequency and considerably corrosion of sporomorphs. Both grave and settlement samples are characterised by a very high percentage of herbs and graminids among which representatives of the Cichorioideae subfamily prevail, settlement spectra being marked by irregular and less numerous occurrence of trees. Presumably lime-trees and wild lilac (*Sambucus nigra*) occurred in the nearest surrounding of the analysed graves.

The samples from the fills of graves have not provided grounds for plausible inference as to the vegetation period in which a deceased person might have been buried. The representative pollen grains and spores reflect multiseasonal or many years' pollen deposition around the site. A large number of pollen grains of rye (*Secale cereale*) found in the sample of grave 53/94 (remnants of rye straw?) might be the only trace of intentional activities. High percentage of pollen grains of subfamily Cichorioideae in the excavated material is due to the good preserving properties of the pollen grains of this taxon rather than a result of flowers of the said subfamily having been laid on purpose.

The samples of the features from the settlement do not bear the traits, which could indicate function of the features. Likewise in case of grave pits, they seem to be characteristic of the surrounding vegetation. Since the settlement and the burial features come from the same area, whereas the functioning there of dates back to different time horizons, one might infer that the surroundings at the time the burial ground existed changed towards a slight growth of the amount of trees in the neighbouring landscape.

Mirosław Makohonienko

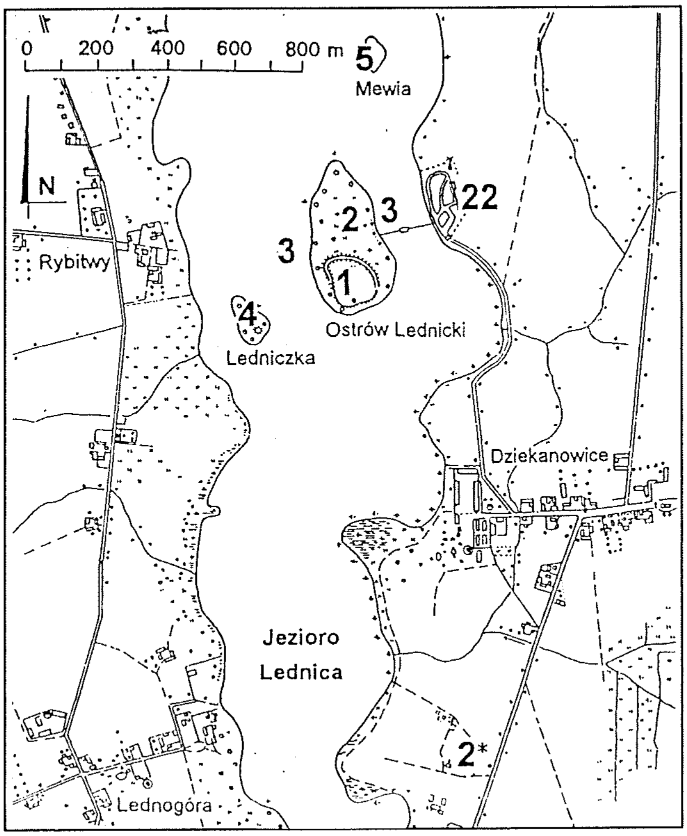


Fig. 124 Location of research sites against the background of other mediaeval archaeological sites in the region of Ostrów Lednicki

1 Rybitwy-Ostrów Lednicki, site 1, stronghold
2 Rybitwy-Ostrów Lednicki, site 2, borough
3 Rybitwy-Ostrów Lednicki, site 3, remnants of bridges
4 Rybitwy-Ledniczka, site 4, conical stronghold
5 Rybitwy-Wyspa Mewia, site 5
2* Dziekanowice, site 2, inhumation cemetery
6 22 Dziekanowice, site 22, settlement and inhumation cemetery

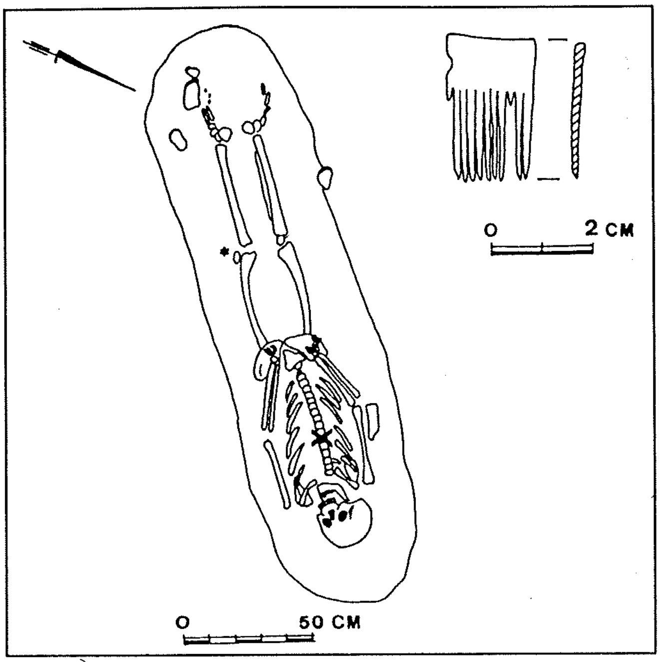


Fig. 125 Dziekanowice, site 22, inhumation cemetery, grave no. 44/94 (Makohonineko et al. 1998)

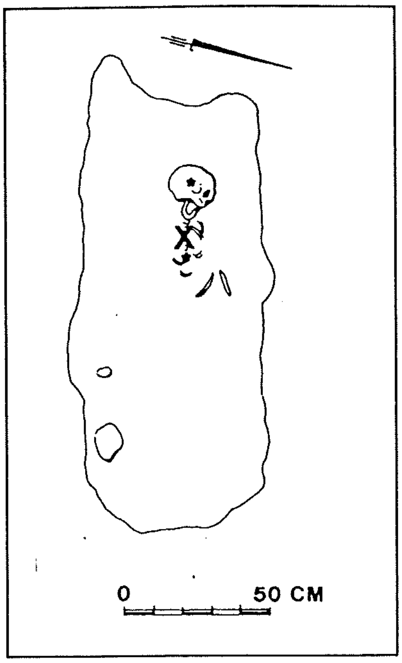


Fig. 126 Dziekanowice, site 22, inhumation cemetery, grave no. 64/94 (Makohonienko et al. 1998)

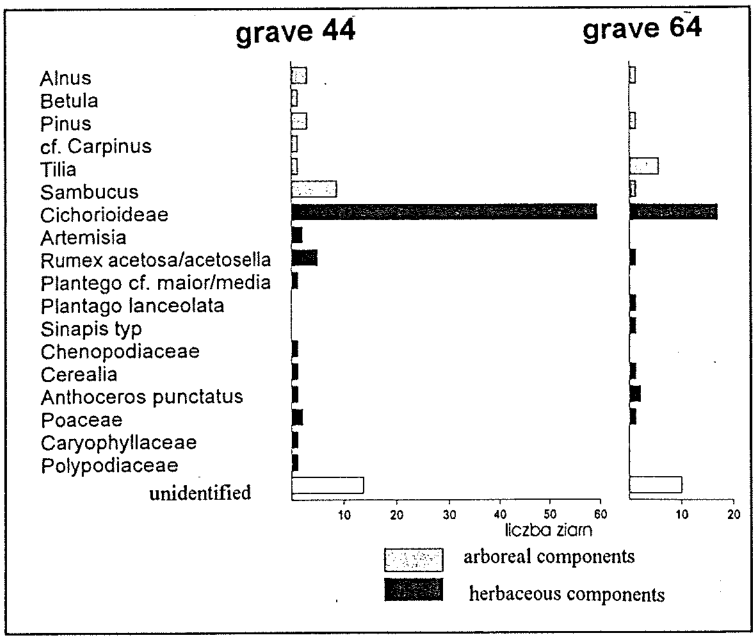
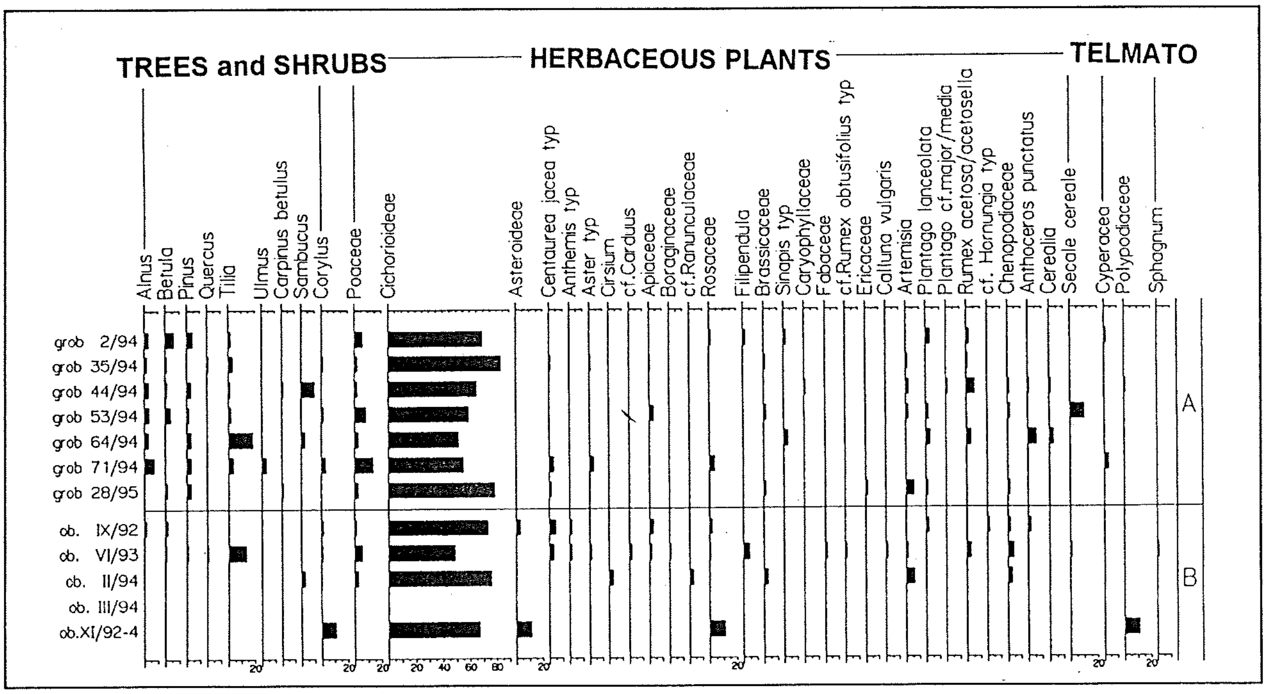


Fig. 127 Dziekanowice, site 22. Pollen analysis of the samples from, inhumation cemetery, grave no. 44/94 (Makohonienko et al. 1998)

Fig. 128 Dziekanowice, site 22. Pollen analysis of the samples from graves (A), andsettlement features (B) (Makohonienko et al. 1998)



Subaquatic cultural layers at the Gniezno and Poznań Bridge

The Early Mediaeval settlement on Lednica Island left rich cultural layers and many archaeological finds with a variety of uses (Fig. 128, 129), and it also exerted a peculiar influence on the environment of the inshore waters surrounding the island, manifested in the formation of a specific sediment type which we may term an "underwater cultural layer". The occurrence of such a layer is particularly well marked in the vicinity of the remains of two bridges which used to extend from the island to the lake shore. This layer has been subject to excavations for several years now, as it is abundant in archaeological artefacts. Many cores collected from the bottom sediment below the remains of the Poznan and Gniezno bridge, have been analysed archaeobotanically so far (Fig. 130).

The underwater cultural layer differs considerably from the other sediments on the bottom of Lake Lednica, particularly in its distinctive colour and structure, so that unlike the predominant carbonate sediment in the lake, it is a highly organic, thick detritus gyttja with varying amounts of sand. The greatest recorded depth of the layer is about 80 cm, but it seems that the closer to the shore it is, the deeper it becomes, and those within the abutment of the Gniezno Bridge are 2 m deep.

The only method used extensively to study the cultural layers up to the present has been the analysis of macroscopic plant remains. The main results are presented by Polcyn in hist still unpublished doctor thesis (Fig. 131).The lists of taxa obtained as a result of the analyses of particular cores fall into six groups: algae, aquatic plants, mire plants, trees and shrubs, herbaceous plants, and weeds and cultivated plants. The frequencies of occurrence of these taxa can then be used to produce diagrams of ecological groups, the last two of which, the herbaceous plants and the weeds and cultivated plants, are considered to serve as indicators of the development of the underwater cultural layer. Experience has shown the usefulness of such diagrams for the description and identification of layers of this kind.

Kazimierz Tobolski

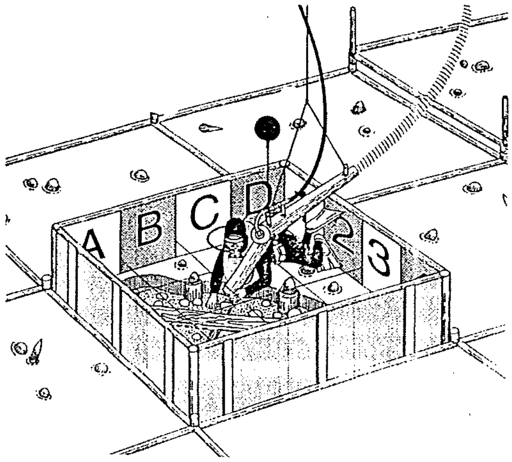


Fig. 128. Scheme of underwater exploration of the bridge relics (Kola 2000)

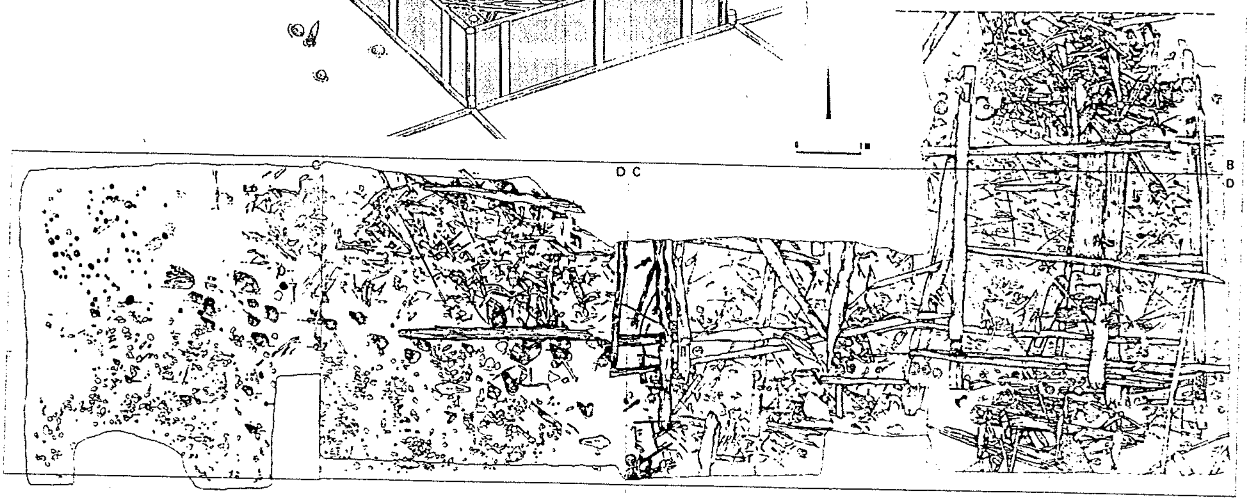


Fig. 129. The Gniezno-bridge.Horizontal projection of uncvered bridge structures (Kola 2000)

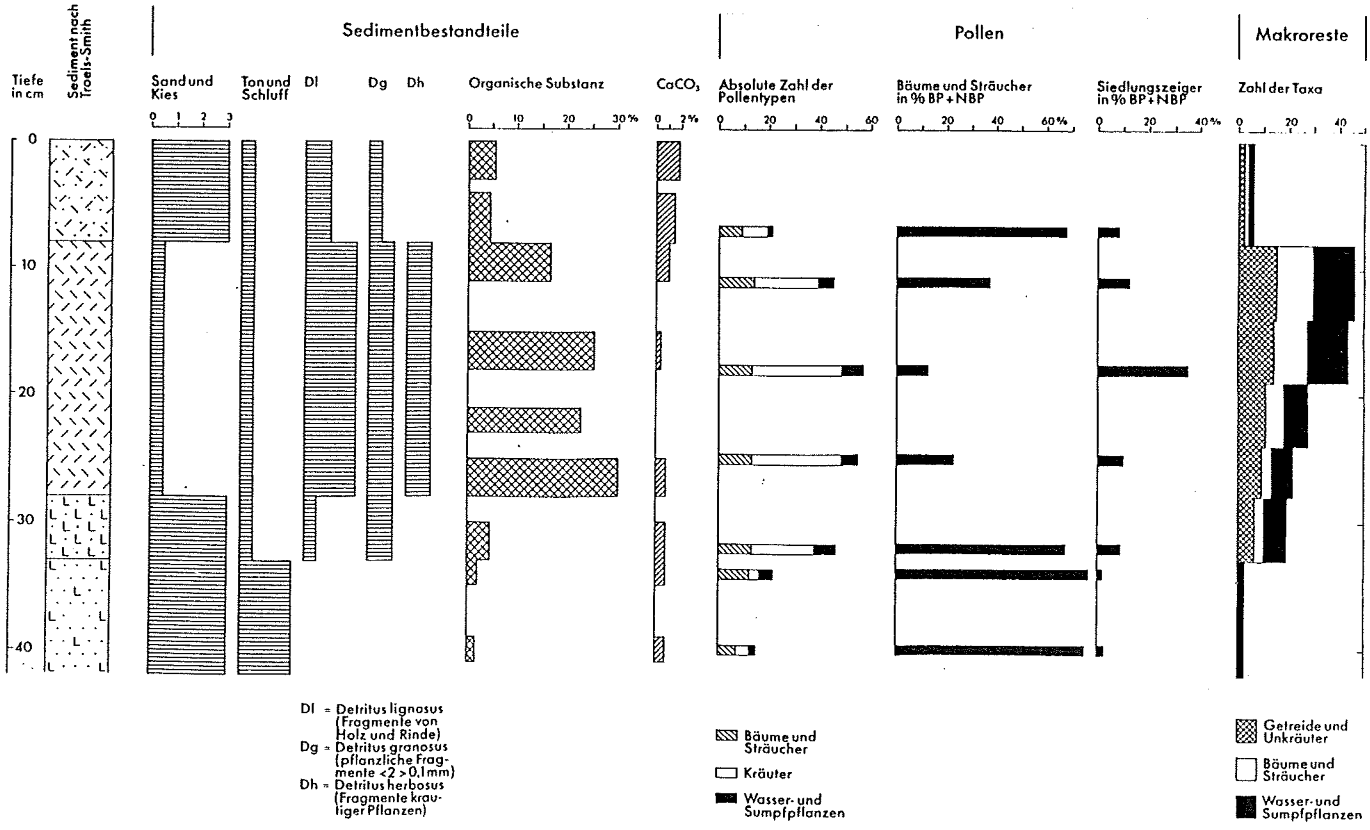


Fig. 130. Sediment components, groups of pollen and plant macrofossils in a subaquatic cultural layer (Tobolski 1990)

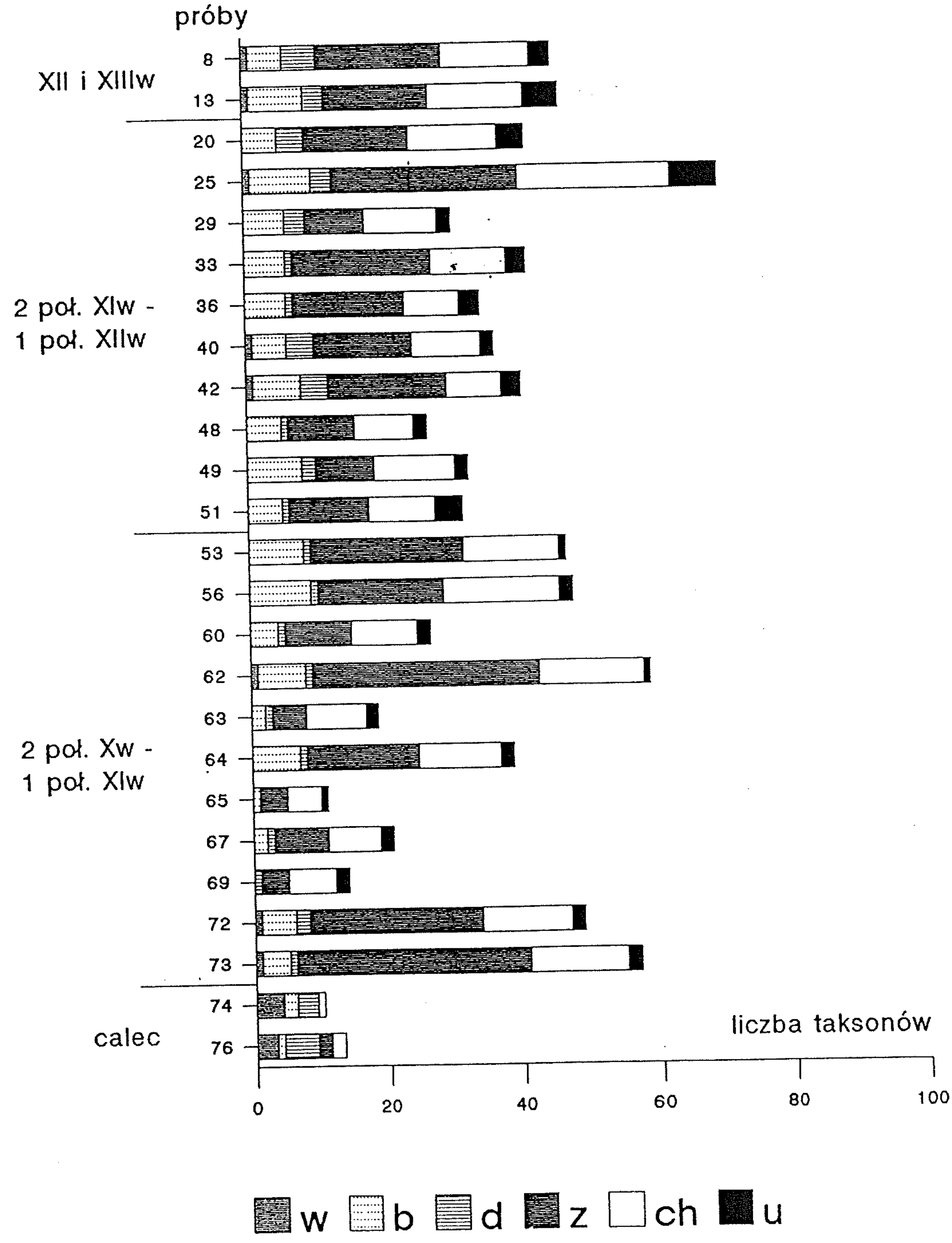


Fig. 131. Diagram of ecological groups of the underwater cultural layer (PMG-2/90): w - aquatic plants, b - telmatophyte, d - trees, z - herbaceous plants, ch - weeds, u - cultivars (Polcyn 1998).

Cladocera (Crustacea) in the sediments of the Lednica Lake and Skrzetuszewskie Lake

An analysis of subfossil Cladocera was conducted on sediment cores taken from two lakes: Lednickie (core I/86) and Skrzetuszewskie (core S/87). The studied lakes are located closly to one another and for centuries have been subjected to the same climatic and environmental impact. However, each reprersents another lake type. Changes in the species composiotion and high variation of specimen frequency in the two lakes allow to reconstruct the development of Cladocera since the begining of the Preboreal period until recently.

Lednickie Lake

Subfossil Cladocera fauna in this lake sediments is presented by 36 species, belonging to 6 families. The obtained results are presented in diagrams showing the total number of individuals and the ratio of planktonic to littoral forms. The data of Cladocera analysis were compared with abudance of some plants reflecting human activity. On the diagrams local Pollen Assemblage Zones (PZ) and phases of human impact are shown, acccording to the results of palynological analyses (Makohonienko, 1991). The eutrophication phases are marked basing on the results on the Cladocera analysis (Figs. 132, 134). The species composition of Cladocera and the variability in the frequency of littoral and plankton specimens make it possible to distinquish 7 zones of their development:

Zone I - corresponds probably with the Pre-boreal period. The species composition of Cladocera indicates, that at that time, the lake possessed a completely developed pelagic and littoral zone, although, this phase was not connected with the initial phase of the lake.

Zone II - corresponds to the Boreal period and partially the Atlantic one. It was characterized by a stable development of planktonic forms, with simultaneous gradually increasing frequency of the eutrophic species of *Bosmina longirostris*.

Zone III - corresponds to the Atlantic period. It is a period of a great frequency of planktonic forms; their share grew up to 85 %.

Zone IV - corresponds to the first half of the Subboreal period. The species composition of plankton is reminiscent to that found for this period in other lakes. In this period, considerable fluctuations of water level were usually found, which was connected with changing climatic conditions, as well as an increase in trophy, which was probably the result of man's activity. In Lake Lednickie, a similar state was found, although it was registered on a much smaller scale. This probably results from morphometric differences of hitherto investigated lakes. Lake Lednickie, of large surface and quite deep, reacted more slowly and to a lesser extent to the influx of eutrophic substances.

Zone V - corresponds probably to the second half of the Subboreal period. The species composition continues to show a rather high water level, and a fluctuation of the species connected with more fertile waters, and to a changing trophic state, which, in the case of Lake Lednickie, probably oscillated around the level of mesotrophy.

Zone VI - corresponds probably to the Subatlantic period. This period, in most of the investigated lakes, was characterized by a considerable growing share of species preferring eutrophic waters: *Alona rectangula, Chydorus sphaericus* and *Bosmina longirostris*. This was probably a result of economic activity of settlers gathering around the lakes. In Lake Lednickie, there was also a greater share of these species indicated, although it does refer to the presence of *Bosmina longirostris* to a lesser degree.

Zone VII - corresponds to the most recent part of the Subatlantic period. The species composition of Cladocera changed considerably in comparison to the previous zone. There was an increased count of littoral forms. Planktonic forms, even the eutrophic species *Bosmina longirostris*, showed a decreased frequency. This phenomenon was accompanied by an increased share of hitherto not too frequently occurring *Chydorus sphaericus*. As was shown in the investigations of sediments and waters of other lakes, this species often occurs in the open water zone and accompanies the *Pediastrum*.

Skrzetuszewskie Lake

This lake is located in a perpendicular branch of the Lake Lednickie. The lakes are separated by a raised threshold, whose existence caused differences in the sediments of both lakes.

An analysis of subfossil Cladocera was conducted on sediments from a depth of 6.70-12.50 m, which were deposited from the Atlantic period to contemporary times. The results is shown in diagrams showing the total number of individuals and the ratio of planktonic to littoral forms. (Figs. 133, 134). The data of Cladocera analysis were compared with palynological results (Tobolski, 1991).

The Cladocera fauna is represented by 39 species belonging to 5 families. The main component of plankton, was the eutrophic species *Bosmina longirostris.* The remains of littoral species, amounted 20-50 %. The changing frequency of individuals and species, showed such a similarity to the remaining lakes, that for Lake Skrzetuszewskie, the same numeration for zones was chosen as in the remaining lakes it means from the Atlantic period, three phases of Cladocera development, beginning with Zone III (Fig. 2) were distinguished.

Zone III - occurred in the transition period and includes the final phase of the Atlantic period and the beginning of the Subboreal. This phase was characterized by stabilization of development among the Chydoridae species. Among the planktonic species, there was a simultaneous occurrence of species from the family Bosminidae and Daphnidae.

Zone IV - probably occurred during the second half of the Subboreal period. Plankton was dominated by the eutrophic species *Bosmina longirostris*, and among the littoral taxons *Alona rectangula* and *Pleuroxus.*

Zone V - which included continuation of the Subboreal period and the beginning of the Subatlantic period. In the lake, one species was dominant - *Bosmina longirostris*, which indicates a progressive eutrophication of the lake. Near the end of this phase, there was a fall in the share of this species, which may suggest stabilization of the eutrophication process, perhaps connected with the cessation of influences of human economy.

Zone VI - probably lasted from the middle of the Subatlantic period until contemporary times. Following the reduction of trophy, which was found at the end of Zone V, there was again a renewed process of eutrophication in the lake, which exists to this day. In this period, the dominant species was found to be *Chydorus sphaericus*, which indicates an advanced eutrophication and development of *Pediastrum* .

History and variations in the development of the two lakes of the Lednica Landscape Park

The investigated sediments of the two considered lakes were deposited in the Holocene period. These Lakes were subjected to the influence of climatic changes, which occurred from Preboreal times onward, as well as ecological changes, which were caused by the presence of humans. The closely located lakes, were exposed to practically the same conditions, which influenced the lakes in different ways. Since each of them, physically represents a different type of lake, as a result, their reaction to climatic and anthropogenic influences was somewhat different.

It is known that eutrophication is a normal and gradual biological process. This process becomes more intensive as the result of a decreasing water volume, caused by a filling in of the basin by bottom sediments. The most significant influence, however, on the fertility of waters is exerted by the excessive supply of nutrients. Excessive eutrophication is the most unwanted anthropogenic disturbance to the functioning of the lakes. In these lakes, among the species of groups indicating increased trophy were present: *Bosmina longirostris, Alona rectangula, Leydigia acanthoceroides, Pleuroxus uncinatus* and *Chydorus sphaericus.* As research on contemporary waters has shown, the lakes of the Lednica Landscape Park, presently represent a differentiated state of trophy . As well, in the Holocene period of development, in each one of them, the course of changes took place somewhat differently.

In the sediments of Lake Lednickie, an increased state of trophy was found only twice: in the middle phase of the Subboreal period and in the Subatlantic period (Figs. 132, 134). In the sediments of Lake Skrzetuszewskie, an increase of trophy was noted 5 times. The first one occurred at the end of the Atlantic period, the subsequent two during the Subboreal period, whereas the fourth and fifth occurred in the Subatlantic, when the plankton was dominated by one species, *Bosmina longirostris.*

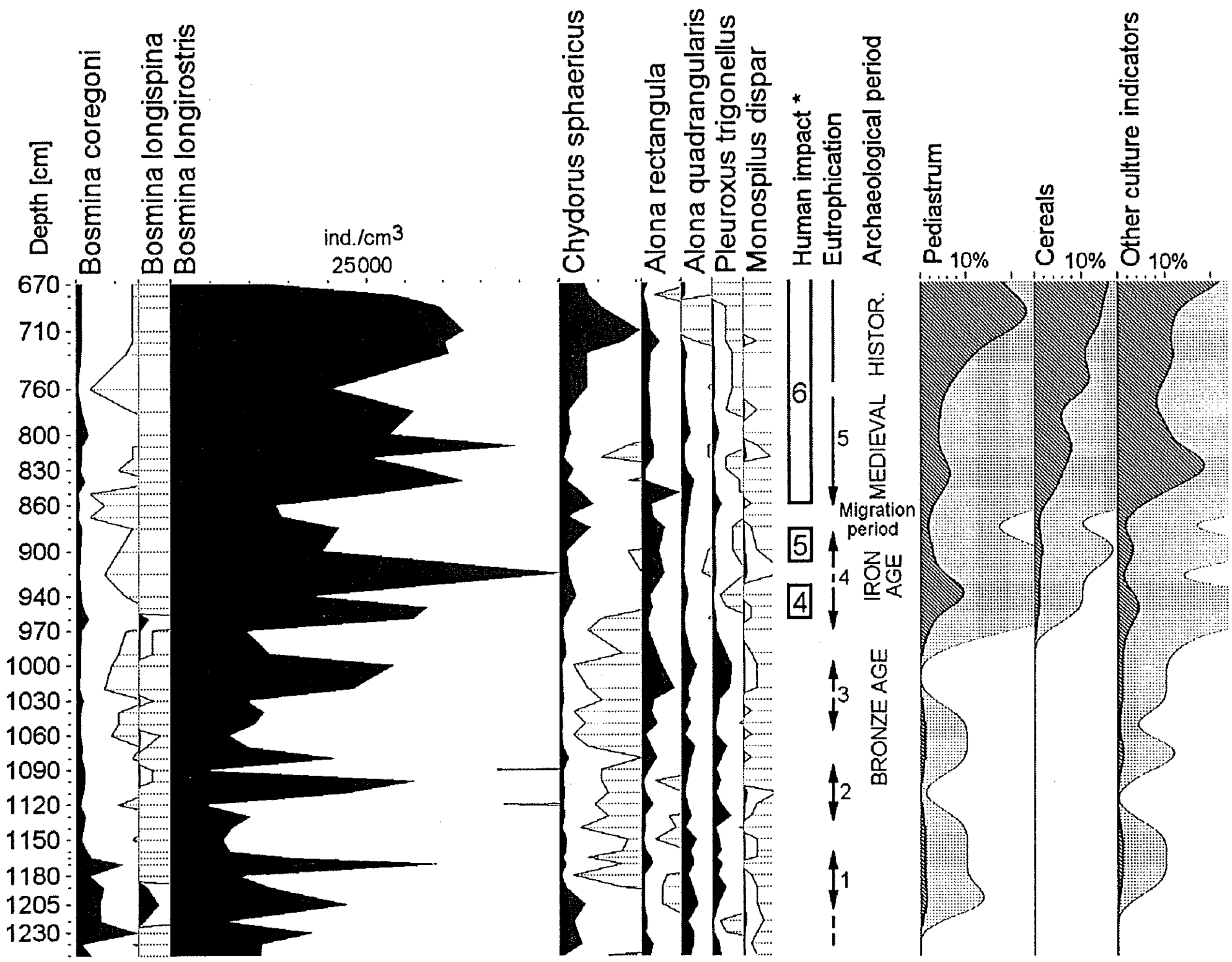


Fig. 133. Selected Cladocera and pollen taxa compared with phases of human impact and eutrophication of Lake Skrzetuszewskie, profile S/87 (From Szeroczyńska, 1998). For explanations – see Fig. 134.

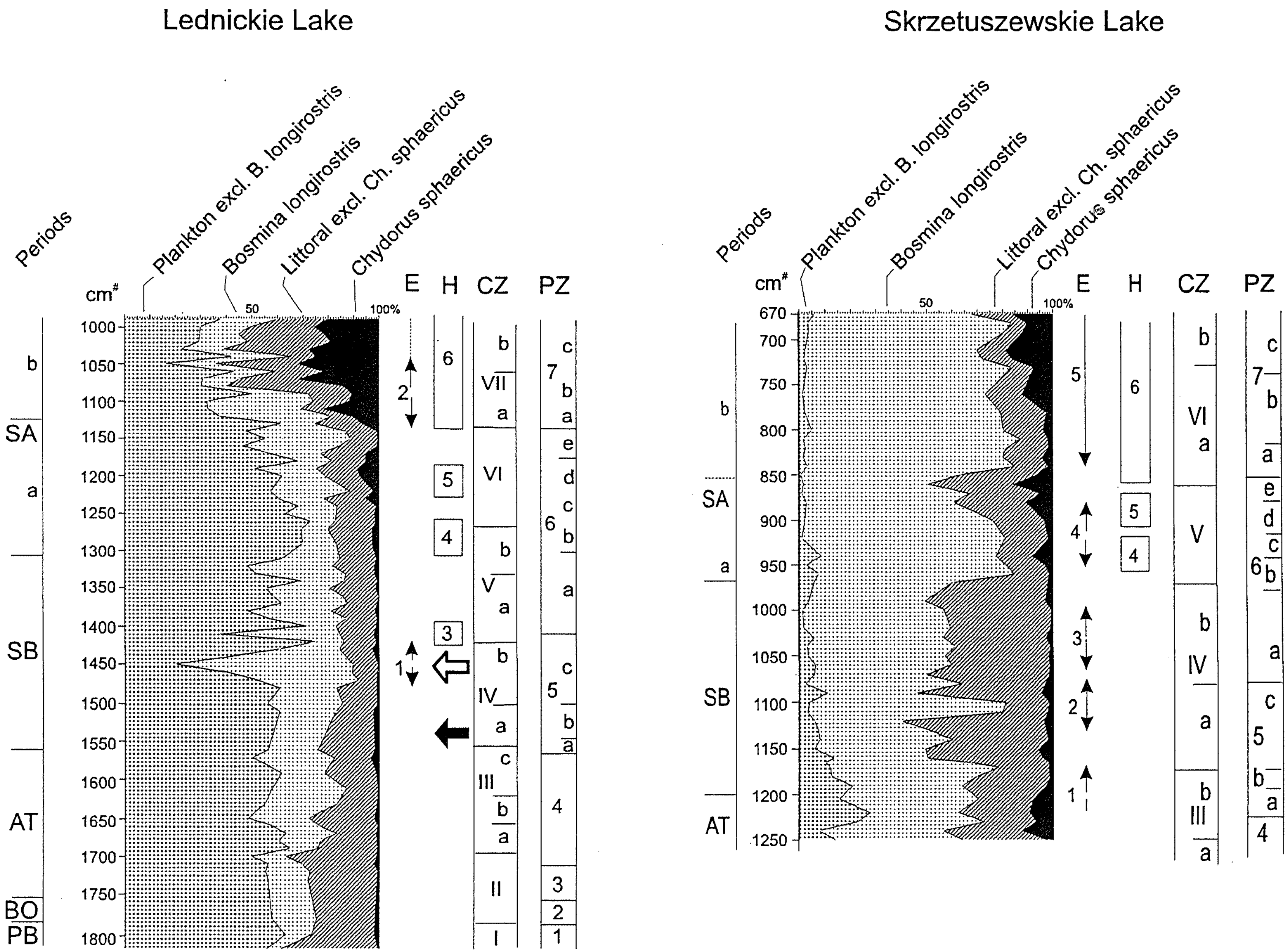


Fig.134. Ratio of planktonic to littoral forms of Cladocera in the sediments of lakes Lednica Landscape Park. E eutrophication, CZ cladoceran zones, H human impact, PZ pollen assemblage zones (after Makohonienko 1991 Lednickie, after Tobolski 1991 Skrzetuszewskie lake), # - depth below water, arrow white - presence of *Triticum,* black *Plantago lanceolata.*

Late-Glacial flora

The Lednica Landscape Park contains some sites with remains of periglacial tundra (the Dryas flora) including (among other) *Salix herbacea*, *Dryas octopetala* and several sites with Late-Glacial plant remnants deposited in the bottom layers of different sedimentation basens (norther part of Lednica Lake, fossil lake on Ostrów Lednicki island, narrow “channels” – elongated ground depressions, scattered on both sides of the Lednica Lake). Some results illustrating the earlier investigations are presented on Fig. 135-137. Pollen and macrofossil analysis concerning the Prealleröd sediments from Central Great Poland and Kujawy Lowland are in progress. Preliminary results from a Hamburgian settlement at Mirkowice near Janowiec Wielkopolski shows Fig. 138.

Kazimierz Tobolski

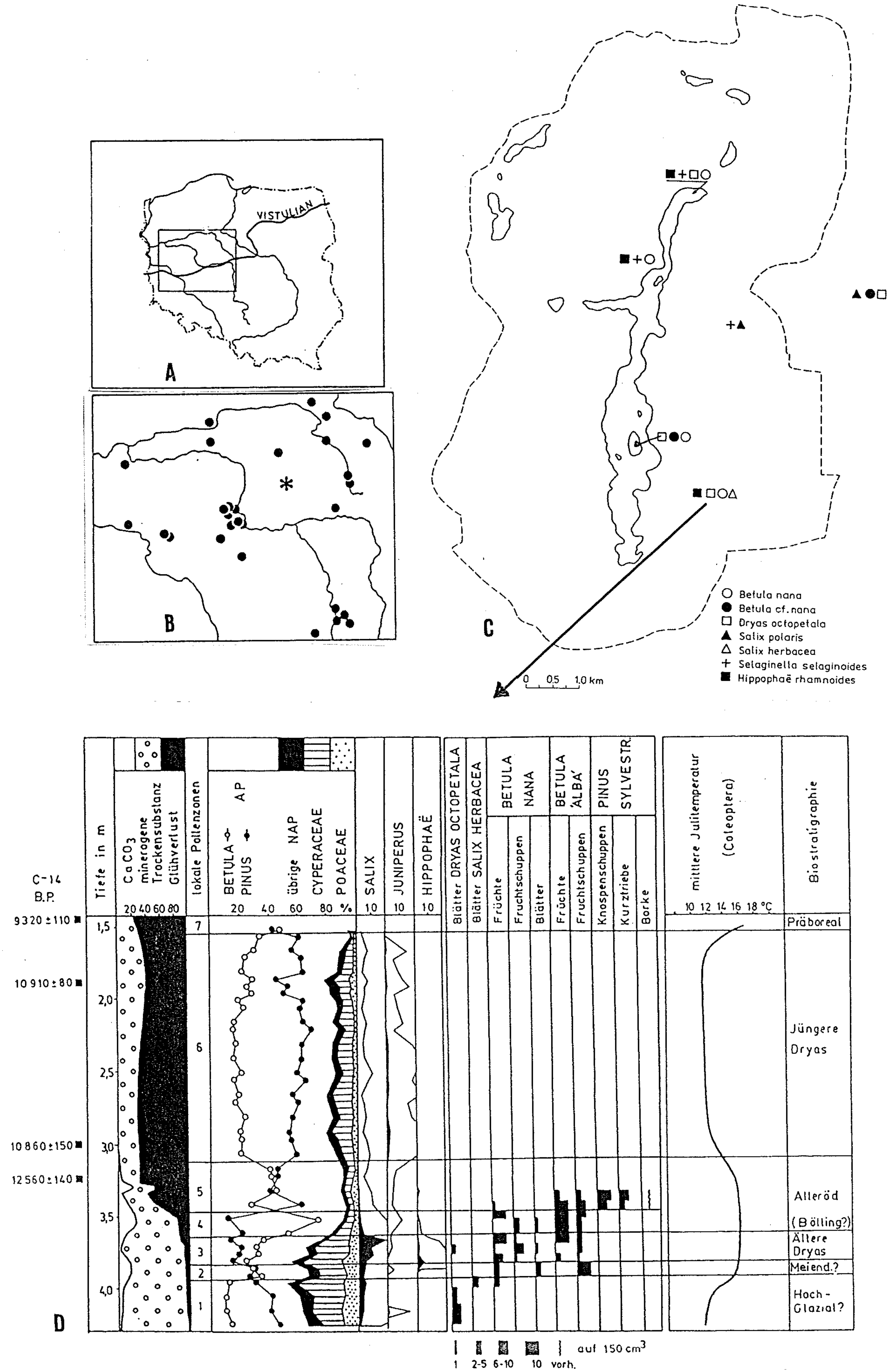
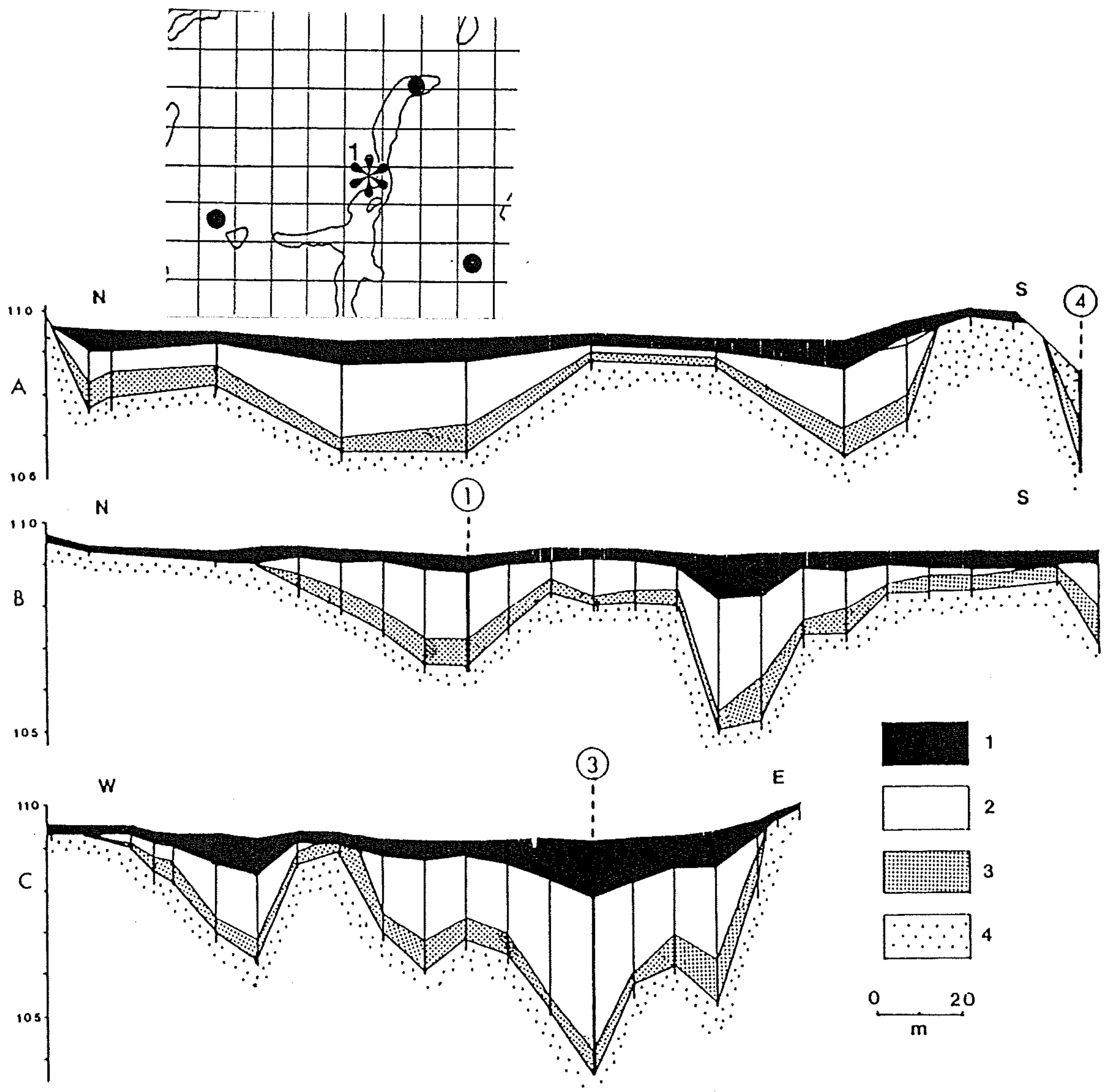


Fig. 135. Late-Glacial flora in the vicinity of Lednica Lake: a, b - more important localities with Late-Glacial sediments c - Lednicki Ladscape Park, d - Dziekanowice; simpified pollen- and macrofossil diagram (Litt 1994).



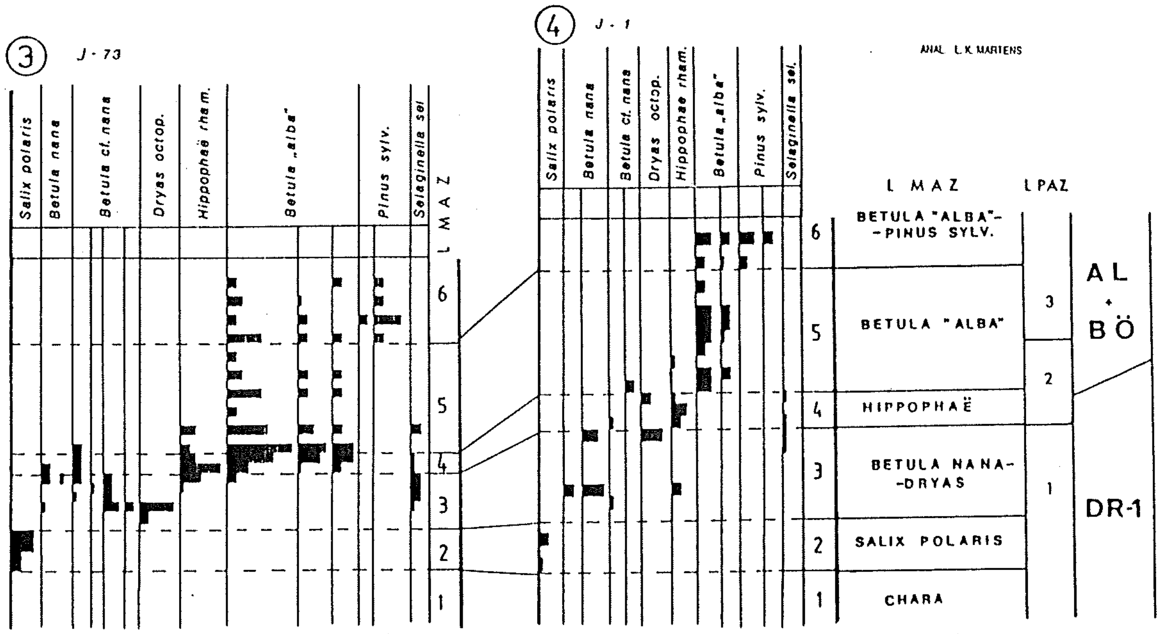


Fig. 136. Imiołki (Tobolski, Litt 1994).

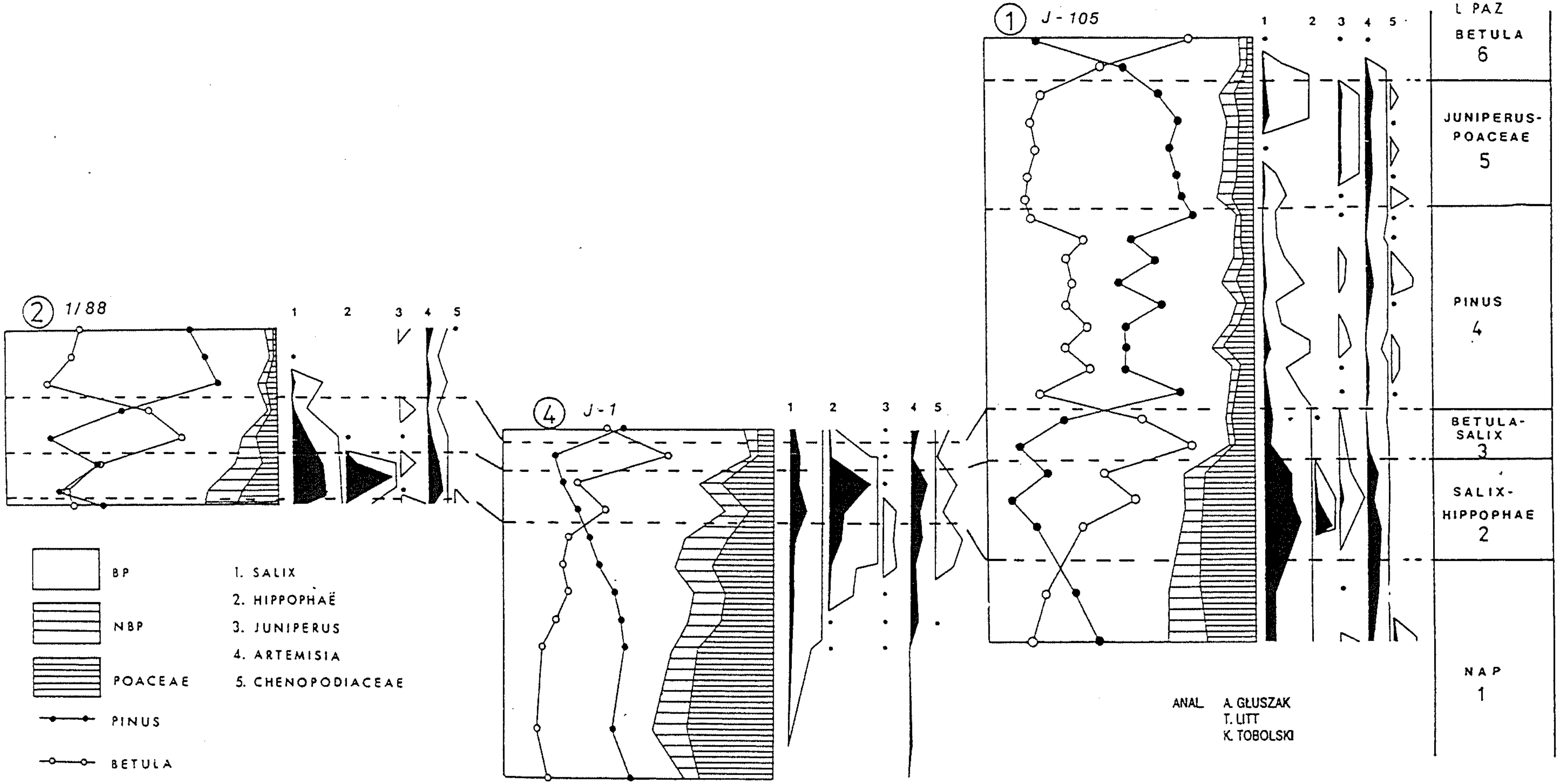


Fig. 137. Imiołki (Tobolski, Litt 1994).

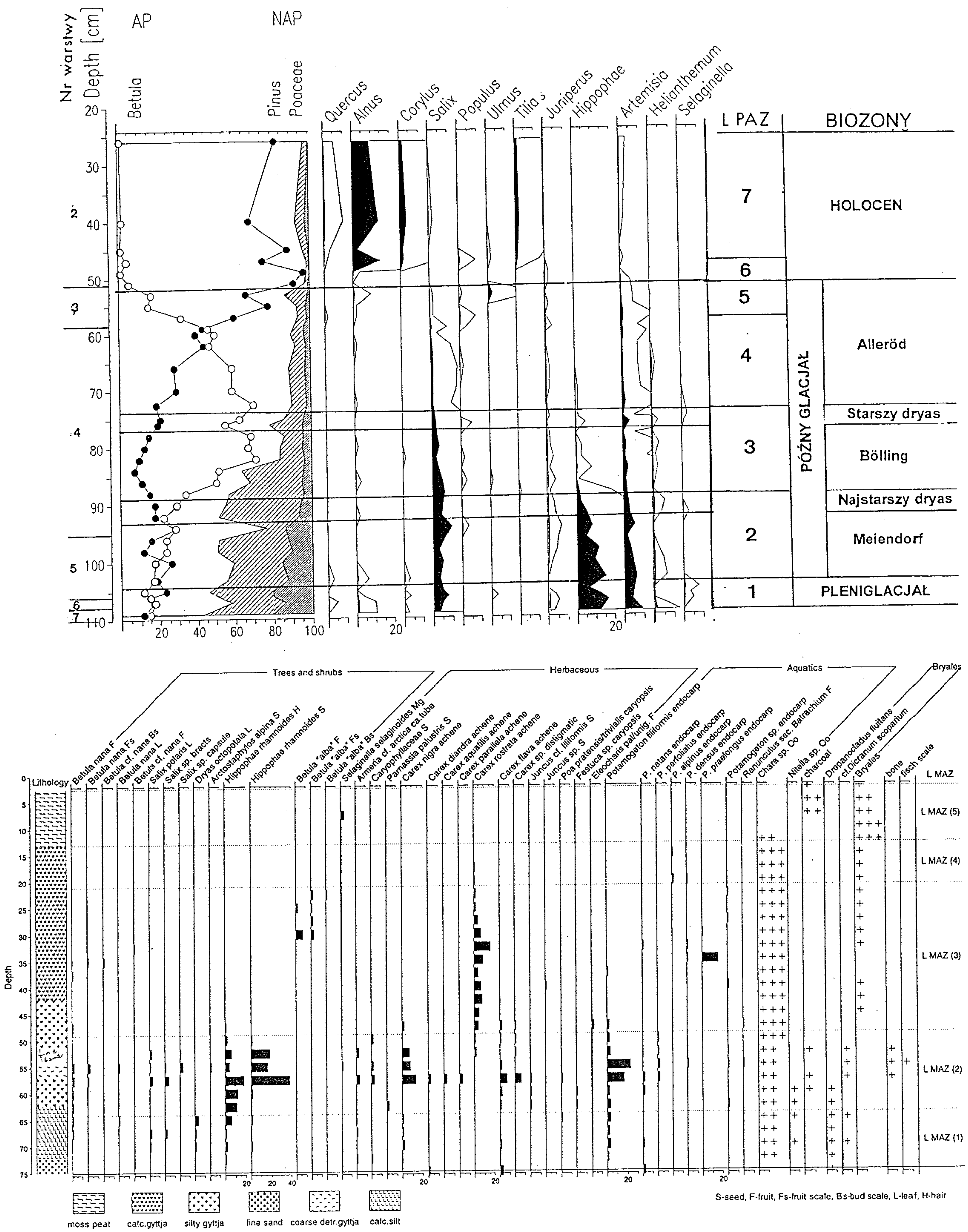


Fig. 138. Mirkowice near Janowiec Wielkopolski. Simplified pollen and macofossil diagram.

Gniezno – vegetation history and human impact recorded in the sediments of Świętokrzyskie Lake

Historical Gniezno was a centre of the early medieval Polish state in the times of Mieszko the I (920/940 – 992 A.D.) and his son Boleslaw Chrobry (967 -1025), the founders of the Piast Dynasty, place of first coronation (1025 A.D.) in the Polish history and seat of archbishop (since). Archaeological studies well confirmed historical significance of the place and reconstructed the beginnings of early medieval open settlement in Gniezno Hill to the tern of 8/9 century A.D. and the first stronghold with wooden-earthen rampart construction dated between 940-980 A.D.

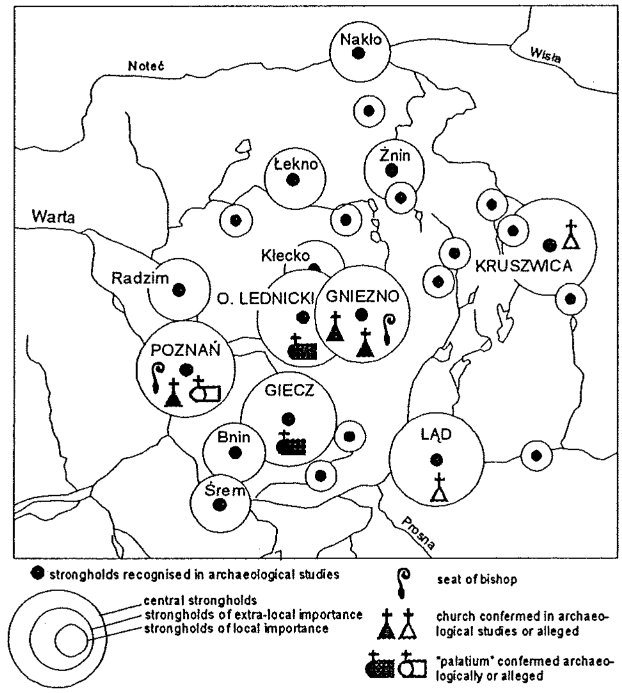


Fig. 139 Location of strongholds in Central Great Poland in early piast period during (second half of the 10th to half of the 11th century A.D.), acc. to Kurnatowska 1987.

Palaeoecological studies of the sediments from Świętokrzyskie (Holly Cross) Lake were curried out to reconstruct Holocene vegetation changes and development of settlement processes of the Gniezno region in a long time perspective. Chronology of the core was established by palynological correlation with well-dated cores of Skrzetuszewskie Lake located in a distance of 16 km. The following stages in the development of Holocene vegetation were recognised:

- Phase of pine forest with *Juniperus communies* in the undergrowth (prior to 9700 uncal.BP)
- Phase of pine-birch forests with initial spread of *Ulmus* and *Corylus*(9700-8450 uncal.BP)
- Early phase of deciduous forest with *Qurcus, Ulmus, Tila, Fraxinus* and significant role of *Coryllus avellana* coincided with rapid expansion of *Alnus* (8450-7550 uncal.BP)
- Mature phase of deciduous *Qurcus-Ulmus-Tila-Fraxinus* forests, marked by appearance of *Acer* (7550-5250 uncal.BP)
- Phase of elm destruction (5250-4950 uncal.BP)
- Phase of elm regeneration (c.4950-4500 uncal.BP)
- Phase of elm and ash decline, evidence of Carpinus migration 4500-4300 uncal.BP),

- Subsequent phase of elm regeneration (4300-4100 uncal.BP)
- Phase of initial expansion of *Carpinus betulus* (4100-3500 uncal.BP)
- Phase of hornbeam forests domination (with stages of human induced deforestations, and stages of forest regeneration)(3500 uncal.BP to c.8 century A.D.)
- Since c.8th century A.D. predominance of open vegetation, cultural landscape, remnants of deciduous forests and increase of pine representation
- Since 12th century A.D. further spread of open habitats, intensification of rye cultivation, appearance of communities wit *Juniperus communis*
- Since the beginning of 20th century, decline of pine representation, urban plantations of deciduous trees; *Tilia, Ulmus, Fraxinus, Aesculus hippocastanum*

First more clear evidence of human activity appeared during the later phase of first elm decline and could be connected with the penetration of Funnel Beaker Culture groups of the middle Neolithic. Pollen data indicate rather weak Neolithic settlement activity. Intensification of habitation processes occurred since the Bronze Age, most probably since the third period of BA and would be connected with the Lusatian Culture. The scale of deforestation was higher than in the neighbouring Lednica region. Settlement activity of the Bronze Age resulted in destruction of hornbeam forests and promoted development of birch stands in the landscape, which maintained their broader distribution until 14th century A.D.

Settlement activity of the Early Iron Age (Halstatt period) was strongly pronounced in pollen record by evidence of cutting out deciduous trees - hornbeam, oak, lime, elm and ash. Next phase of intensive anthropogenic activity was correlated with the settlement of Przeworsk Culture (dated approximately to the period of Roman influence). This phase was characterised by selective cutting hornbeam trees and likely purposeful protection of oak stands. The Przeworsk Culture settlement phase was followed by full regeneration of forest cover indicating break in settlement process. The new settlers connected with the early medieval period and represented Slavic ethnicity entered depopulated area. Palaeobotanical data from Gniezno region clearly indicate discontinuity between settlement phase of Roman influence period and the earliest phases of Medieval Age.

Palynological record from Świętokrzyskie Lake was used to estimated Holocene changes of floristic diversity. The results showed progressive trend. Essential change due to increase of herbaceous elements occurred since the first elm decline showing in the subsequent stages close correlation with anthropogenic phases. Changes in terrestrial environments induced by elm decline influenced strongly biodiveristy of lake ecosystem as well. Most pronounced changes in terrestrial environments were observed since the early medieval times along with process of extensive deforestation and diversification of habitats. Tendency to increased floristic diversity was reversed in last century.

Two cores of sediments from Świętokrzyskie Lake were subjected to pollen analysis. Core Sw 1/89 was taken from the littoral zone, and core Sw 3/91 from the central part of the lake basin where it has a depth of 6.5m. The sediments from the littoral zone, which is now 0.5m below water level, consisted of gyttja at the bottom, overlain with peat, on which a thin layer of gyttja accumulated. Through the palynological correlation of the cores, the lowermost gyttja of the littoral zone was found to start accumulating during a high water stage some 4500-4300 years BP, after which time peat was being deposited until around 4000 BP. The gradual drop in the water level put a stop to peat accumulation. In modern times, gyttja started to accumulate on the peat again as a result of a rise in the water level. A longer sedimentary hiatus in late Holocene was observed as well in the core (Wal/87) from the nearby Lake Lednica taken at the water depth of 6.65m. The sedimentary break started in this profile around 3000 BP. The high water-level episode discovered in the sediments of Lake Świętokrzyskie, followed by a prolonged downward tendency, is consistent with the reconstruction of the effective precipitation for Poland during Holocene proposed by Ralska-Jasiewiczowa and Starkel (1991).

Mirosław Makohonienko

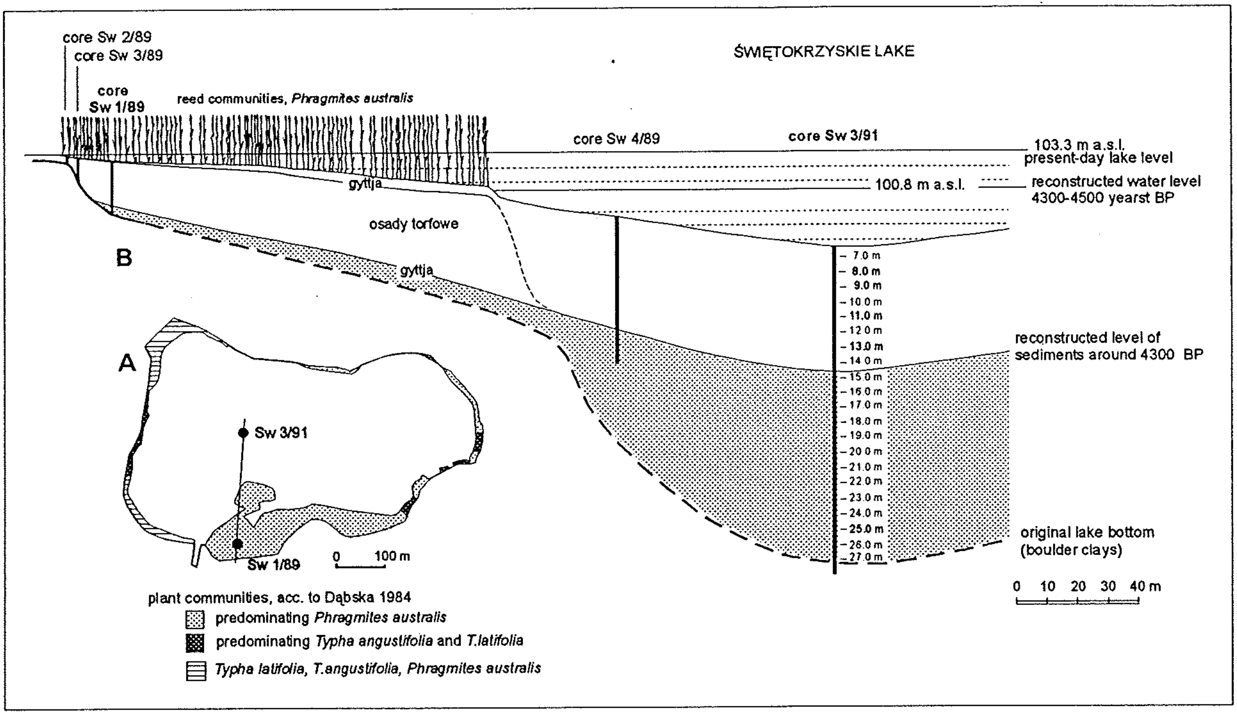
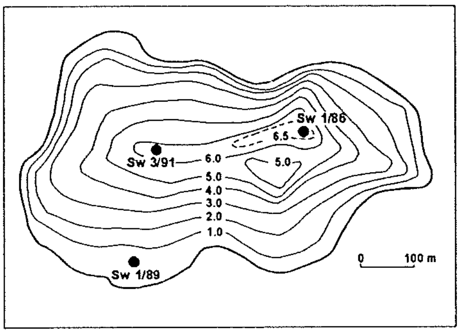
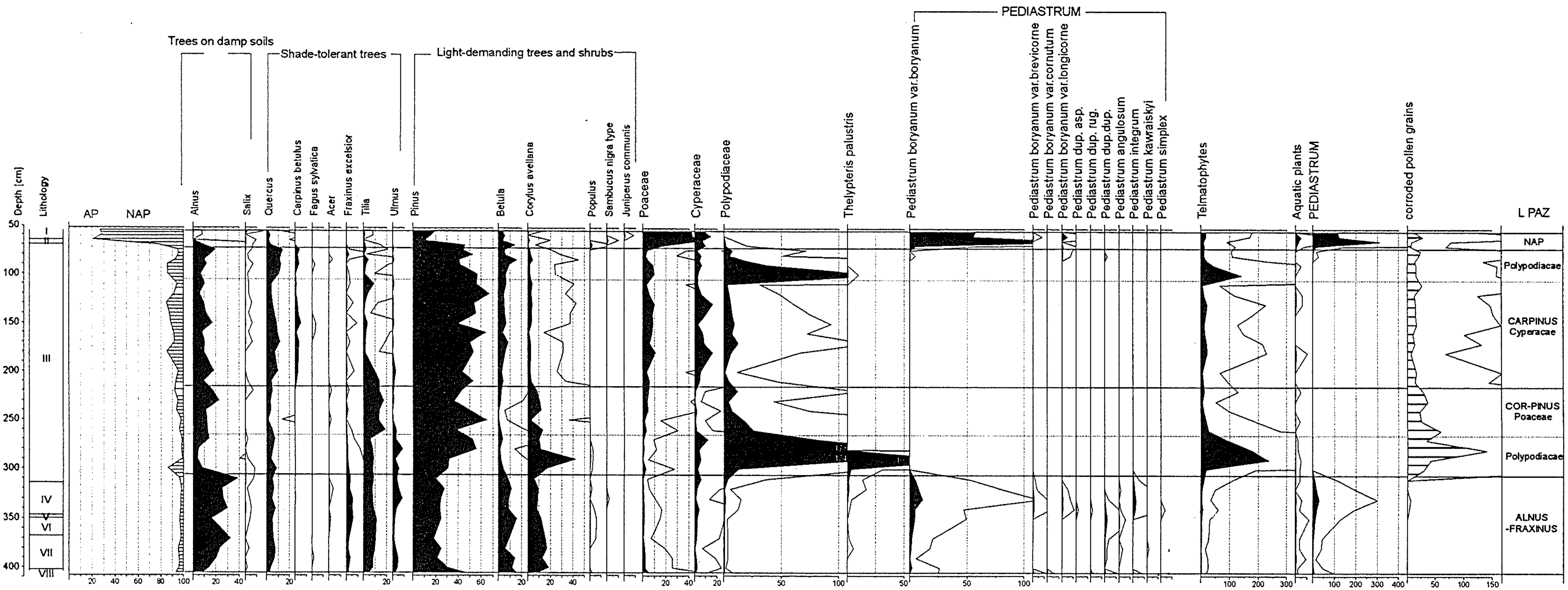


Fig. 140. Świętokrzyskie Lake in Gniezno, A) Plant communities of the lake according to Dąbska (1984) and the direction of the transect with the profiles examined using pollen analysis. B) Contemporary distribution of sediments and reconstruction of the water level and depth of sediments in the period 4500-4300 BP.

Fig. 141. Bathymetry of Świętokrzyskie Lake





I - calcareous gyttja, II - sand, III - weakly decomposed peat, IV - coarse detritus gyttja, V - calcareous fine detritus gyttja, VI - wood, VII - sandy calcareous gyttja, VIII - morainic clay

Fig. 142. Świętokrzyskie Lake in Gniezno, core Sw 1/89 taken from littoral zone - percentage diagram of selected pollen taxa and *Pediastrum*.

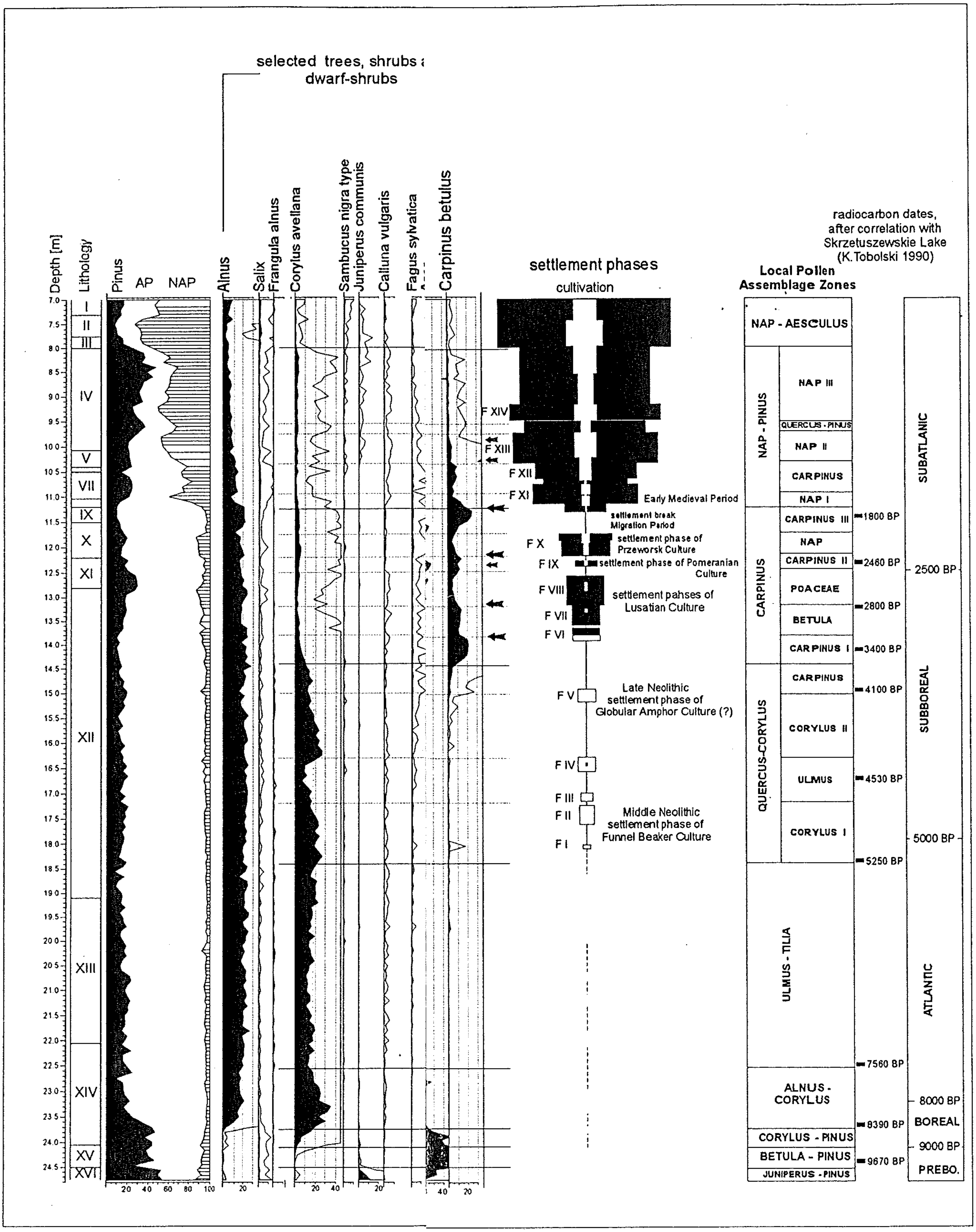


Fig 143 GNIEZNO, Świętokr
illustrating human impact on

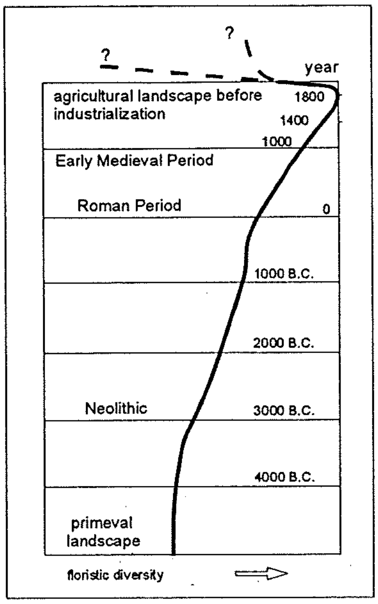


Fig. 145. Changes in floristic diversity in CentralEurope during last 7000 years, after Fukarek, 1979 (from Kornaś and Medwecka-Kornaś 1986)

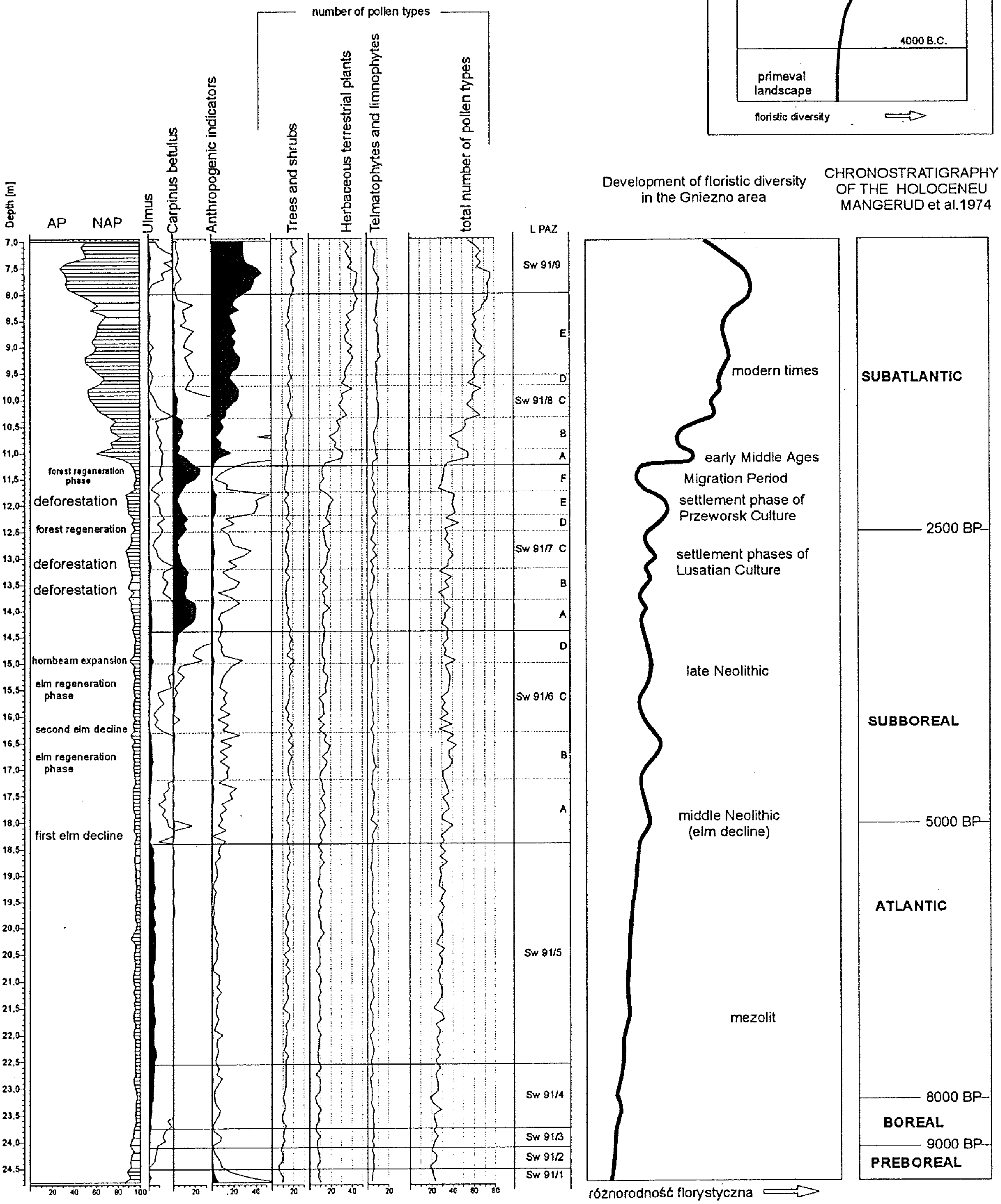


Fig.144. Development of floristic diversity during Holocene based on palynological results from Świetokrzyskie Lake.

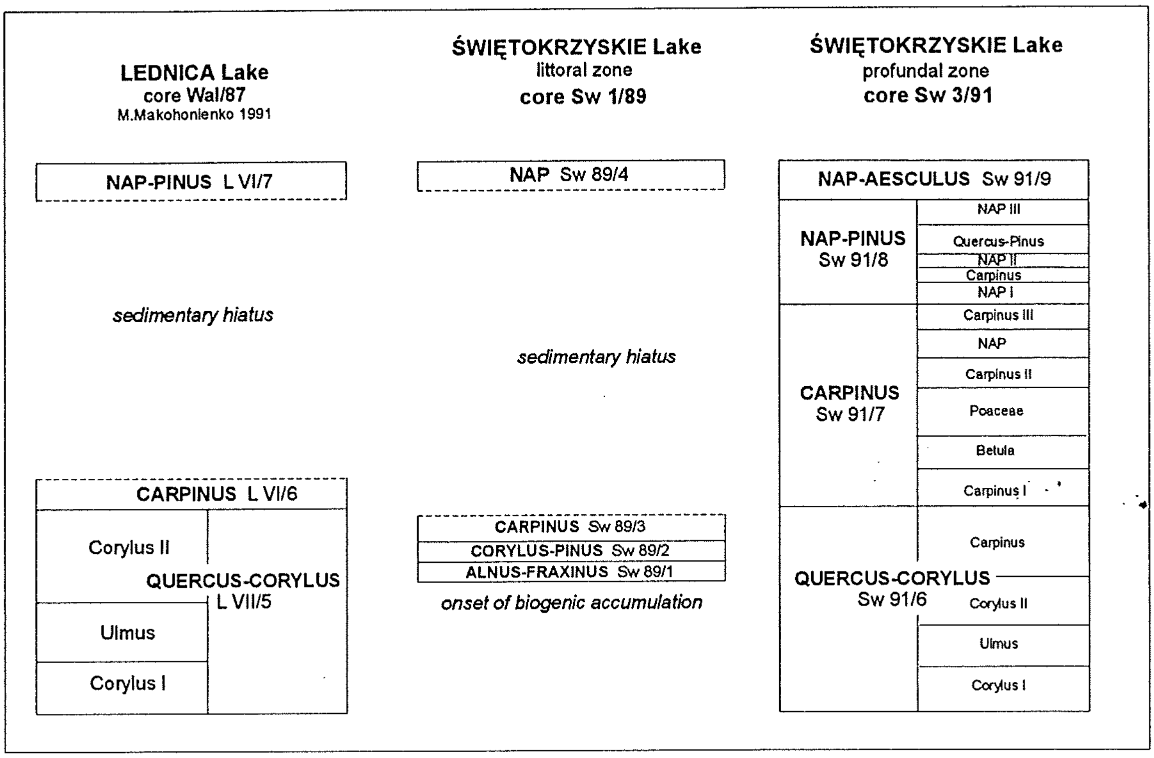


Fig. 146. Correlation of local pollen assemblage zones in the sediment cores from lakes Świętokrzyskie and Lednica Lake (core Wal/87) and Lednica in the late Holocene.

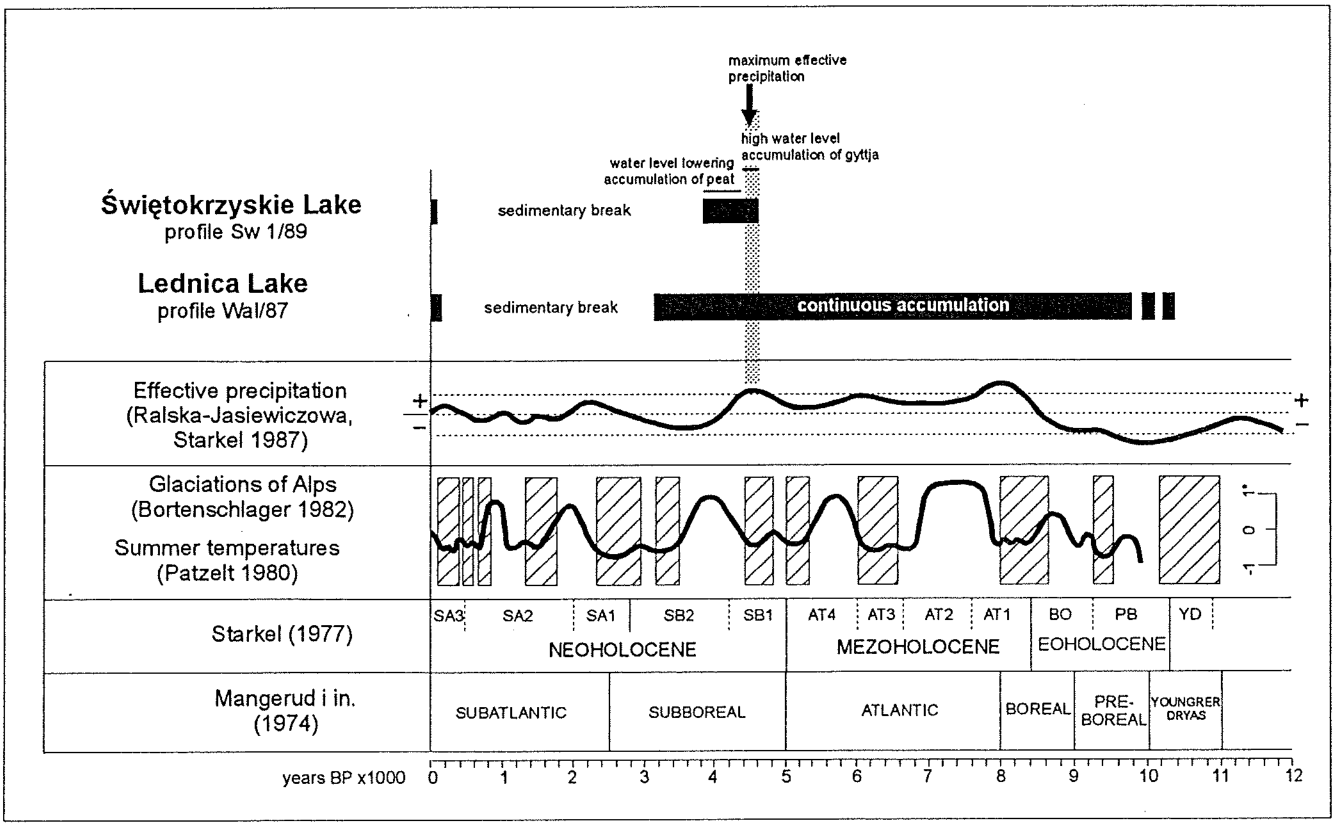


Fig. 147. Comparison of periods of accumulation and sedimentary breaks in the cores from lakes Świętokrzyskie and Lednica and their corresponding palaeoclimatic reconstructions, after Ralska-Jasiewiczowa and Starkel (1991).

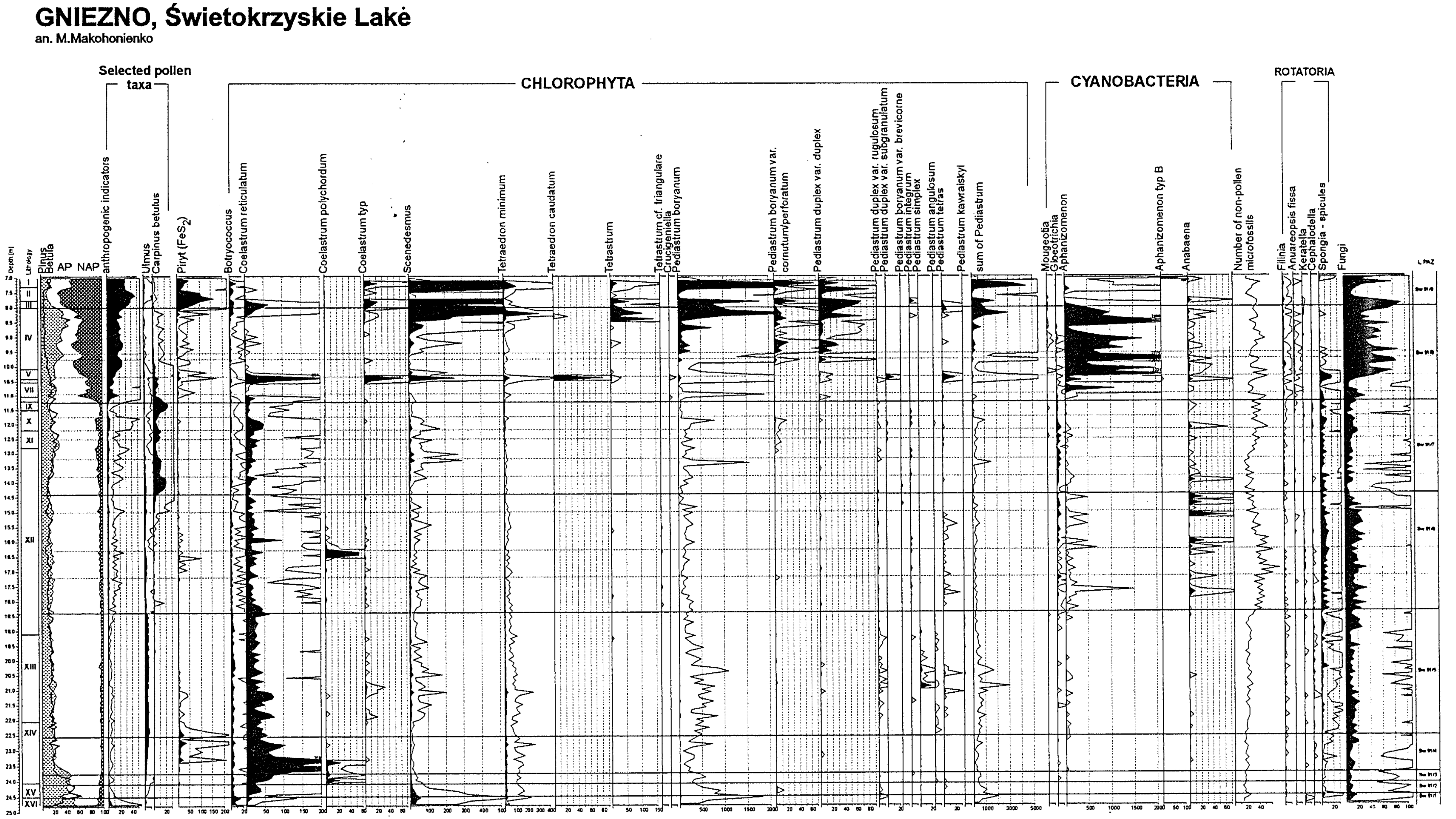


Fig. 148. Świętokrzyskie Lake - core Sw 3/91. Percentage diagram of selected non-pollen microfossils, calculations based on sum AP+NAP =100% without telamtophytes and limnophytes. Exaggeration curves for Aphanizomenon and the sum of Pedistrum x100, for the other taxa x10.

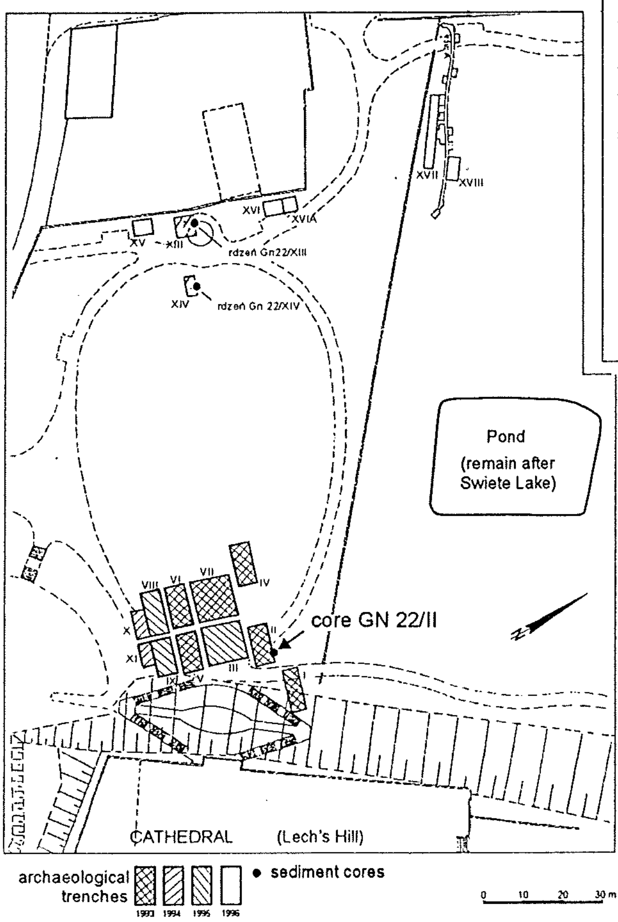
Subfossil remains of parasites in culture layers of the bank zone of the former Święte Lake (Holy Lake) in Gniezno

During the pollen analyses of culture layers in the bank zone of the former Święte Lake (Holly Lake) in Gniezno, at the foot of an early medieval stronghold on the top of Góra Lecha (Lech's Hill), assemblages of parasite microfossils were found, identified as *Ascaris* and *Trichuris (Platyhelminthes, Nematoda)*. Fossil eggs of *Ascaris* could have been represented by two species *Ascaris lumbricoides*, human parasite, or *Ascaris suum*, being pig parasite. *Trichuris* remains may have originated from *Trichuris trichura* or *T. suis*, the first one being human parasite and the second pig parasite. Morphological features of the fossil eggs do not allow distinction on the species level. The finds were discovered in layers coming from the Roman-influence period and the early Middle Ages. In the layers from the Roman-influence period the maximum concentration of *Ascaris* eggs was about 240, and of *Trichuris* eggs, 390 per 1 cm^3 of sediment. In the early medieval times the concentration of *Ascaris* and *Trichuris* eggs increased, respectively to 1140 and 2040 per 1cm^3 of sediment. The presence of microfossils of parasites, excreted from the body with faeces, throws light on the process of sediment formation in the bank zone, and on potential source of eutrophication of habitats in the past times. The fossils may have got into the sediments together with waste from the stronghold, possibly also as a result of pigs being pastured or people defecating.

Fossil remains of parasites from Poland have been previously reported from two dead bodies found in a peat in former East Prussia (Szidat 1944), and belonging to *Trichuris trichiura*, *Ascaris lumbricoides* and *Diphllobotrium latum*. Eggs of parasite *Fasciola hepatica* were found in coprolites from a cultural layer of the Lusatian Culture fortified settlement in Komorowo (Great Poland) (Kowalski et al. 1976).

Mirosław Makohonienko

Fig. 149. Gniezno, former Swiete Lake at the foot of Lech's Hill, archaeological site 22, location of trenches and sampled cores for palaeocological studies.



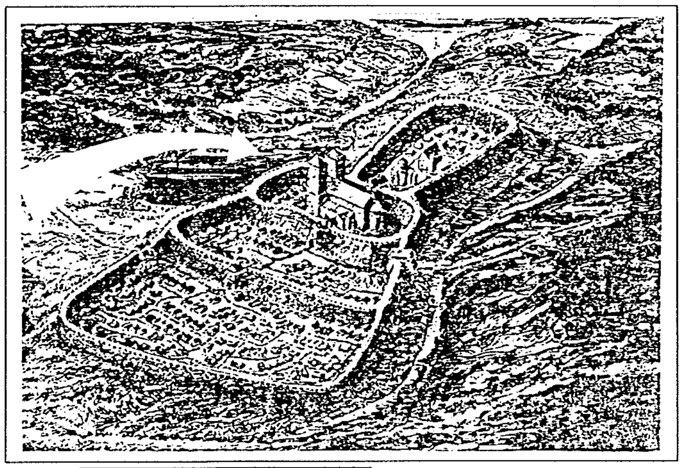


Fig. 151. Reconstruction of the Gniezno stronghold

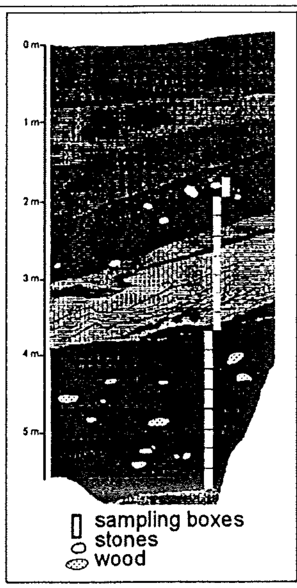


Fig. 150. Cultural layers of the site 22, trench II

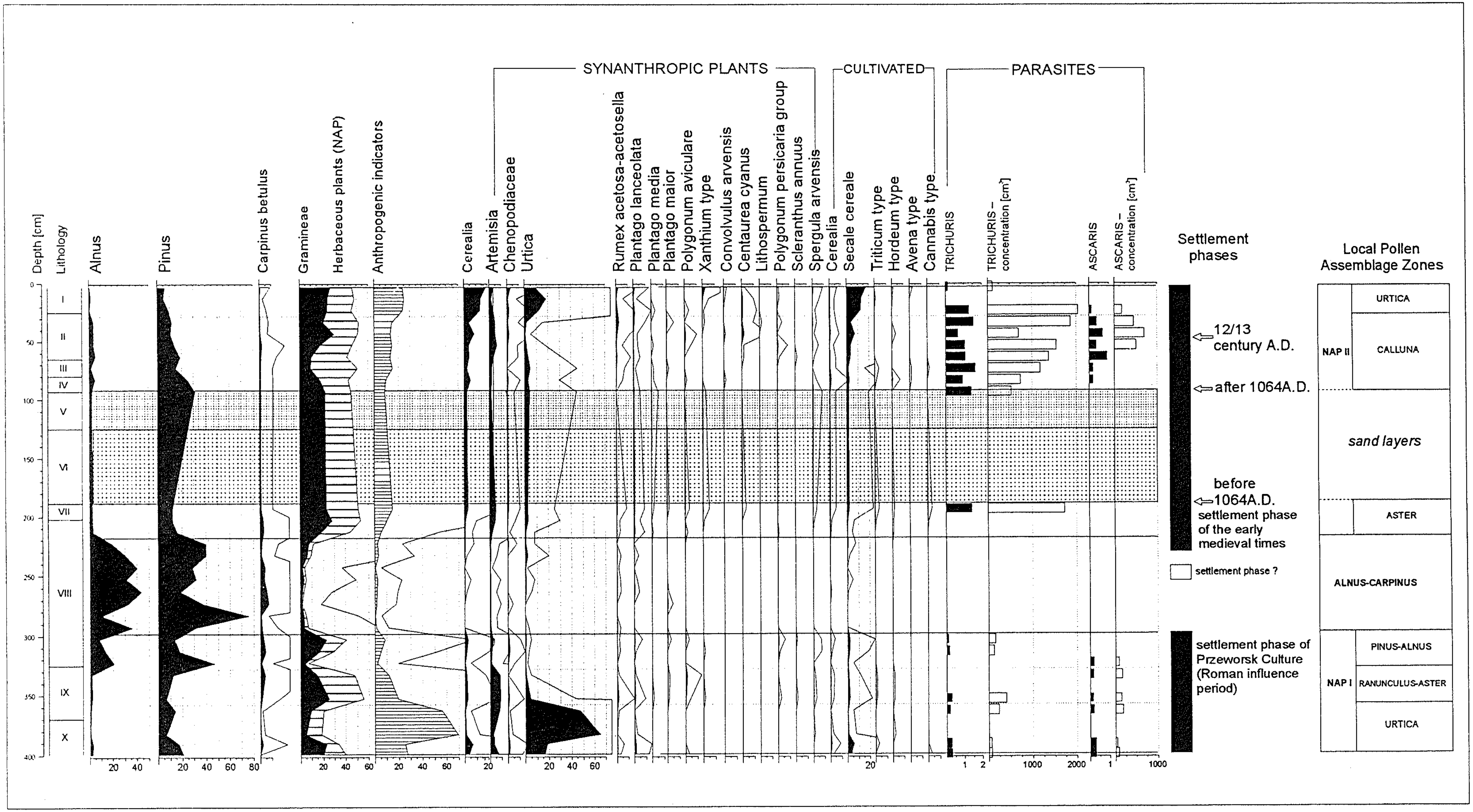


Fig. 152. GNIEZNO, archaeological site 22, trench 2, profile N, taken from the bank zone of the former Święte Lake (Holly Lake) at the foot of Lech's Hill (Makohonienko 2001).

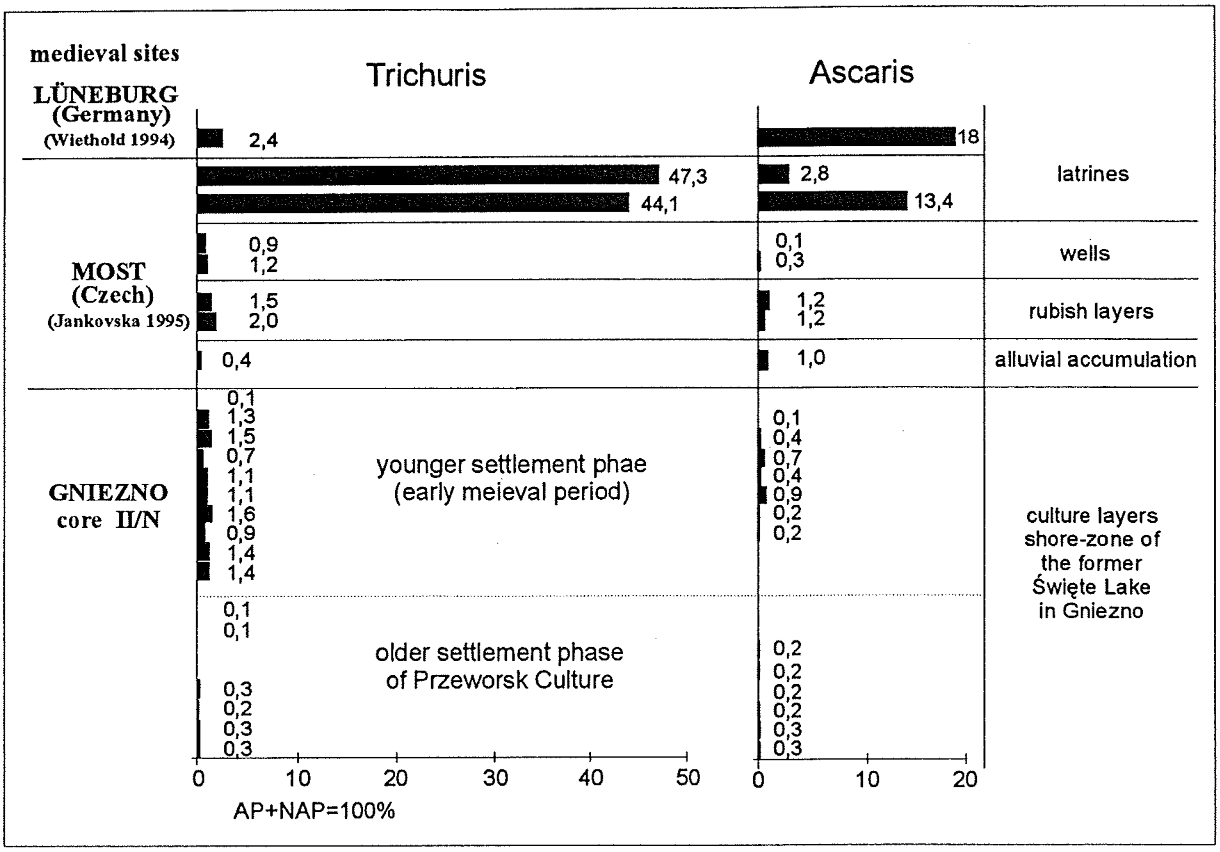


Fig. 153. The representation of *Trichuris* and *Ascaris* in various sediments of anthropogenic origin. Percentage calculations based on AP+NAP sum.

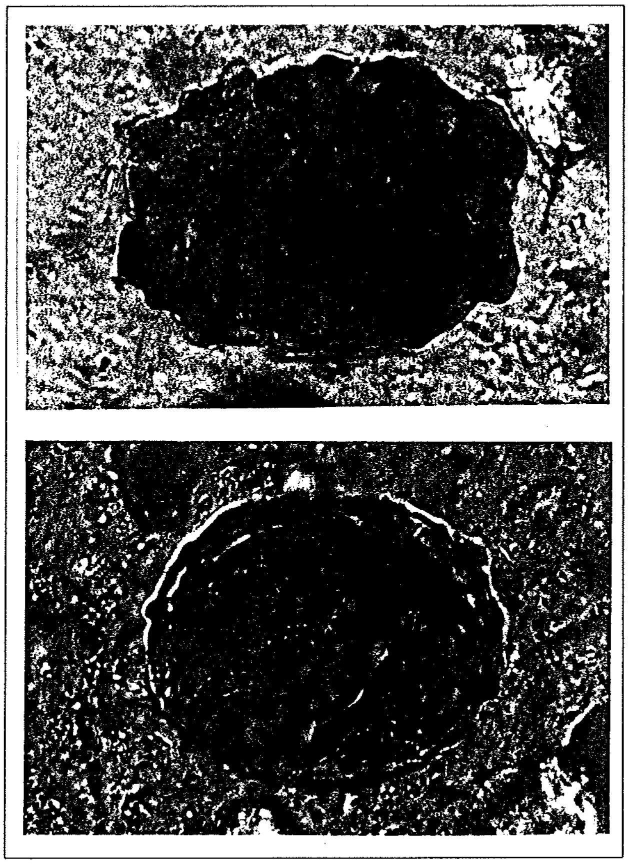


Fig. 154. Fossil eggs of Ascaris.

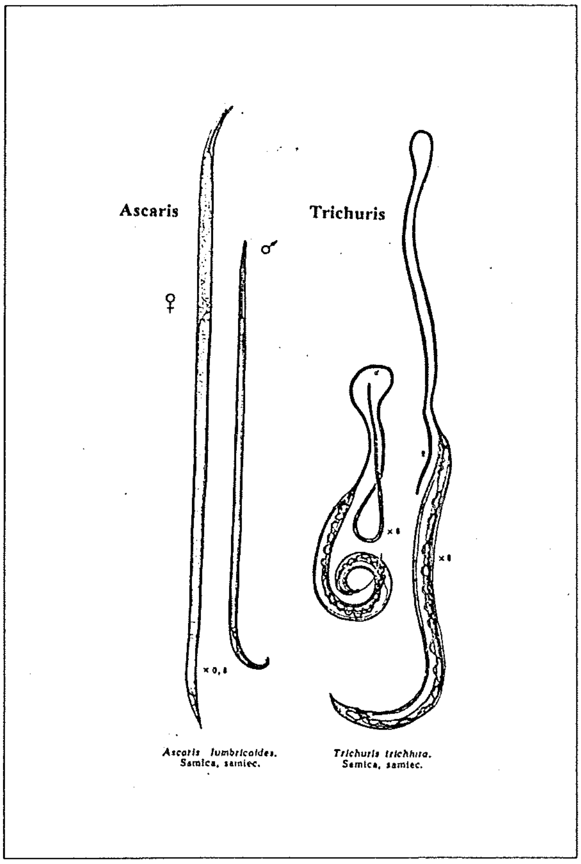


Fig. 155 . *Ascaris lumbricoides* and *Trichuris trichiura*.

Early Middle Ages settlement in Giecz

Giecz is presently a small village, lying between Środa and Nekla, in the Wielkopolska voivodship. Between the village and the early medieval fortified settlement once flowed the narrow Moskawa River, whose broad floodwaters, creating a lake several ages ago, defended access to the embankments (fig.161). At present the reservoir has been completely shallowed out, so that within a radius of several-score meters it is surrounded by peaty soils with a heavy detritous gytia base, and in the deeper layers, a layer of calcified fine detritous gytia. Organic sediments also occur along the rivers and canals in the vicinity of Giecz (fig.156, 157).

The climate of this area is largely oceanic, but the proximity of the distribution limits of species such as *Fagus silvatica* and *Hedera helix* suggest that continental air masses have some influence. Small forest complexes form deciduous and mixed communities with *Quercus robur*, *Q. sessilis*, *Carpinus betulus*, *Fagus sylvatica*, *Ulmus* sp., *Tilia cordata* and *Pinus sylvestris* being the dominant species. Riverside communities such as *Fraxino-Ulmetum*, *Circaeo-Alnetum* and *Salicetum albo-fragilis* are present but have suffered considerable damage due to the regulation of the rivers and drainage (fig.158-160).

In order to represent the early medieval anthropogenic pressure, the results of the palinological analyses of three different biogenic sediments cores are presented here in the form of pollen diagrams. Core G 2/90 illustrates the sequence of changes in the flora of the Giecz vicinity from the beginning of the Holocene, up to contemporary times. This profile is most representative in connection with regional changes in the plant cover due to its origin from the deep (the deepest hitherto investigated) portion of the fossil lake. It also shows undisturbed sequence of sedimentation from the beginning of the Holocene. The remaining pollen profiles, G 4/90 i G 1/96, are connected with archeological structures, hence their greater interpretative value with relation to historical correlations and local changes. Profile G 4/90 comes from the bridge/dike functioning in the Early Middle Ages. Profile G 1/96 is connected with the building of defensive embankments, accordingly its interpretative value is primarily based on the phases of building the architectural foundations for the defensive advantages of the fortified settlement (fig.169).

Vegetation before the arrival of Middle Age settlers

Giecz surrounding has been a traditional settlement area (fig.162-166). Following the decline of anthropopressure in the period of Roman influence, there was a quick regeneration of mixed deciduous forests with a dominant share of hornbeam (Milecka 1998). These were accompanied by oak, elm, linden, ash, beech and maple (fig.167, 168). To a lesser extent, hazelnut regenerated itself, creating along with the saplings of other trees an element of a second layer of woods. The nature of these communities, with an unusually high share of *Carpinus betulus* were defined by K. Tobolski (1988), who analysed the history of plant communities in Wielkopolska. This author, on the basis of vegetative and fossil analysis and contemporary surface spectra, states that the nature of hornbeam woods of the Subboreal and Subatlantic, was quite different from those areas known presently in the Polish oak - hornbeam woods. In fossil communities, the decisively dominant element was *Carpinus betulus*, which created a single level of crowns. The content of these communities limited the number of elements comprising the undergrowth, whose presence could represent only some species such as: ranunculaceous, umbellifers, ferns and grasses. On the edges occurred lightdemanding heaths. These woods occurred over a considerable area of Wielkopolska (Litt. Tobolski 1991; Makohonienko 1991, 1998; Filbrandt-Czaja 1998; Milecka 1998). In Giecz the culminaction of their development, mirrored in the maximal content of pollen grains was dated to 1590 years B.P. (profile G-1/89, Milecka 1998). Due to the high degree of woodiness, which is suggested by the AP pollen grain content (above 95%), there was a drastically limited area occupied by open communities. Their presence is confirmed by only individual pollen grains of meadow plants: *Centaurea scabiosa*, *Aster* types and *Cichorioidae*.

The increasing *Alnus* curve as well as the small culmination of *Salix* indicates the functioning of forest communities of wet habitats with a dominant share of alder as well as willow and ash. There was a less frequent occurrence of cottonwood. There was a decline of the vegetation of open telmatic communities, which is expressed in a drop in the curves of: *Carex* types, *Schoenus* types and *Humulus* types. There is a lowered share in these communities of ferns (*Dryopteris thelypteris*).

The regenerative phase of forest communities is not long lasting. As archeological data indicate, it was, at the latest, in the VII century that the penetration of central Wielkopolska began with more intensive settlement processes, also in the vicinity of Giecz. From that time, gradual changes in the vegetative cover, based on its synanthropization began, with a decreasing share of forest communities brought on by more open areas being used for crop cultivation, the grazing of farm animals and the building of human dwellings.

Changes in vegetation during the Early Middle Ages

Settlement during the Early Middle Ages caused overall changes in the appearance of vegetation. Advancing deforestation was expressed in the successive percentage drop in AP content (fig.167, 168). The curves of all deciduous trees such as oak, hornbeam, elm, ash and alder declined. The greatest drop was noted in the share of oak and hornbeam. *Quercus* sp. and *Carpinus betulus,* at the border levels in the two subsequent spectra, lower their curves by 11.4% and 13.2%, respectively. This confirms a drastic fall in the hornbeam and oak count in the nearby woods as early as the oldest phase of the early medieval period. The alder curve declined by 14%. A decided drop is also noted in the concentration of the pollen grains of forest elements. Simultaneously, the NAP curve in all the diagrams from Giecz is in excess of 50%. There is a noted count of the grains of plant pollen connected with human economy as well as a taxonomic variety of individual spectra for this period. There was a shrinking of areas occupied by rich forest communities with a multispecies composition. The fertile soils occupied by them were needed by people as cultivable land, and the increasing area of these fields resulted from the growing number of people in the intensively developing early Piast center.

In place of the shrinking forest areas, there was a development of various open communities, processed and utilised by man. Within the immediate vicinity of housing or on the embankments, there grew ruderal communities with a dominant share of sagebrush, goose-foot types, nettles, butt leaf sorrel and normal and medium plantain. The area occupied by this type of vegetation had to be relatively large, adequate to the area occupied by the built-up areas of the settlement and fortification. Nevertheless, its extent limited the proximity of garden and field crops where the natural plant communities were subject to total destruction and the annual crop changes caused the growth of unique, impermanent segetal communities.

The increasing intensity of the anthropopressure on the natural environment was a cause that, apart from conscious actions leading to the meeting of basic needs of the population, also had unintended results. These led, first of all, to the elimination of or considerable transformations in the occurrence of many plants. These, primarily, were those communities whose area had been drastically limited, e.g. deciduous forests and marshy meadows. An example of this is the considerable drop in the *Alnus* curve in the early medieval spectra of all the diagrams from Giecz. The shores of the water reservoir had to be subject to the changes connected with the building of the fortification, the need for easy access to the water, as well as a demand for alder wood, often used in over-water structures (Stępnik 1997).

A subsequent effect of anthropogenic pressure was eutrophication of lake waters. The reservoir of the Maskawa River basin was located between the fortifications and the trade settlement and, as such, was subjected to very strong changes, which were further increased by the presence of the bridge, and later a dike joining the two structures. Evidence of trophic changes in the water can be seen in the sharply increasing curve of *Pediastrum*, which in profile G-2/90 reaches a cenobiae content above two thousand percent of the AP+NAP sum. An analysis of fossil *Cladocera* content in lake sediment accumulated during the Early Middle Ages indicates a shallowing of the reservoir as well as an increase in trophy expressed in a drop of *Cladocera* varieties and an increased proportion of a species common to eutrophic waters, *Chydorus sphaericus* (Polcyn 1997).

For people living in Giecz at the time, the most important basic crops were wheat, rye and millet. Secale pollen grains are the commonest cereal type in the pollen diagrams. Due to the fact that it is anemophilious species with relatively high pollen productivity, the *Secale* curve in the early-medieval period in the area of Wielkopolska was, as a rule, at least 3-4% (Jankowska 1980; Litt, Tobolski 1991; Noryśkiewicz 1995; Makohonienko 1998, Filbrandt-Czaja 1998, Milecka 1998, 2000; and others). The percent share of *Triticum* type grain pollens is not high; this plant does not produce much pollen but the occurrence of wheat crops is confirmed by a macroscopic analysis of plant remains. In the early medieval layers, the occurrence of grains of *Triticum compactum*, *T. vulgare* and *Triticum* sp. was confirmed. Analysis of macroscopic remains showed, what is more, the considerable significance of millet among the crops of Giecz (Klichowska 1954; Polcyn 1998), which according to these authors, was a significant element in the diet of the Polish population. Current research shows that discoveries of *Panicum miliaceum* grains on sites in Wielkopolska are the most numerous, which suggest their large, if not fundamental, significance to the diet of the early medieval dwellers of this vicinity (Strzelczyk 1999).

Oil bearing crops constitute another important group. The Giecz diagrams show individual grains of *Linum usitatissimum* pollen from the times of Roman influence as well as the Middle Ages. Although the pollen discoveries are scarce, it is due to their characteristic morphology that they are certain proof of the crops cultivated. The discovery of numerous uncharred grains, parts of fruits and boons in the cultural layers of the Giecz reservoir are, according to Polcyn (1998), evidence of the production of raw material for weaving. On the whole, it may be said with certainty that flax was significant, both as a crop plant, a source of oil and fibre and a raw material for local processing and manufacture. This is confirmed by archeological finds: spindles, flails for hemp straw as well as spinning wheels (Kostrzewski 1955, 1965; Błaszczyk 1978).

A second important oil-bearing crop plant utilised by the Slavs of Wielkopolska was hemp. In the pollen diagrams, the presence of pollen grains of *Cannabis sativa* have been noted. In diagram G-2/90 the *Cannabis* type curve reaches 10%, which is a significant value and may be connected with the activity of retting hemp in the waters of the fossil lake. However, it is difficult to confirm this practice, particularly insofar as the soaking of fibres caused a poisoning of the waters (Bradshaw, Coxon 1981; Whittington, Edwards 1989), and both the fortified settlement, as well as the trade settlement were the immediate vicinity. It is possible that the soaking area was located at a considerable distance, and the current washed away the sporomorphs floating upon the water. An immediate confirmation of hemp cultivation are the finds of *Cannabis sativa* fruits in the sediments of the fossil reservoir (Polcyn 1998). Hemp was cultivated as a source of edible oil as well as a fibre used in the manufacture of ropes, cords and nets. Since it is more coarse than flax fibre, it was less frequently used for the making of fabrics and clothing (Sobisiak 1968). The presence of hemp in many folk ceremonies and customs bears witness to the universality and significance of *Cannabis sativa* cultivation on Polish lands.

Among the other oil-bearing plants probably cultivated in Giecz, in the sediment of the bridge/dike were found the uncharred remains of poppy seeds (Polcyn 1998). *Papaver somniferum,* originating in the western part of the basin of the Mediterranean Sea, is a crop plant that has been known for several centuries (Zohary, Hopf 1988). On Polish lands, apart from an infrequent occurrence of poppy seeds in Neolithic settlements (Wasylikowa 1983), a significant number of discoveries are noted as late as the Middle Ages, among others at Ostrów Lednicki (Polcyn 1998). According to Moszyński (1967), the cultivation of poppies was known to the Slavs from the earliest times.

The pollen analysis method is not very useful for identifying garden crops. The pollen grains of well known and consumed plants such as turnip, cucumber or peas are "hidden" among identified hybrid and papillonaceous plants. Only the increasing curves of these types of pollen in the diagrams provides indirect evidence about the cultivation and consumption of these plant. An indirect confirmation of the occurrence of *Brassica campestris*, *B. nigra*, *Cucumis sativus*, *Pisum sativum* and *Vicia faba* in the cultivations of the Giecz inhabitants are the macroscopic discoveries of these plants in the culture layers of the fossil reservoir (Klichowska 1954; Polcyn 1998).

Crop plants of both field and garden are inseparably accompanied by weeds. The seeds of weed pollen occur most frequently in the early medieval culture layers of sediments in Giecz and they are connected with particular crop plants. Thus, for example, on the fields of grain, there appeared *Centaurea cyanus*, *Papaver rhoeas*, *Cirsium arvense*, *Polygonum aviculare*, whose pollen grains were determined in the sediments, and among the garden varieties of row crops appeared *Polygonum persicaria* and *Chenopodiaceae*. The occurrence of sporomorphs of weeds was never frequent, but their direct connection with segetal communities was confirmed by the short distance of the crop field from the research site (Aaby 1994). They also bear witness to the extent of the crops as well as the plants mentioned in the diet of the early medieval Slavs on the lands of Wielkopolska. It is interesting that in the early medieval phase, despite the continuous *Secale* curve with values of several percent, there are only individual grains of cornflower pollen present. *Centaurea cyanus* is considered as a typical weed of winter crops, particularly rye. Cultivation of this crop is manifested by a higher curve in the newer phase of the last millenium, hence the simultaneous, continuous raised presence of grains of cornflower pollen in the top sub-PAZ of the diagram.

In order to make a fuller list of weeds of cultivated plants, it was necessary to compare an analysis of macroscopic remains of plants, which allowed for the identification of their considerable number. According to Polcyn (1998) cultivated crops, apart from those mentioned above, were contaminated with *Agrostemma githago*, *Bromus secalinus*, *Lolium temulentum*, *Melandrium album*, *Polygonum convolvulus* and *Spergula arvensis*. Some researchers consider *Spergula arvensis* as another cultivated crop due to its advantages as an animal fodder (Podbielkowski 1989). Due, however, to infrequent discoveries of this species, it is difficult to determine its role at this site. Furthermore, it is not known whether this crop was raised in the early middle ages. Communities of weeds of garden row crops were composed of *Chenopodium album*, *Ch. hybridum* and *Ch. polyspermun*, *Polygonum lapathifolium*, *P. persicaria*, *Setaria glauca*, *S. verticillata/viridis*, *S. viridis, Agropyron repens*, *Anagallis arvensis* and *Capsella bursa-pastoris*. A number of the plants mentioned may occur as weeds on cultivated fields, but due to the size of the habitats changed by man, their eutrophication and high nitrogen content, must have appeared as well in the ruderal areas and wastelands. To these belong, among others, *Anagallis arvensis*, *Capsella bursa-pastoris*, *Polygonum aviculare*, *Urtica* sp.

The next group of anthropogenic indices informing about the means and extent of human economy are meadows and grazing lands. The meadowlands in the early Middle Ages were more extensive areas compared to those in earlier settlement phases. They were probably also larger than contemporary grazing areas, due to the present day farming practices. The shaping of the lands around Giecz, the situation of the fortified settlement and the hydrological conditions, had a decisive influence on two basic types of meadowlands. Fresh and moist meadows were situated around the fortified settlement as well as naturally occurring along the Maskawa River, whose annual spring runoff caused an increase in the use value of the open communities occurring there. The basic ingredients of such communities were formed by *Poaceae*, *Cyperaceae*, *Rumex acetosella*, *Plantago lanceolata*, *Filipendula* sp., *Ranunculus* sp., *Xanthium* sp. Somewhat further on, away from the open water reservoirs, on the gentle morainal hills around the site, grew the plants of communities less endowed with water. Communities of this type were represented by *Poaceae*, *Rumex acetosa*, *Centaurea rhenana*, *Jasione montana* and others. Meadowlands were certainly intensively used for grazing, since the growing numbers of people, and also the army residing in the Giecz area (Błaszczyk 1978) continuously needed large amounts of food. These needs had to fulfill the needs connected with an increasing area and efficiency of the crops and animal husbandry. Most certainly, the food was also supplied from more distant lands, since auxiliary villages near the fortified settlement would not suffice to produce such an amount of food.

In the XIII century, substantial decline of Giecz is seen because of its considerable distance from newly created trade routes, the territorial limitations of the castellany as well as the transferal of administrative-judicial powers to the starostship in Pyzdry (Błaszczyk 1978). Till the end of the second millenium, only the small village of Giecz survived together with the embankments of the fortified settlement, which persist as a reminder to tourists of the former splendor of this place.

Krystyna Milecka

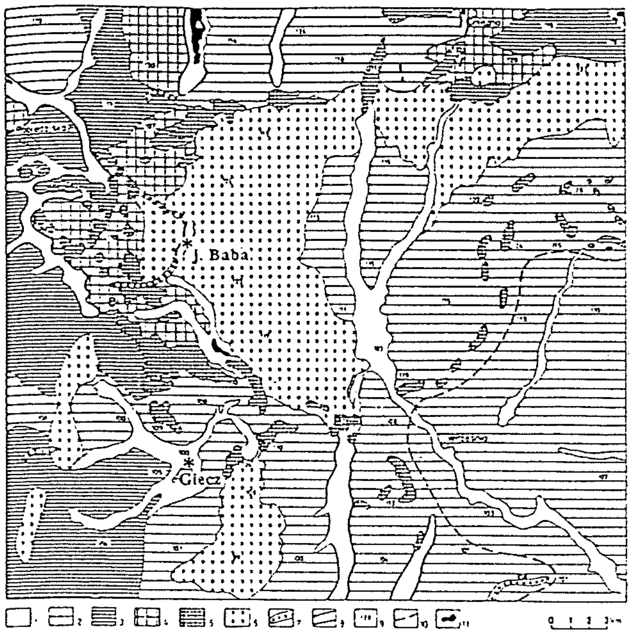


Fig. 156. Geomorphological map of suurounding of Giecz and Lake Baba (Krygowski 1961) 1-flood terraces; 2-morainic upland flat; 3-morainic upland wavy; 4-hummocky morainic upland of accumulative origin; 5-zone of terminal moraine hills of small rhythm; 6-outwash plains; 7-esker ridges 8-thought; 9-height points; 10-limit of Leszno phase of Vistula glaciacion; 11-lakes;

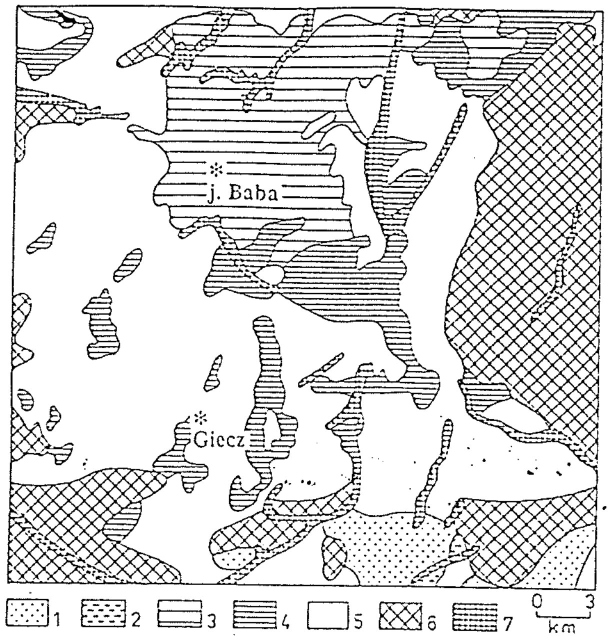


Fig. 157. Soils of surrounding of Giecz and Lake Baba (Terlikowski 1961) 1-brown soils; 2-stony and gravelly soils; 3-sandy, podzolic soils; 4-sandy, slightly loamy soils; 5-podzols from light and medium boulder clay; 6-black earth soils from boulder clay; 7- peat soils;

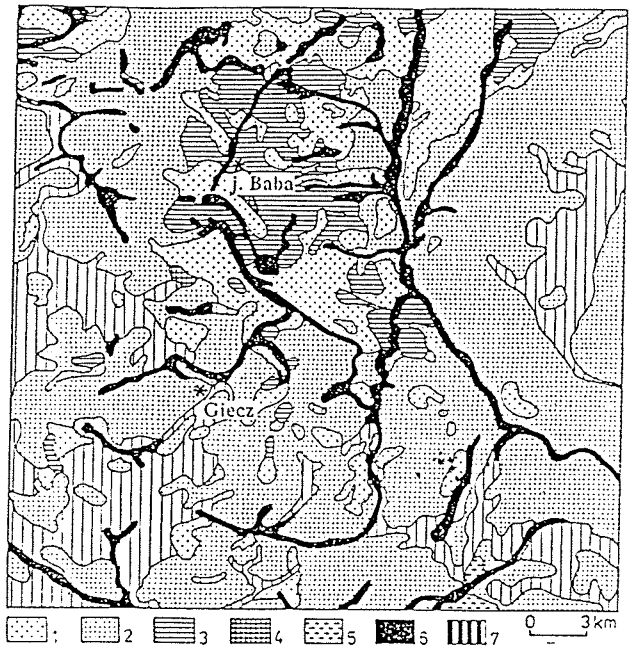


Fig. 158. Potential vegetation in the surroun-ding of Giecz and Lake Baba (Wojterski et al. 1981) 1-Galio sylavatici-Carpinetum (poor variant); 2-Galio sylavatici-Carpinetum (rich variant); 3-Calamagrostio-Quercetum; 4-Pino-Quercetum; 5-Salicetum albo-fragilis; 6-Circaeo-Alnetum; 7-Fraxino-Ulmetum;

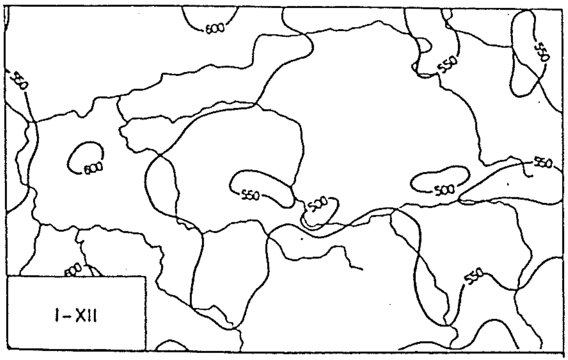


Fig. 159. Annual rainfall total. Means for the years 1951-1980 [mm] (acc. to Woś 1994).

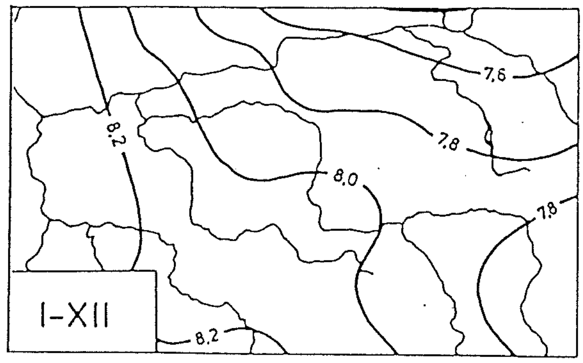


Fig. 160. Air temperature of the year. Means for the years 1951-1980 [°C] (acc. to Woś 1944).

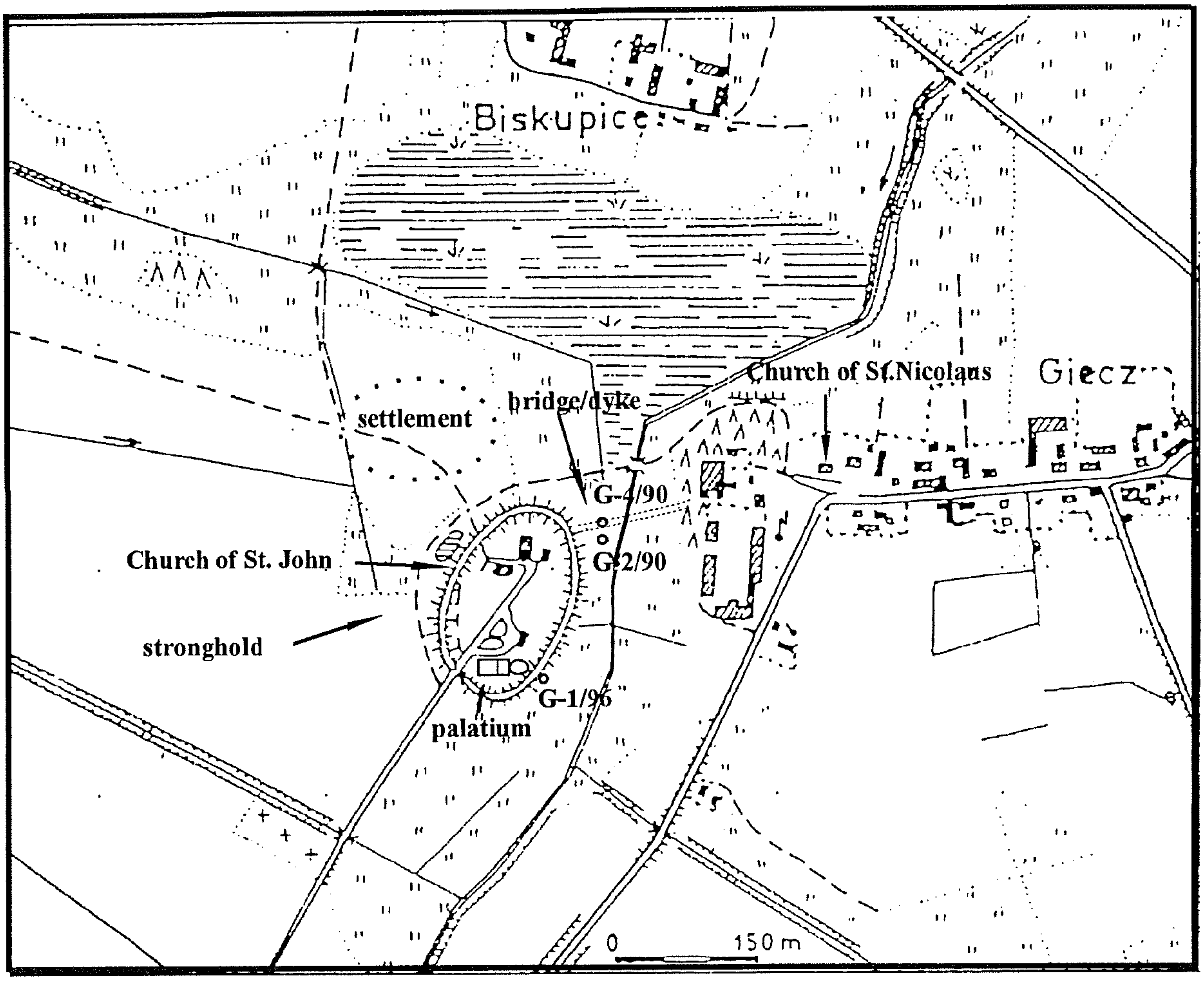


Fig. 161. Stronghold in Giecz and its surrounding

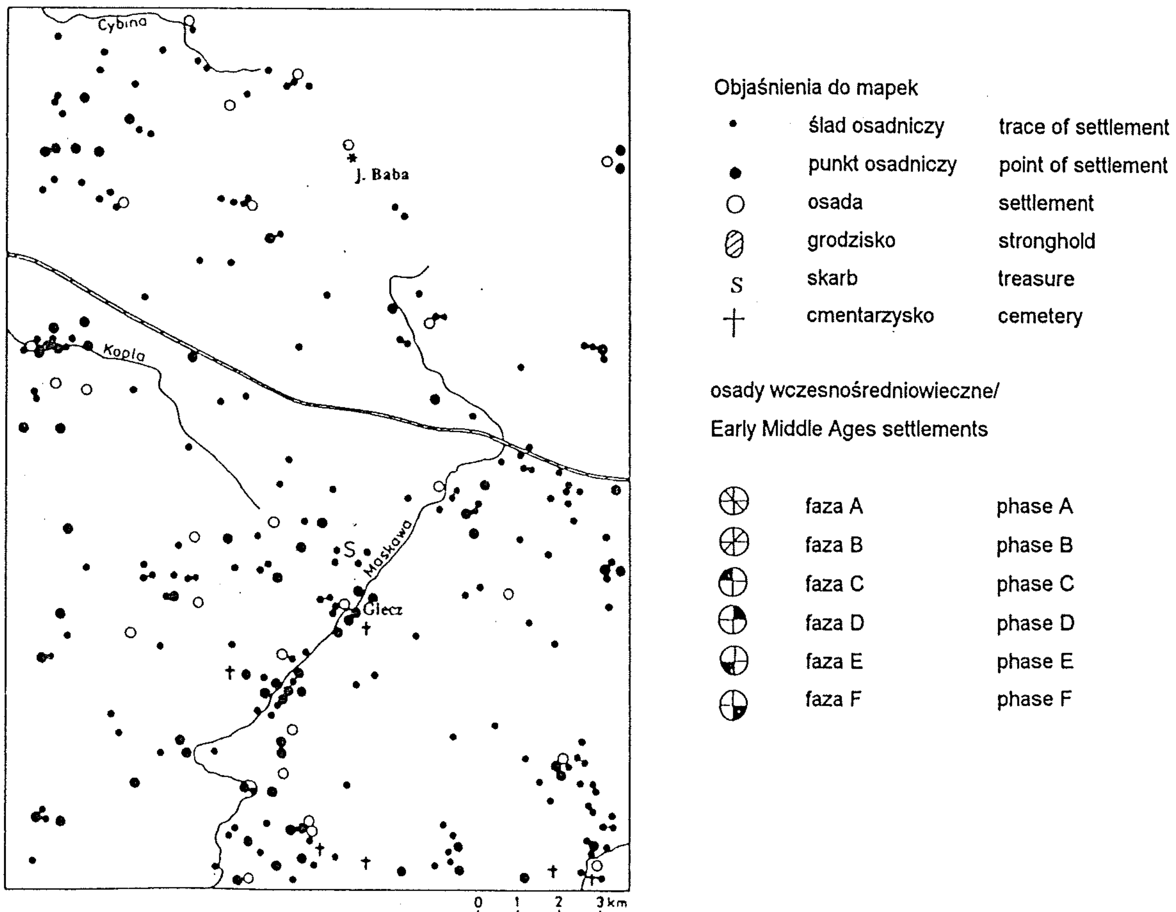


Fig. 162. Archaeological sites of Lusatian Culture.

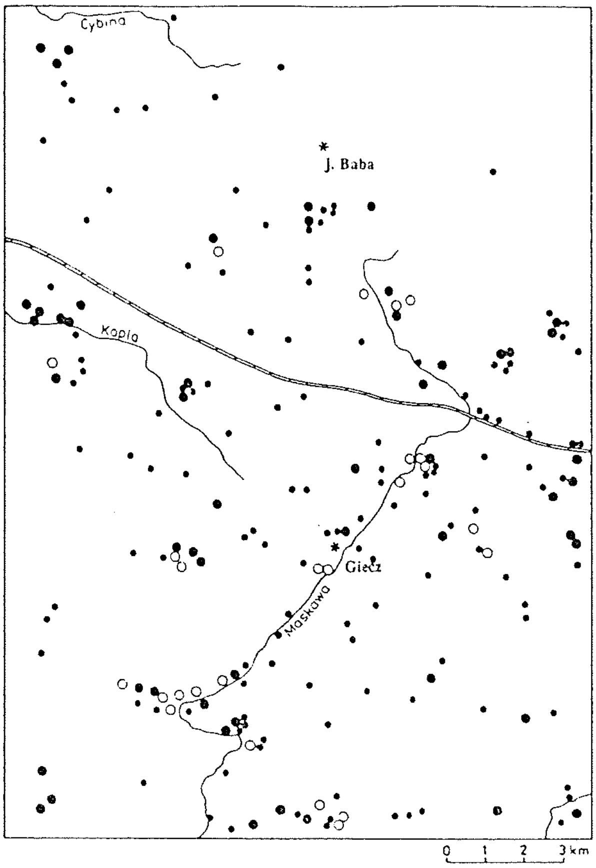


Fig. 163. Archaeological sites of Pomeranian Culture.

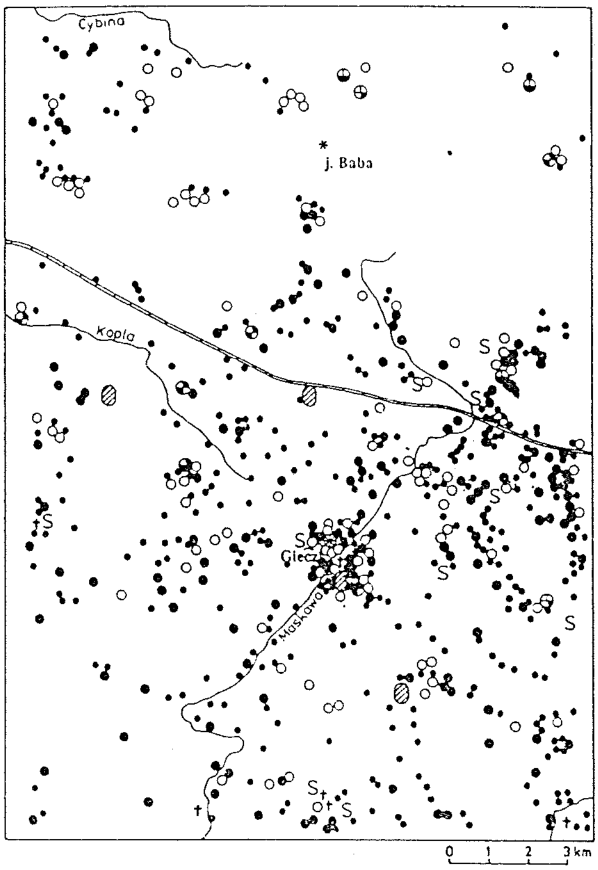


Fig. 165. Archaeological sites of Early Middle Ages.

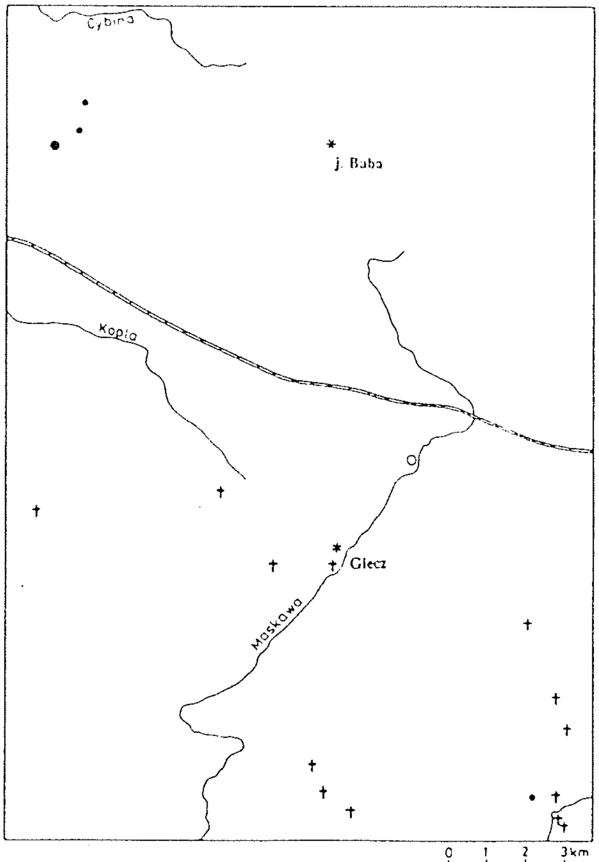


Fig. 164. Archaeological sites of Przeworsk Culture.

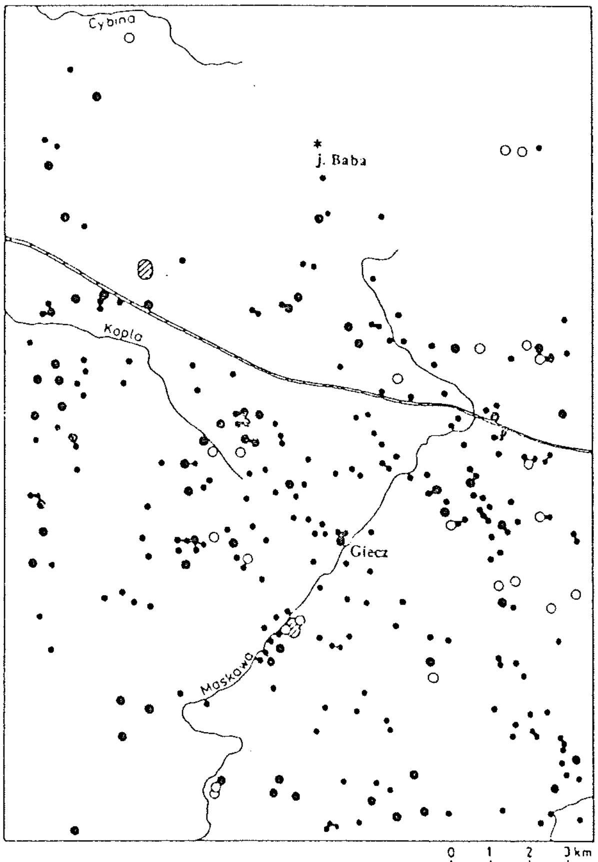


Fig. 166. Archaeological sites of Late Middle Ages.

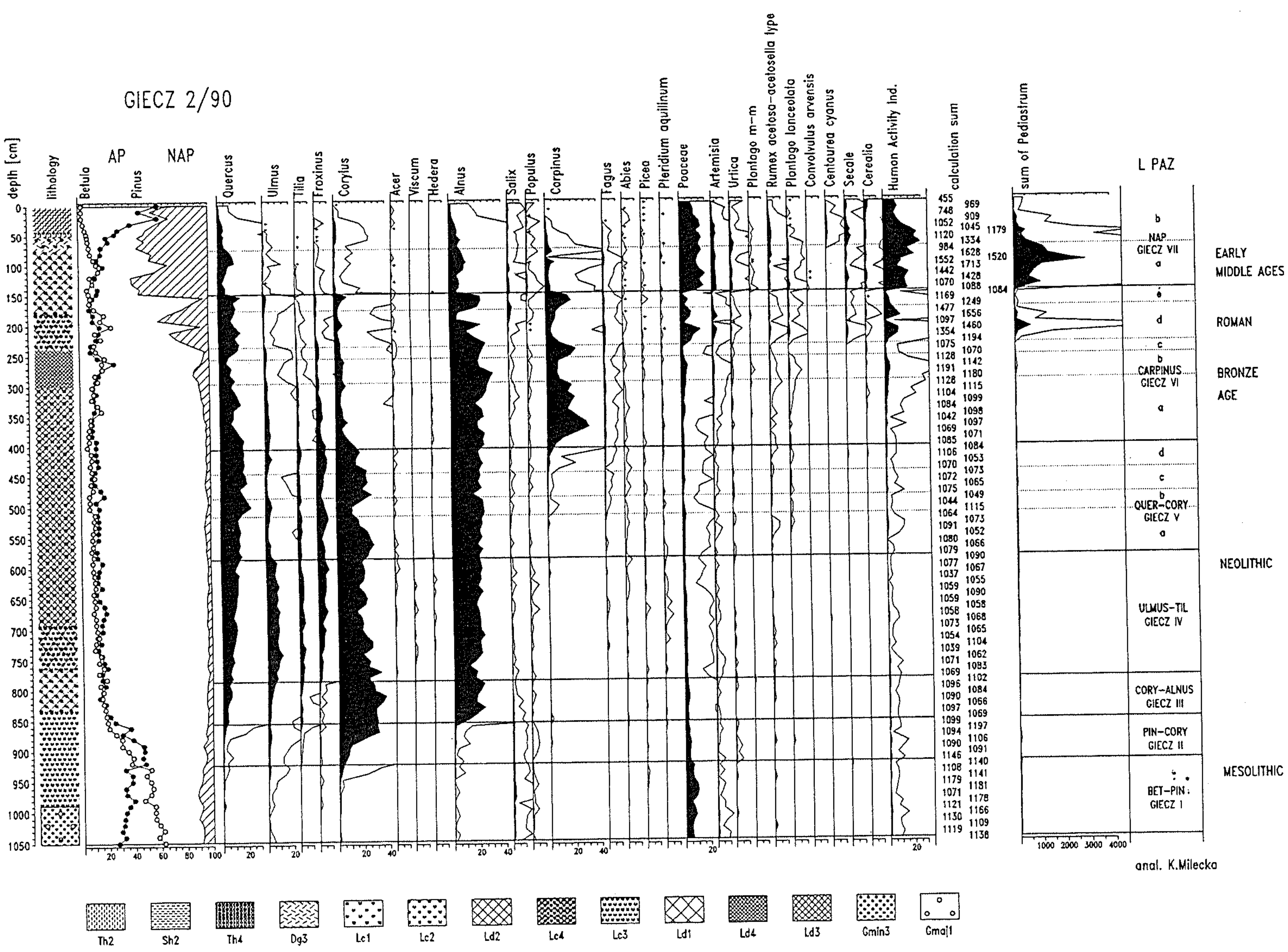


Fig.167. Simplified pollen diagram Giecz 2/90

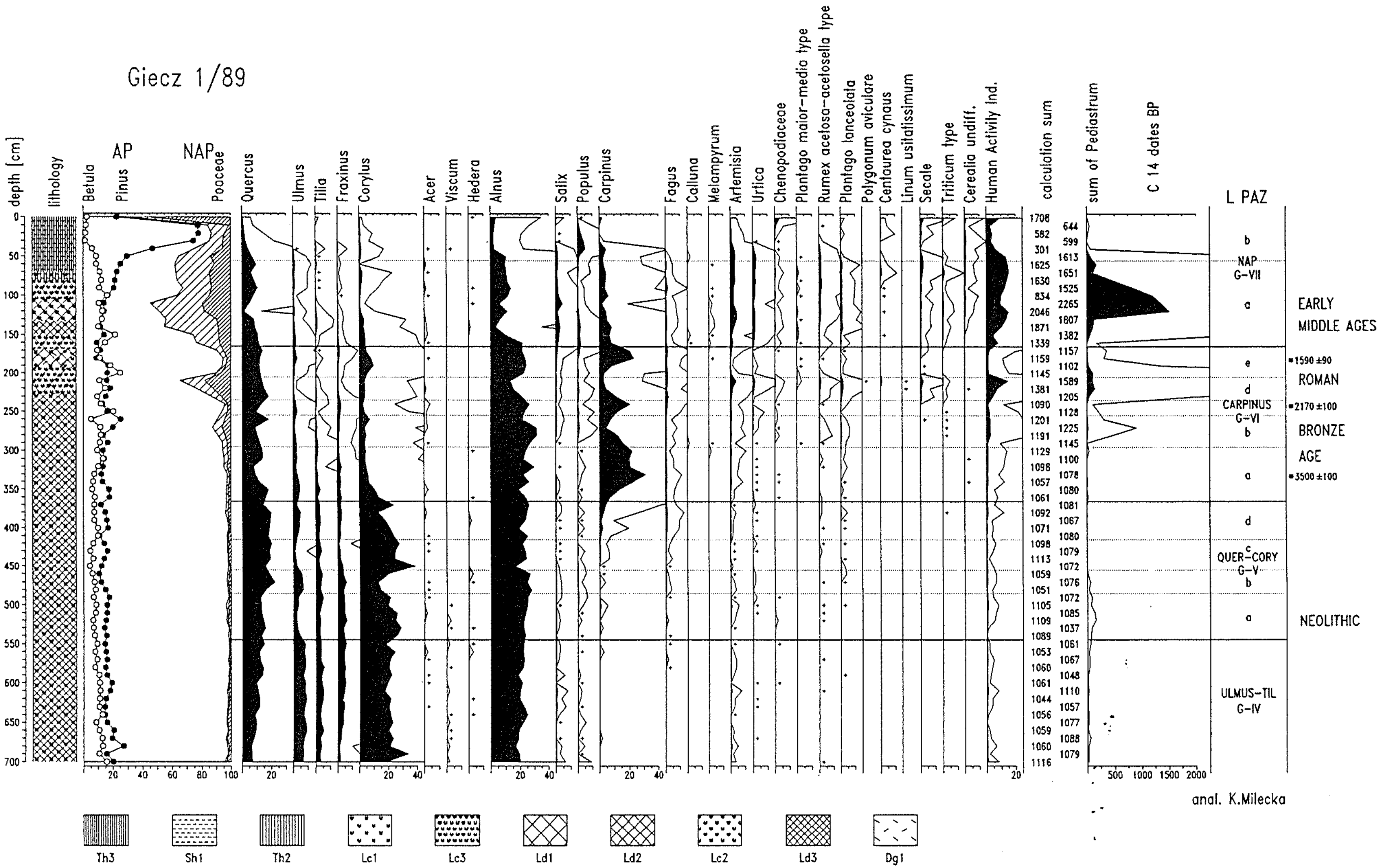


Fig.168. Simplified pollen diagram Giecz 1/89

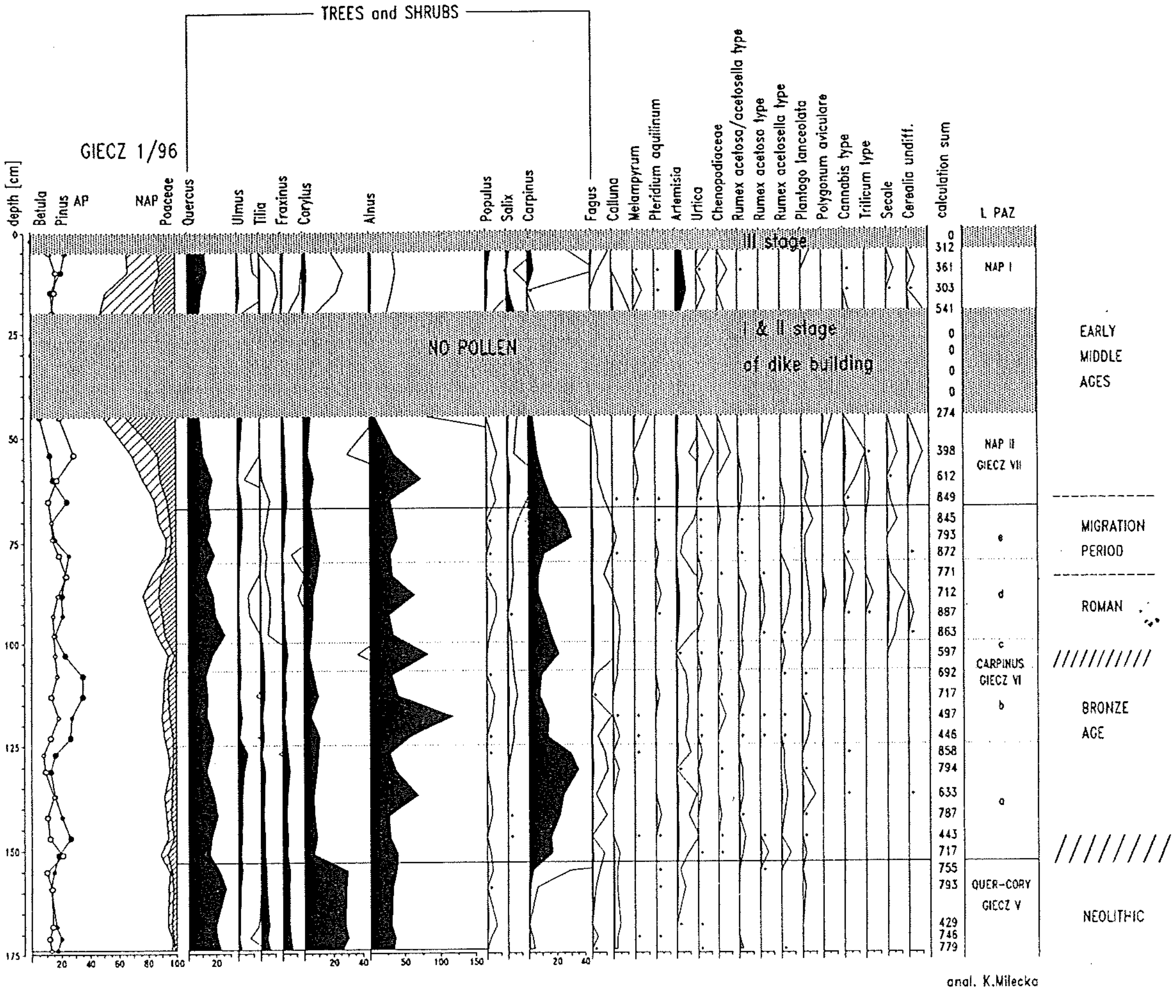


Fig.169. Simplified pollen diagram Giecz 1/96

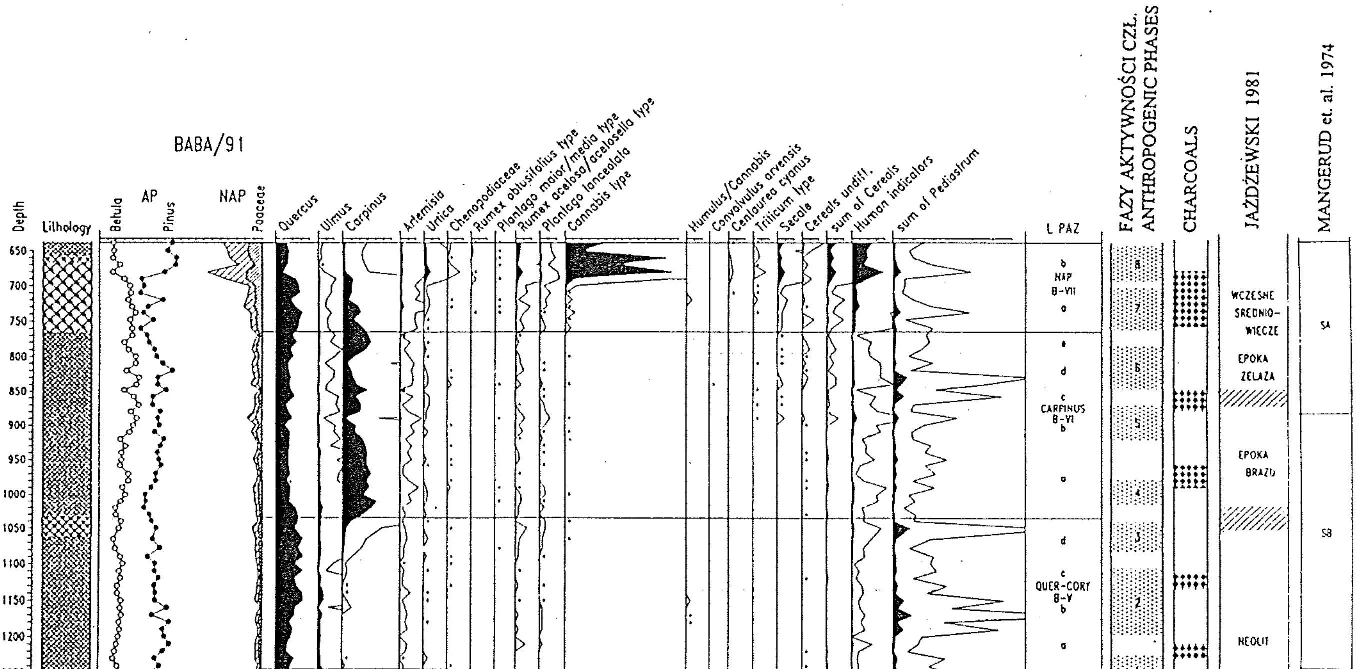


Fig. 170. Lake Baba - simpliefied pollen diagram and correlation of anthropogenic phases and stratigraphy

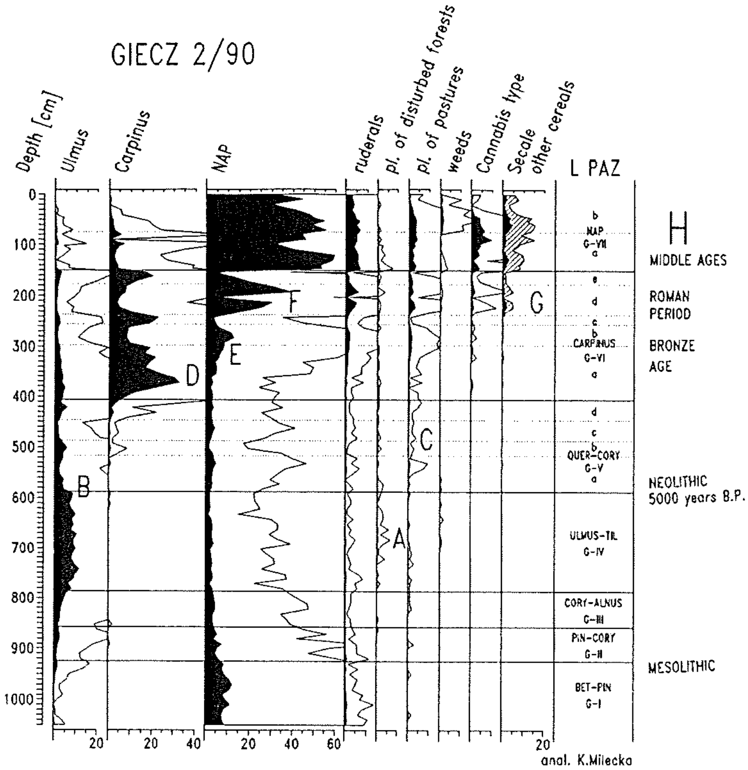


Fig.171. Anthropogenic changes in plant cover of central Wielkopolska on the basis of the diagram from Giecz

A. Burning out of the undergrowth and the grazing of animals in the deciduous forest causing an introduction of photophilous species requiring a high content of mineral compounds in the soil.
B. A decline in the elm curve; human activity being one of the main reasons of this universal phenomenon throughout Central Europe.
C. Changes in open assemblages, the appearance of grazing indicator plants due to the Neolithic animal husbandry practices.
D. Expansion of hornbeam forests with a small share of beech, promoted by a loosened structure of mixed forests by man.
E. The first limiting of forest areas signalled in diagrams of increased shares of herbal plant pollen grains in the Bronze Age.
F. A second, stronger deforestation during the Roman Period.
G. The considerable significance of crop plants, the introduction of many new species utilised by man (e.g. *Secale cereale, Cannabis sativa*), resulting in the development of segetal weed assemblages.
H. The last Millenium - a decidedly lasting deforestation; in plant assemblages - a high share of ruderal, meadow, crop and weed varieties.

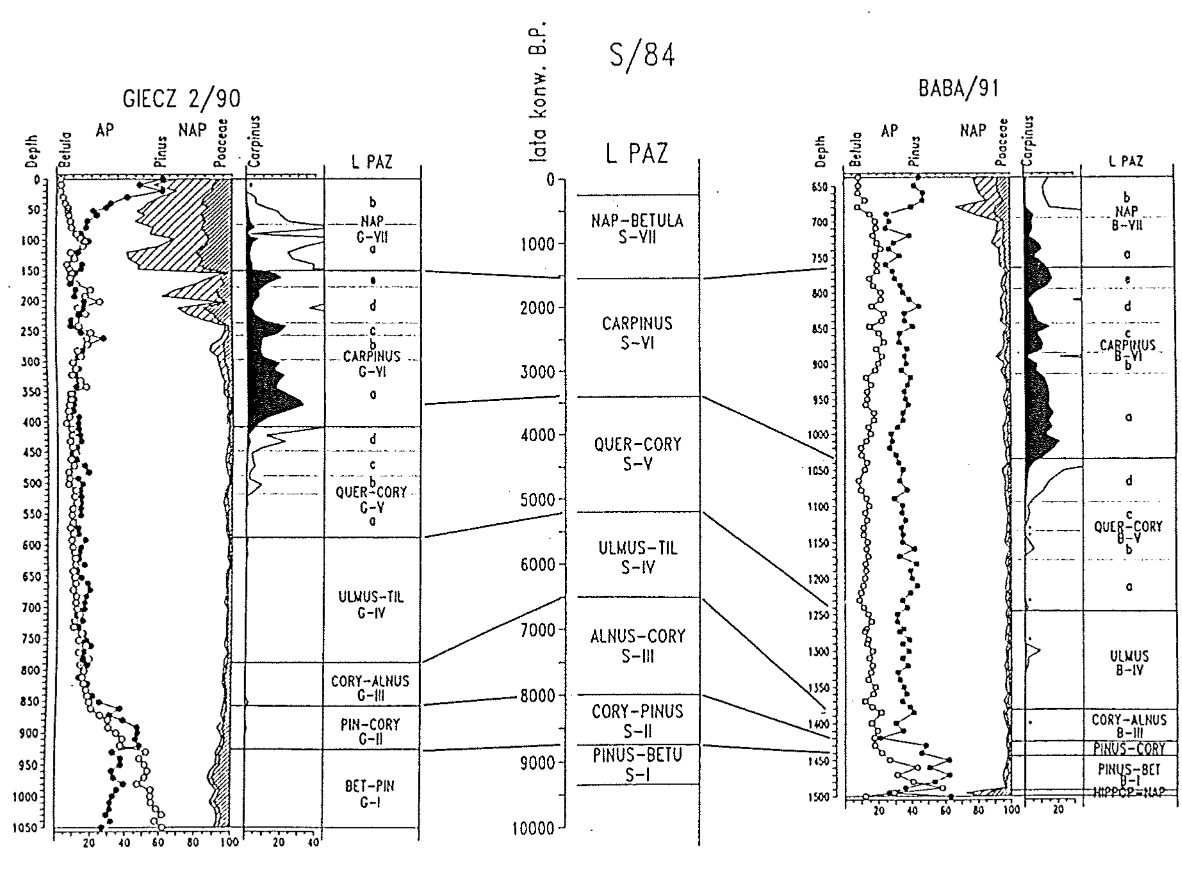


Fig. 172. Correlation of L PAZ from Giecz, Lake Baba and Lake Skrzetuszewskie.

Common millet (*Panicum miliaceum* L.) in the early medieval Wielkopolska

Panicum miliaceum (Fig.173) is an old-cultivated plant that has been domesticated in the central Asia. It had accompanied old agriculture groups in their migrations to the West and East. It belongs to cereals, but unlike wheat or rye it is not resistant to weeds such as *Echinochloa crus-galli, Setaria pumila, Setaria verticillata* and *Setaria viridis*. They are also known from archaeobotanical finds in the central and west Europe from the Neolithic period. Common millet is a warm season plant, which stands up well to heat and is also drought-resistant. Its dehusked grains have been boiled and eaten as porridge, and flour made of them has been used for baking. It's straw could has been grazed by cattle. There is archaeobotanical evidence, which show us, that millet has been cultivated from the Neolithic times in Poland (Fig.174). Its importance was increasing until early Middle Ages, when rye (*Secale cereale* L.) came into prominence.

The above remarks were starting point to the study of archaeobotanical finds from early medieval forts that were placed in the Wielkopolska: Bruszczewo, Spławie, Łekno, Piaski-Rochy, Gniezno (Fig.175). The material from first four sites came from conspicuous archaeological objects:

- Bruszczewo – from cultural deposits – destroyed and burnt residential buildings and magazines; the probes were more or less mixed (21 probes)
- Spławie – from cultural deposits (from pots etc.) inside residential structures (15 probes)
- Łekno - from cultural deposits - conspicuous deposits and from the embankment (69 probes)
- Piaski-Rochy – layer consisted of millet becoming from the granary (1 probe)
- Gniezno – sediment from a profile section, from site 22 – north bank of Święte lake (12 probes)

There was no rests of millet in the material from Gniezno. However, J. Koszałka (2000) recorded a few glumes in a core from the opposite side of Święte lake. Similar results obtained T.Schubert (2000) from the core from the littoral of Łekno lake.

The material from remaining forts contained of charred cereal grains. The probes were divided into three categories:

- deposits of millet grain for storing purposes (whole grains) or for cooking (dehusked ones – millet groats)
- the probes in which the millet was an admixture to another cereals
- "mixed probes" which consisted of several sorts of plant diaspores

The Common millet finds have been the biggest and therefore of great importance in the investigated settlements. In Bruszczewo *Panicum miliaceum* remains composed 76% of the whole crop. In Spławie - 25% of cereal deposits, the rye predominated. In Łekno, millet dominated in proportion over cereals, and the material from Piaski-Rochy composed a deposit of stored *Panicum miliaceum*.

There were also analysed weeds that contaminated deposits of millet. Little frequency of weeds seeds in probes can be explained by the biology of millet and the way of its cultivation. Planting millet needs removing of weeds during growth. It ripens in a late autumn, when lot of weeds finishes natural seeding. The analysis of weeds consisted in defining their habitat preferences using the scale of Ellenberg (1991), confronting their life forms and phytosociological characteristics. These data helped to identify habitat in which millet was planted: dry to moderate wet, rich in nutrients, pH little acidic to neutral. They also allowed confirming thesis that millet is a root plant (Table 1-4, Fig.176).

Joanna Strzelczyk

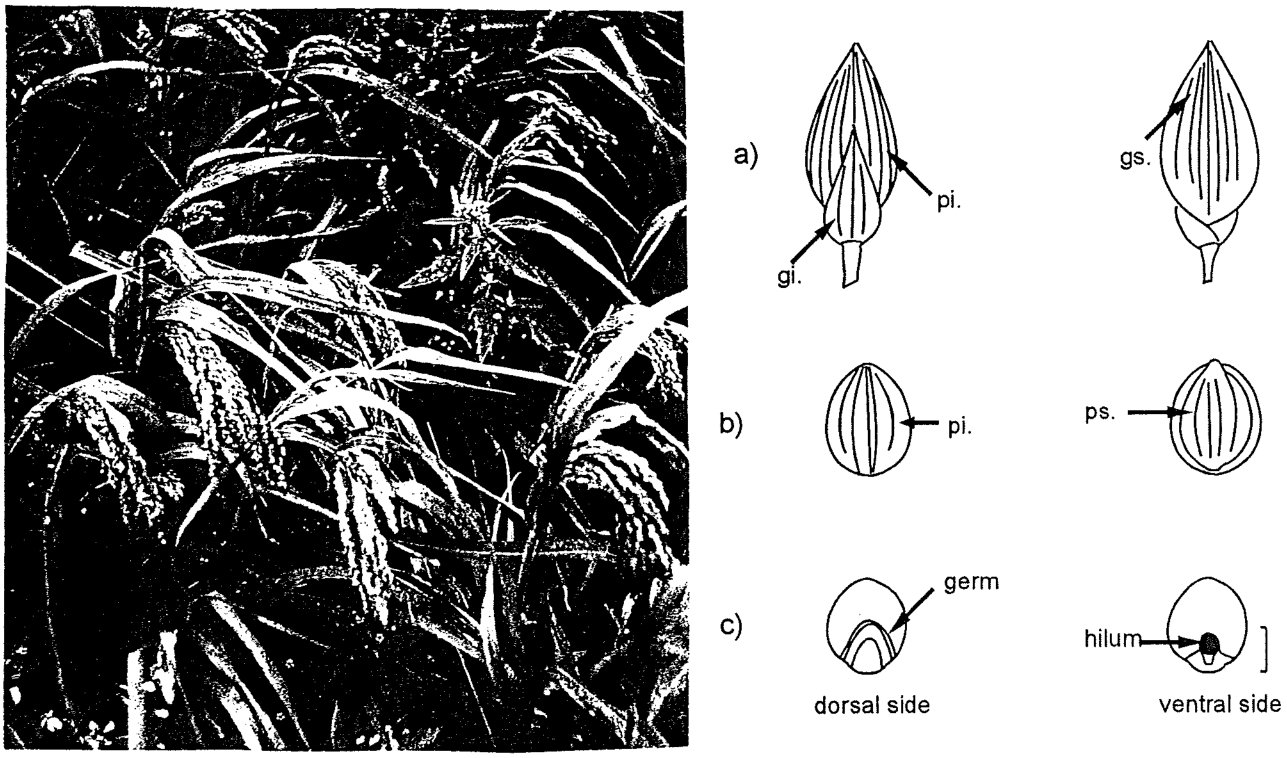


Fig. 173. *Panicum miliaceum* -

a) spikelet (gi.:gluma inferior of fertile flower,gs.: gluma superior of fertile flower, pi.: palea inferior of steril flower)

b) grain with glumes (pi.: palea inferior, ps.: palea superior)

c) dehusked grain

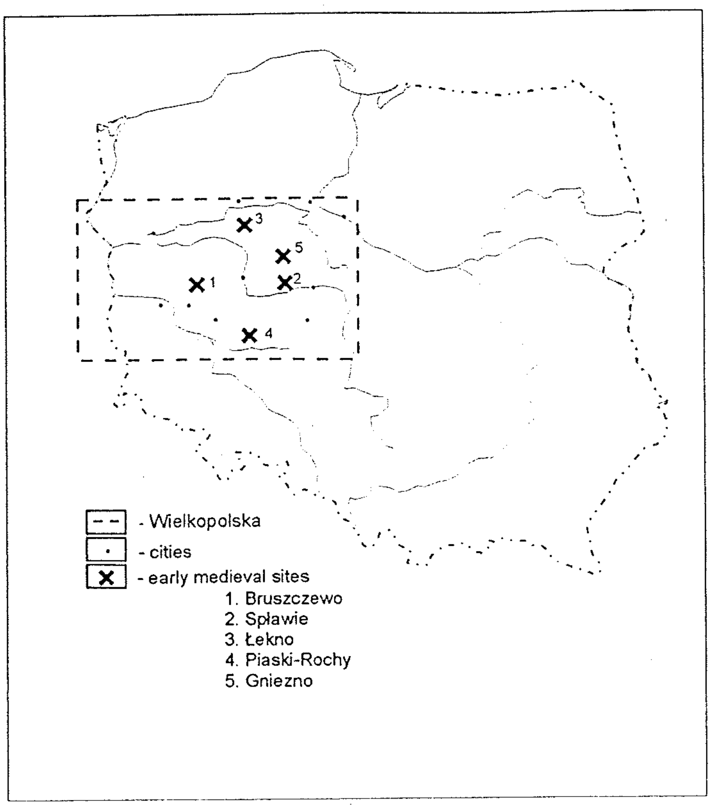


Fig. 175. Location of investigated sites

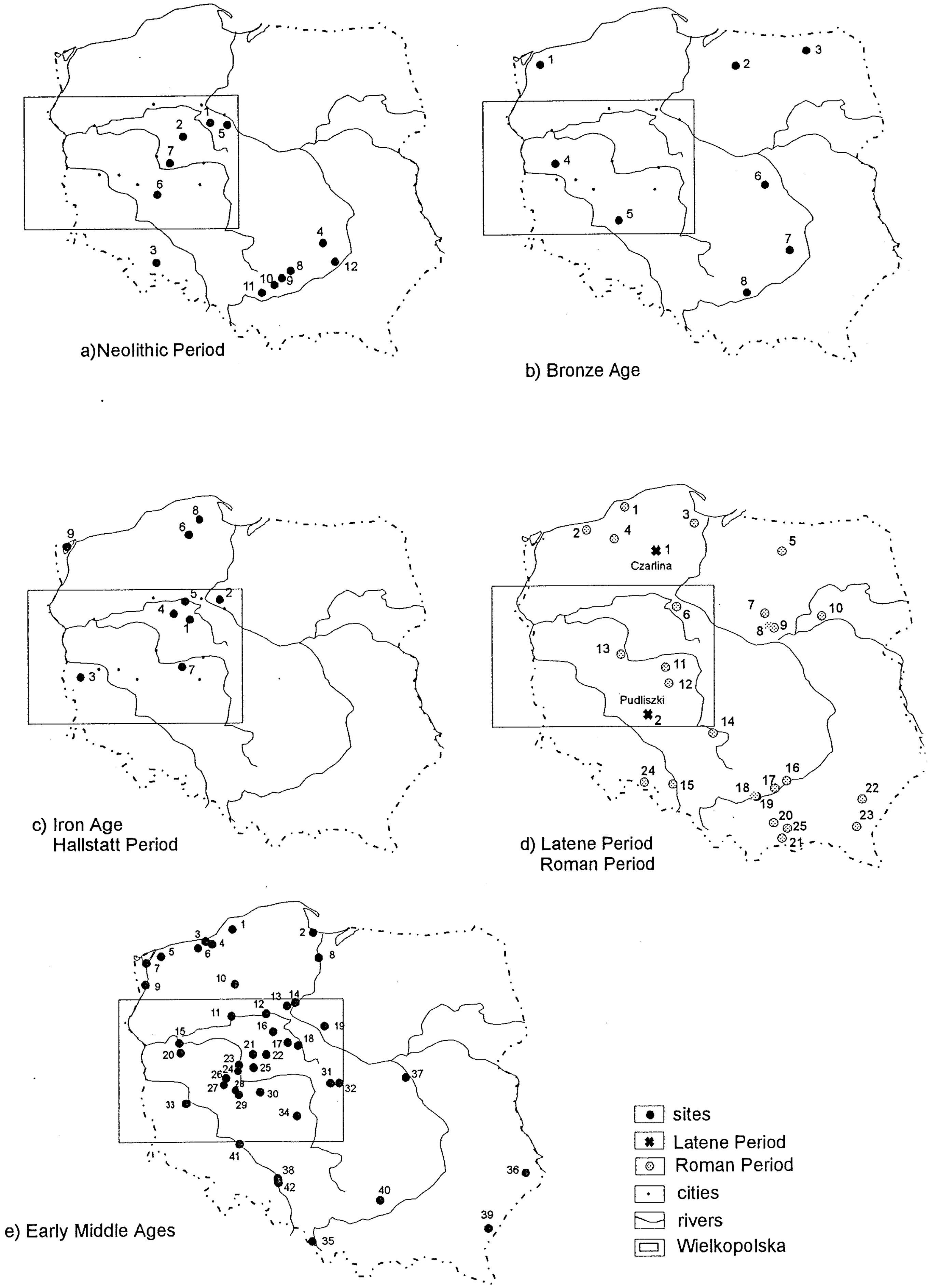
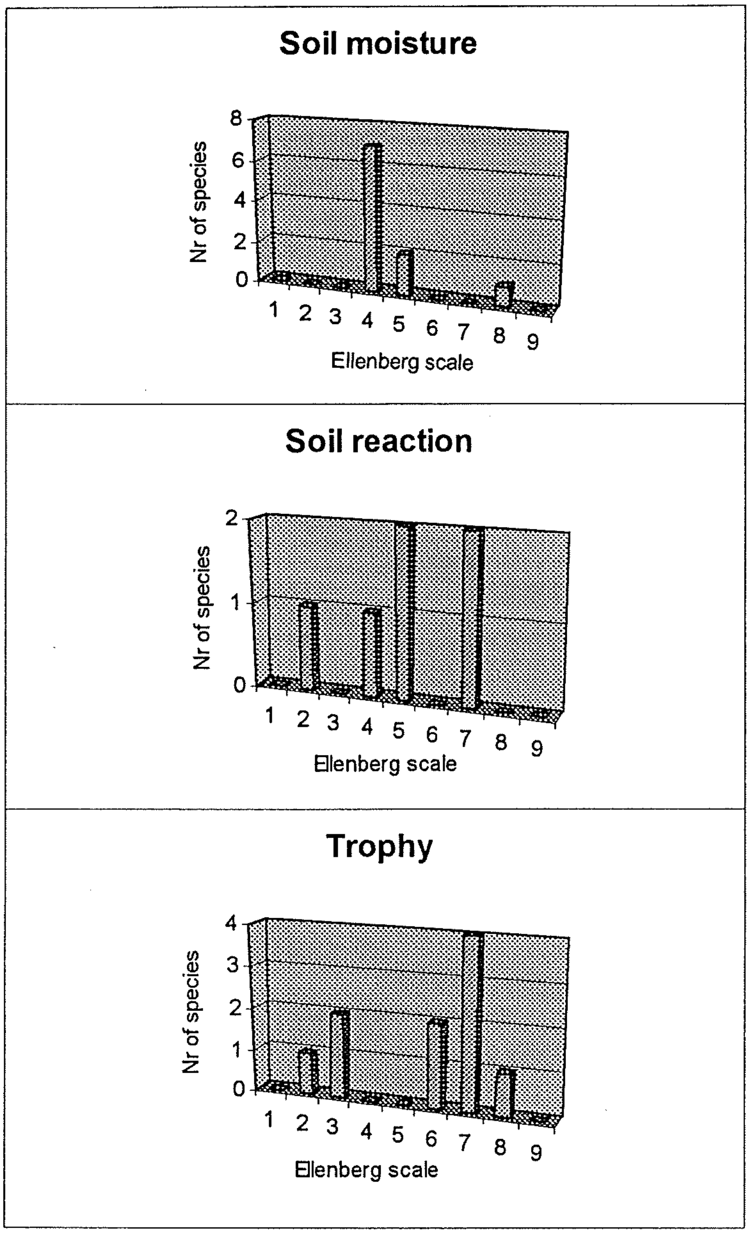


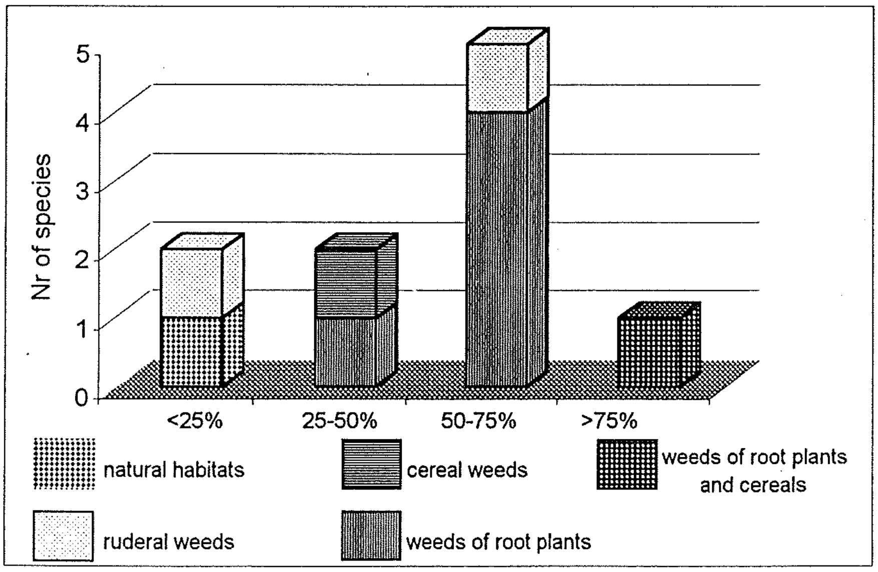
Fig 174. History of common millet finds in Poland



a)

b)

c)



d)

Fig. 176. a)-c):Edaphic conditions for the species regarded as weeds of *Panicum miliaceum;*
d): Number of weed species according to habitat groups in the sections of frequency of weeds in all probes

	Species	Probe nr 7 Nr of taxa in 500 ml	Probe nr 8 Nr of taxa in 200 ml	Probe nr 10 Nr of taxa in 300 ml
cultivated	*Panicum miliaceum*	7025	1490	87900
	Secale cereale	1	15	40
	Triticum aestivum	15	45	31
	Hordeum vulgare	3	29	2
	Avena sativa/fatua	2	4	-
	Pisum sativum	21	-	1
	Vicia faba	4	2	-
	Linum ustiatissimum	3	-	3
weeds	*Agrostemma githago*	-	3	-
	Setaria pumila	-	1	5
	Setaria viridis	-	-	2
	Fallopia convolvulus	5	5	17
	Polygonum persicaria	4	2	4
	Chenopodium album	3	7	92
	Chenopodium sp.	19	3	16
	Silene dioica	-	-	1
	Rumex acetosella	-	-	7
	Galium sp.	-	1	-
	Lamiaceae	-	1	-

Table 1. List of species from three probes (Bruszczewo, on the dark background – cultivated plants)

	Species	probe 11 [75ml]	probe 13 [100 ml]	probe 15 [5 ml]
cult.	*Secale cereale*	56	14	3
	Triticum aestivum	13	10	5
	Hordeum vulgare	-	1	-
	Avena sativa/fatua	2	1	-
weeds	*Agrostema githago*	-	1	-
	Setaria pumila	1	3,5	-
	Setaria viridis	2	-	3
	Fallopia convolvulus	3	6	2
	Polygonum persicaria	-	-	1
	Chenopodium album	-	-	2

Table 2. List of species from three probes from Spławie (on the dark background – cultivated plants)

Species		probe / volume [ml]					
		1/ 250	4/310	6/100	10/150	12/4700	13/500
cultivated	*Secale cereale*	19	7	6	-	-	-
	Triticum aestivum	-	-	2	-	-	-
	Avena sativa/fatua	1	-	-	-	-	-
	Lens culinaris	1	1	-	-	-	-
	Vicia faba	70	-	-	-	1	-
weeds	*Chenopodium album*	-	-	2	-	-	-
	Chenopodium sp.	-	-	-	-	-	1
	Stellaria graminea	-	-	1	-	-	-
	Galium verum	-	-	-	1	-	-
	Galium sp.	1	2	-	-	-	1
	Corylus avellana	-	-	-	1	1	-

Table 3. List of species found in probes (Łekno)

	Species	Number of specimens
cult.	*Panicum miliaceum*	ok. 28 300
	Secale cereale	35
	Cerealia	21
weeds	*Chenopodium album*	13
	Chenopodium sp.	20
	Polygonum persicaria	32
	Setaria viridis	14
	Setaria pumila	17

Table 4 . List of species found in the probe from granary (Piaski-Rochy)

Warta River valley and morainic landscape south of Poznań

Paleomeanders in the Warta River valley

The Warta valley floor can be divided (Fig. 177) into three levels (Kozarski 1981):
A/ bifurcation terrace (66-65 m a.s.l.) which belong to the Warsaw-Berlin ice-marginal valley,
B/ transitional terrace (66-61 m a.s.l.),
C/ Floodplain (60-58 m a.s.l.).

On all three terrace levels are developed river paleochannels formed by braded and meandering pattern (Fig. 178). Paleomeanders are developed in two generations: older and younger and were filled by minerogenic and organogenc material. In the older generation is a more or less constant sequence of sediments varying in thickness. According to pollen analysis and radiocarbon datings,the older generation of paleomeander were formed during the Late Vistulian. The chonology of the Warta River chanel changes (southe of Poznań) mainly based on palylological data, are present on Fig. 179.

Rogalin – relicts from former riparian forest

The paleochannels were studied in river valley south from Rogalinek. In Warta River valley near Rogalinek is the largest in Poland stand of old oaks (*Quercus robur*) (Fig. 180), remnances of a former alluvial (riparian) forests.

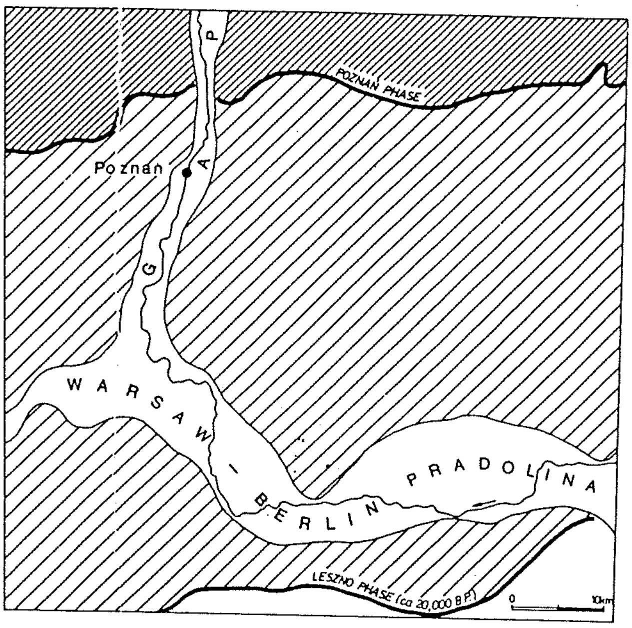
At present, in the vicinity of Rogalin, as much as about 800 magnificent old oaks are scatterede on an area of about 600 ha. Many old oaks grows also in the park surrounding the palace, among buildings in the village, in the forest and along the roads.

Palaeobotany of oxbow lake sediments

The paleomeanders contain very differentiated sediments which contain a rich amount of very well preserved plant and animal remnances. At the bottom lies a layer of fine, medium and coarse sand, which is overlain by silts from several centmeters up to 2 meters thick. The silt are covered with a gyttja layer (calcareous gyttja, coarse gyttja, sporadically mysterious black non-dy sediments). The topmost layer is mostly represented by peats. Paleobotanical studies were carriet out in many places of both generations of paleomeander and also in sediment accumulated in the braided river channels. The paleobotanical studies (mainly by pollen analysis and plant macrofossils, partly also fossil insects) were involved to the IGCP 158 A. Until now only a few preliminary results were published. Fig. 181 presents some simpified results of the investigations in years 1974-1985.

Kazimierz Tobolski

Fig. 177. Main geomorfic sub-units in the surroundings of Poznań (Kozaski 1981).



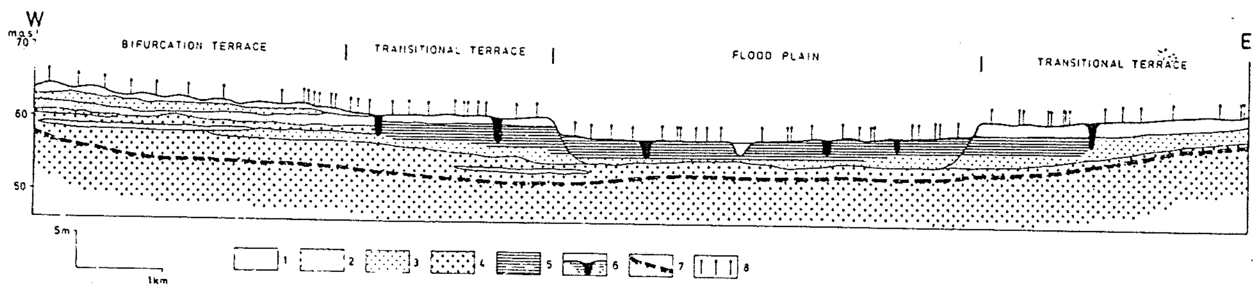


Fig. 178. Geological cross-section of the Warta River valey. 1 - fine-grained sand, 2 - medium-grained sand, 3 - coarse-grained sand, 4 - gravel and pebbels, 5 - sandy-clayey cyclothems, 6 - organc paleochannel fills, 7 - erosional bed, 8 - bore holes (Kozarski et al. 1988).

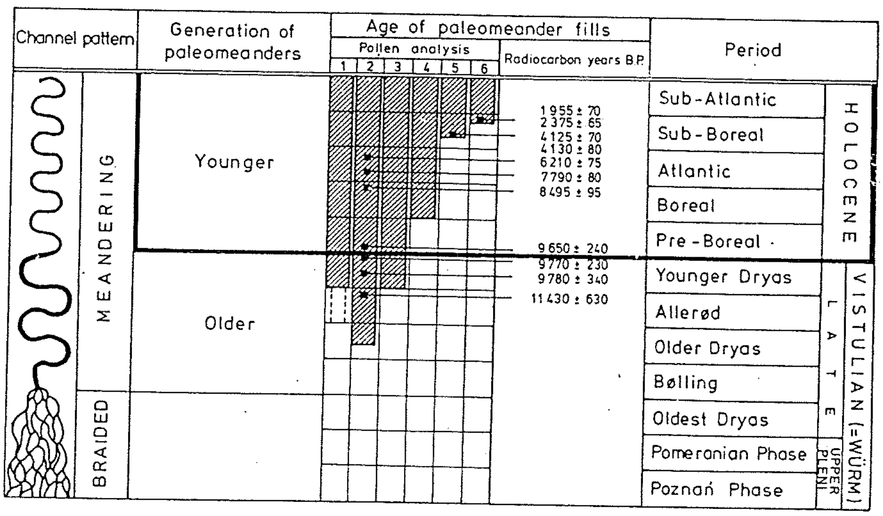


Fig. 179. Chronology of the Warta River channel changes to the south of Poznań (Kozarski 1981).

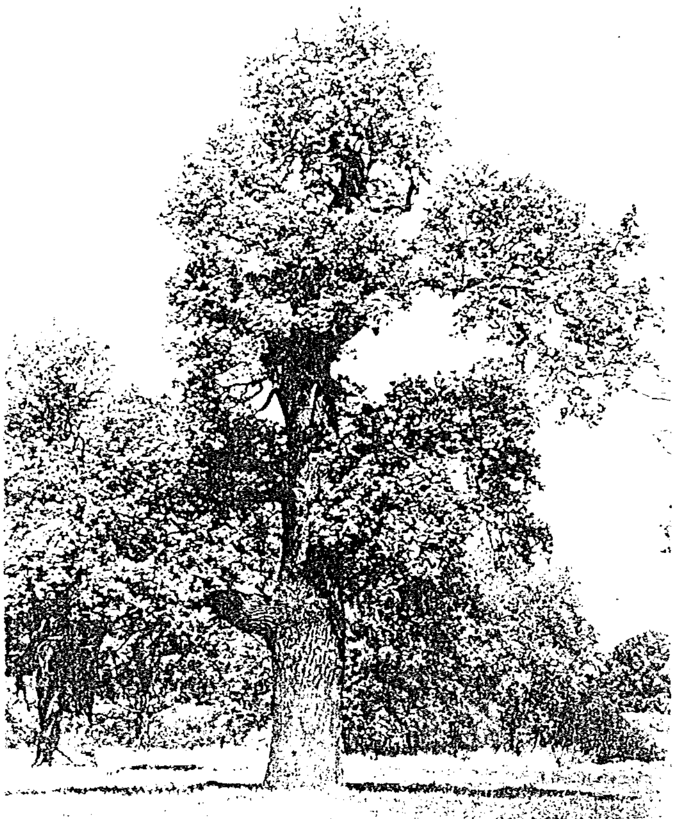
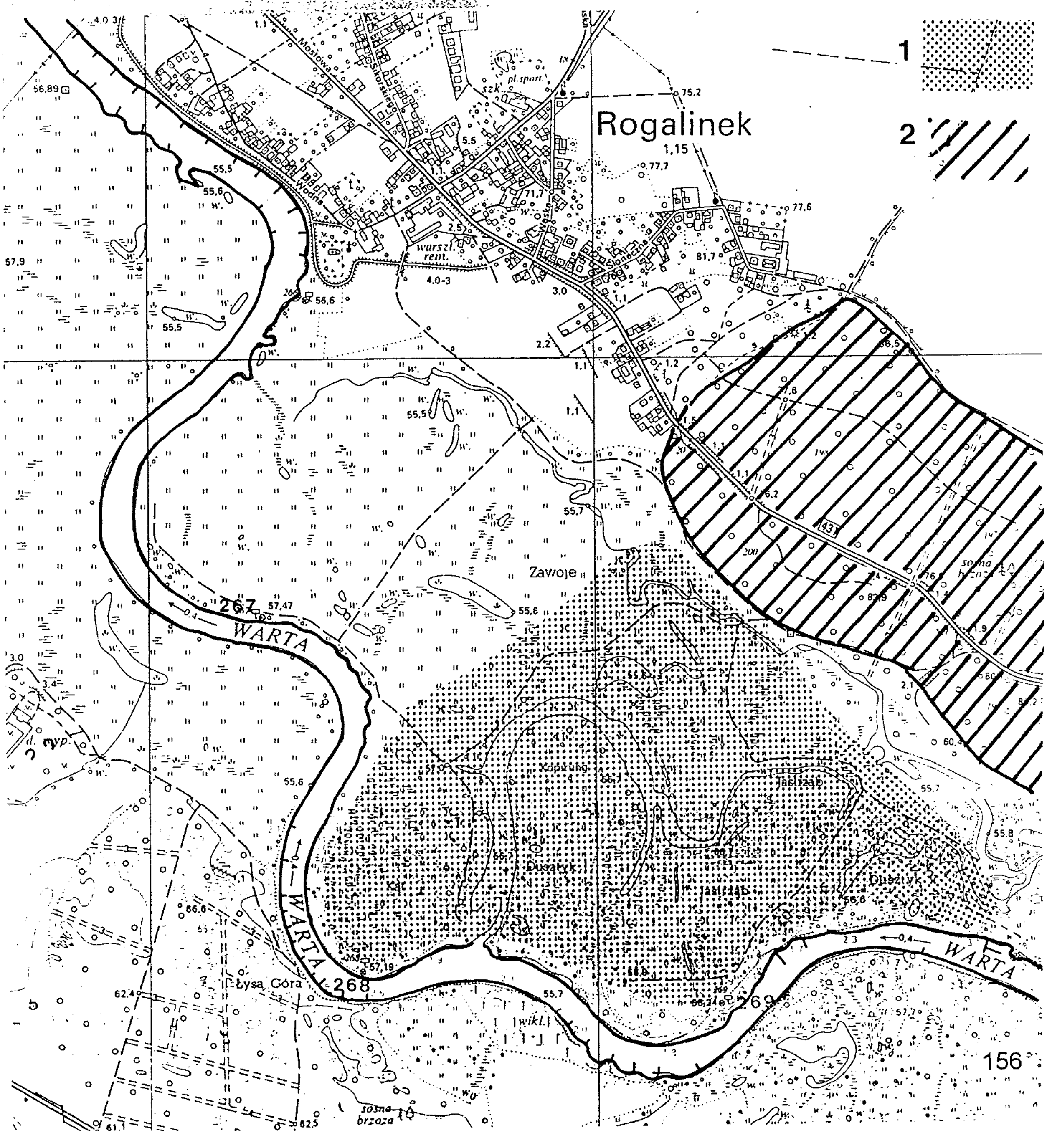


Fig. 180. Old oaks stands in Warta River near Rogalin.



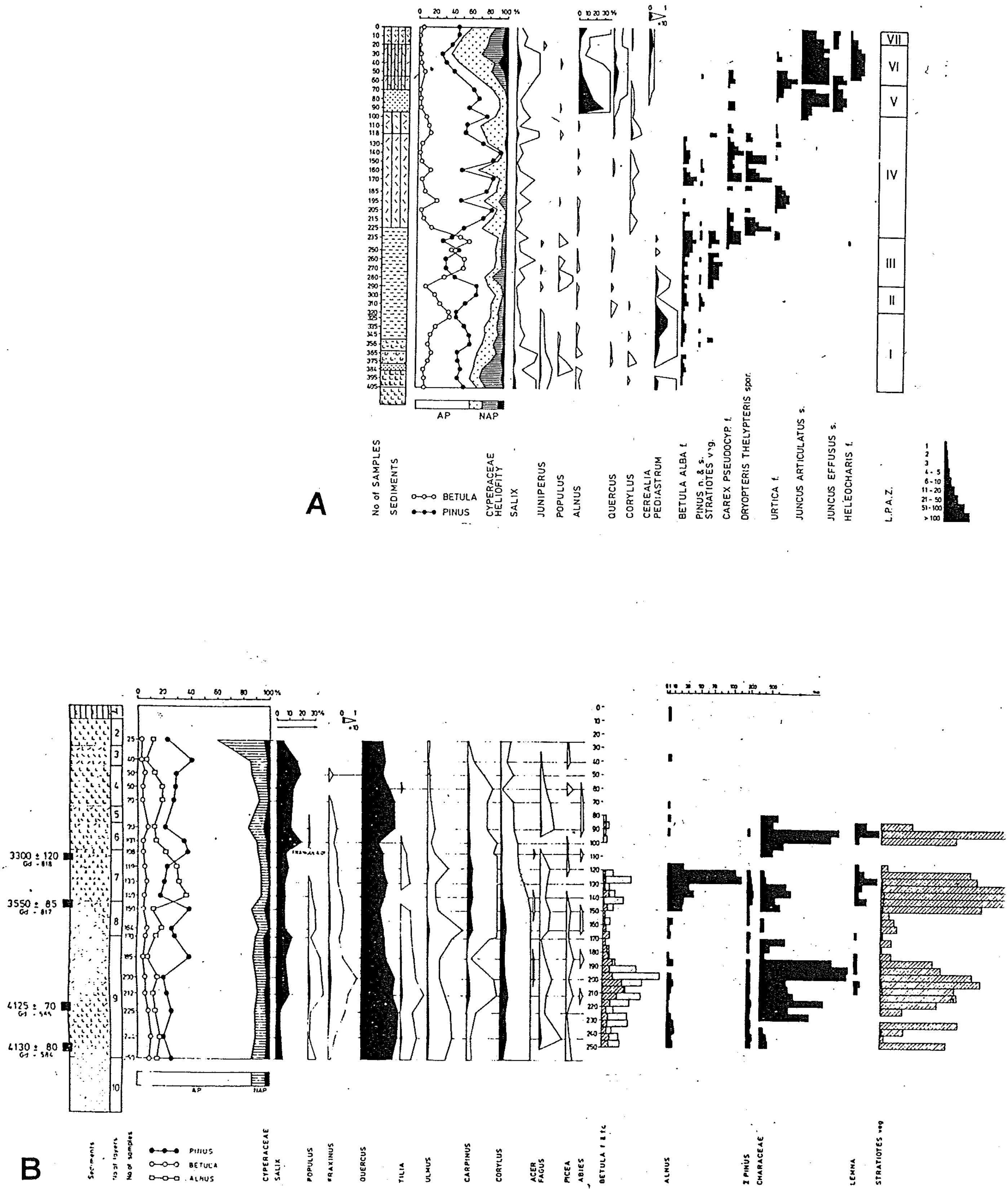


Fig. 181. Simplified pollen and plant macrofossil diagram of older paleomeander fill Zb/I (A), and younger in Czmoniec (B).

Wielkopolski National Park

The Wielkopolski National Park was established at 1957, its area amounts to 10000 ha. The area ich characterized by a relatively high number of lakes in different stages of eutrophization (from mesotrophic to the polytrophic ones). Large areas of the Park are covered by different types of forests: carrs, oak-horbeam forest (*Galio silvatici-Carpinetum*) with distinguishing elements: *Acer campestre* and *Sorbus torminalis*), oak mixed forests as well as pine forests. The spontaneous flora of vascular plants comprise 1120 species (116 families and 494 genera). Over 46% of the flora constitute very rare and rare species.

The palynological study began in 1929. Ołtuszewski (1957) in his monograph includ 8 modern pollen diagrams. He separate Late-Glacial sequences, which divided into Older Dryas, Alleröd and Younger Dryas (later revised by Wasylikowa) and have found large amounts of *Hipophaë rhamnoides*.

New pollen analysis from Skrzynka Lake, restricted to the Holocene gyttja (non calcareou sediments !) and peat were incorporated into a network or primary reference site (P-14) of IGCP 158 B (Fig. 182). The distribution of biogenic sediments were discribed some years later (Fig. 183)

Kazimierz Tobolski

Modern pollen/land-use relationships in cultural and forest landscape of north-western Poland

A modern pollen/land-use data set of 71 surface samples from different vegetation and land-use types in north-western Poland was analysed (Fig. 184). The samples were taken from non-fertilised grazed meadows (8 samples), traditionally or semi-traditionally managed fodder-producing mowed meadows (15 samples), combined mowed and grazed meadows (17 samples), ploughed meadows (4 samples), cultivated fields (13 samples), fallow land (3 samples), natural wetlands (4 samples), nemoral broad-leaved forests (beech, oak and alder forests) (5 samples), and coniferous pine forest (1 sampls) (Fig. 185). An emphasis was placed on mowed and grazed areas and cultivated fields (Secale, Hordeum/Avena, Fagopyrum). In north-western Poland, the prevailing traditional land-uses still in existence are mowing and grazing, combined in the same meadows. This type of site is also dominant in the data-set. Four sites are meadows occasionally subject to ploughing in order to increase the hay production. Ploughing leads to remarkable changes in the vegetation which may be reflected in the pollen record. The sites were selected in order to complete the existing pollen /land-use data-set from South Sweden. The field methods followed Berglund et al. (1986) and Gaillard et al. (1992, 1994). Seventeen environmental (e.g. management type) variables were collected for the 71 sites, and 8 soil chemistry variables are available for 54 of the 71 sites. Patterns of modern local pollen variation in relation to these environmental variables were explored by detrended correspondence analysis (DCA) and canonical correspondence analysis (CCA).

Arboreal/non arboreal pollen relationships

Open -land sites with different management generally show low AP values (Fig. 185). However in a few cases, AP reach 45 to 75%. These sites are either situated inside the forest or close to a forest's edge. Even in highly deforested sites, AP can reach 20 to 30% and includes long-distance pollen as well as pollen from scattered trees or small stands. Besides trees the most abundant pollen are those of general apophytes, in particular Gramineae. Some NAP taxa occur in all samples, from open or forested sites. These are *Artemisia, Urtica*, Chenopodiaceae, *Rumex acetosa/acetosella, Secale* and *Anthemis* type. Even Hordeum type and Avena type occurred in some forested sites. The high amount of NAP in forested sites may be due partly to the relatively open structure of modern forests, and partly to small size of the forests compared to the area of open, man-made vegetation types surrounding these forests.

Mowing and grazing.

They are characterised by high NAP percentages and a much more diverse pollen assemblage of herbaceous taxa. The mown and/or grazed meadows show high values of Gramineae (around 40%) pollen accompanied by the following pollen taxa: *Plantago lanceolata, Plantago maior, Plantago media, Trifolium repens, Heracleum sphodylium, Peucedanum palustre* type, *Ranunculus acris* group, *Rumex acetosa/acetosella*, *Aster* type, Compositae SF, Cichorioidae, Cyperaceae, Juncaceae. After Gramineae, *Plantago lanceolata* and *Rumex acetosa/acetosella* are the dominant herbaceous pollen taxa at these sites. *Plantago lanceolata, Ranunculus acris* group, *Trifolium repens* and *Heracleum sphodylium* pollen, in particular, are clearly associated with mowing and grazing. They are seldom recorded in sites with other land-uses. Morover, *Plantago lanceolata* pollen has a tendency to be better represented in mowed meadows or mowed and weakly grazed meadows. The highest percentages of *P. lanceolata* are found in ploughed meadows. In these cases, *P. lanceolata* is a pioneer species, and is the dominant species growing at the sites after ploughing. *Rumex acetosa/acetosella* type pollen is well reprsented both in meadows and in cultivated fields and fallow. It is also represented in forested sites.

Crop cultivation and fallow

Besides the crop actually cultivated at the sites, good indicator taxa of cultivated fields are *Hornungia* type, *Polygonum aviculare, Polygonum convolvulus* type, *Polygonum persicaria* and, in particular, *Scleranthus annuus, Agrostemma githago*,and *Spergula* type. *Polygonum aviculare* also occurs in in fallow land, and sporadically in grazed and mowed meadows. Fallow land may be difficult to separate from cultivated fields with *Secale*. Centaure cyanus seems to be a well-dispersed pollen type as it is represented in a large amount of meadows, in spite of the fact that the plant is strictly characteristic of cultivated fields and fallow land. *Fagopyrum, Hordeum* and *Avena* pollen show very low percentages, even inside or at the border of the fields. The characteristic spores of *Anthoceros punctatus*, a pioneer species of Hepaticae, were found in cultivated fields, ploughed meadows and fallow land.

Pollen/land use relationships - numerical analyses

Fig. 186 and Fig. 187 show the DCA plot (axes 1 and 2) of the 71 surface samples and 32 selected pollen and spore types in relation to 11 land-use and landscape variables. Axis 1 contrasts mowing with all other land-uses while the Axis 2 contrasts cultivated fields with the other land-uses. It appears that *Plantago lanceolata, Anemone nemorosa* group, *Ranunculus acris* group and *Heracleum sphodylium* are largely associated with mowing, Gramineae, *Urtica,* and *Plantago media* are associated with grazed and mowed sites, and *Secale cereale, Echium, Artemisia, Scleranthus annuus, Hornungia* type, *Polygonum convolvulus* type, and *Jasione montana* are linked to cultivated fields and fallow areas. Position of *Plantago lanceolata* id strongly influenced by the high values of this taxon in the ploughed meadows. A DCA analysis excluding these four sites would place *P. lanceolata* closer to the mowing score. The box-and-whisker plots performed for this taxon (Fig. 188) in different meadow classes (excluding ploughed meadows) show that the range of pollen percentages is largest in mowed sites, and smallest in grazed sites, and that the median and inter-quartile percentages are highest in mowed sites. In this modern data set *P. lanceolata* has a tendency to be best represented in mowed sites (without grazing).

Mirosław Makohonienko

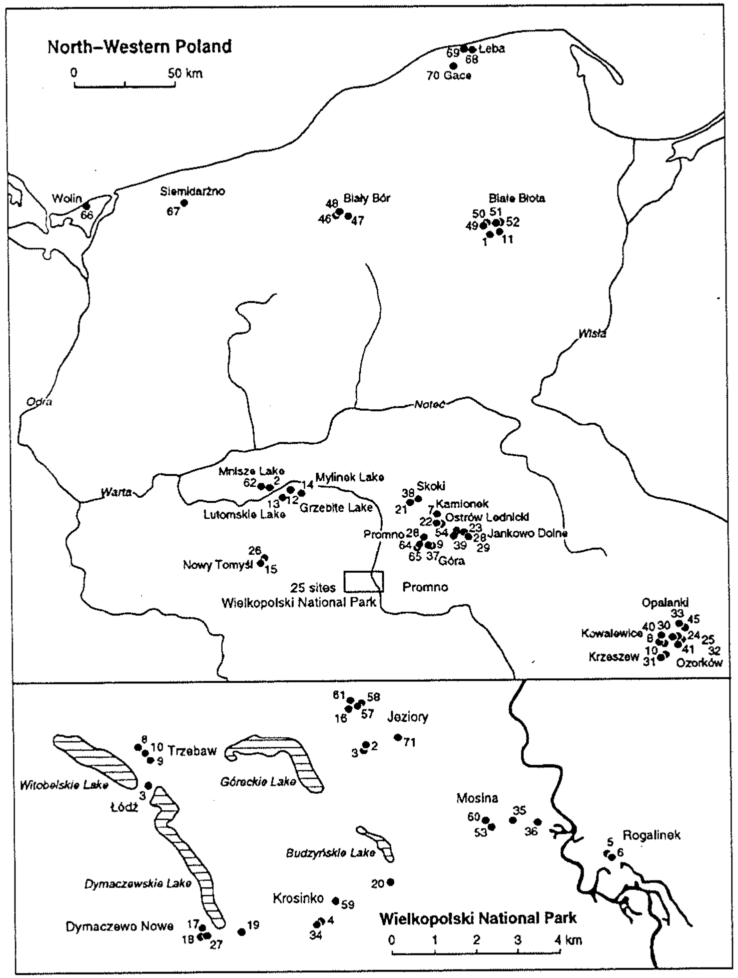


Fig. 184. Location of the 66 sampling sites (71 surface pollen samples) selected in different vegetation/land-use areas of north-western Poland for surface pollen sampling (mainly moss polsters, but also grass foliage, and surface soil), vegetation inventories, soil analysis, and land-use/environment characterisation.(Makohonienko et al. 1998)

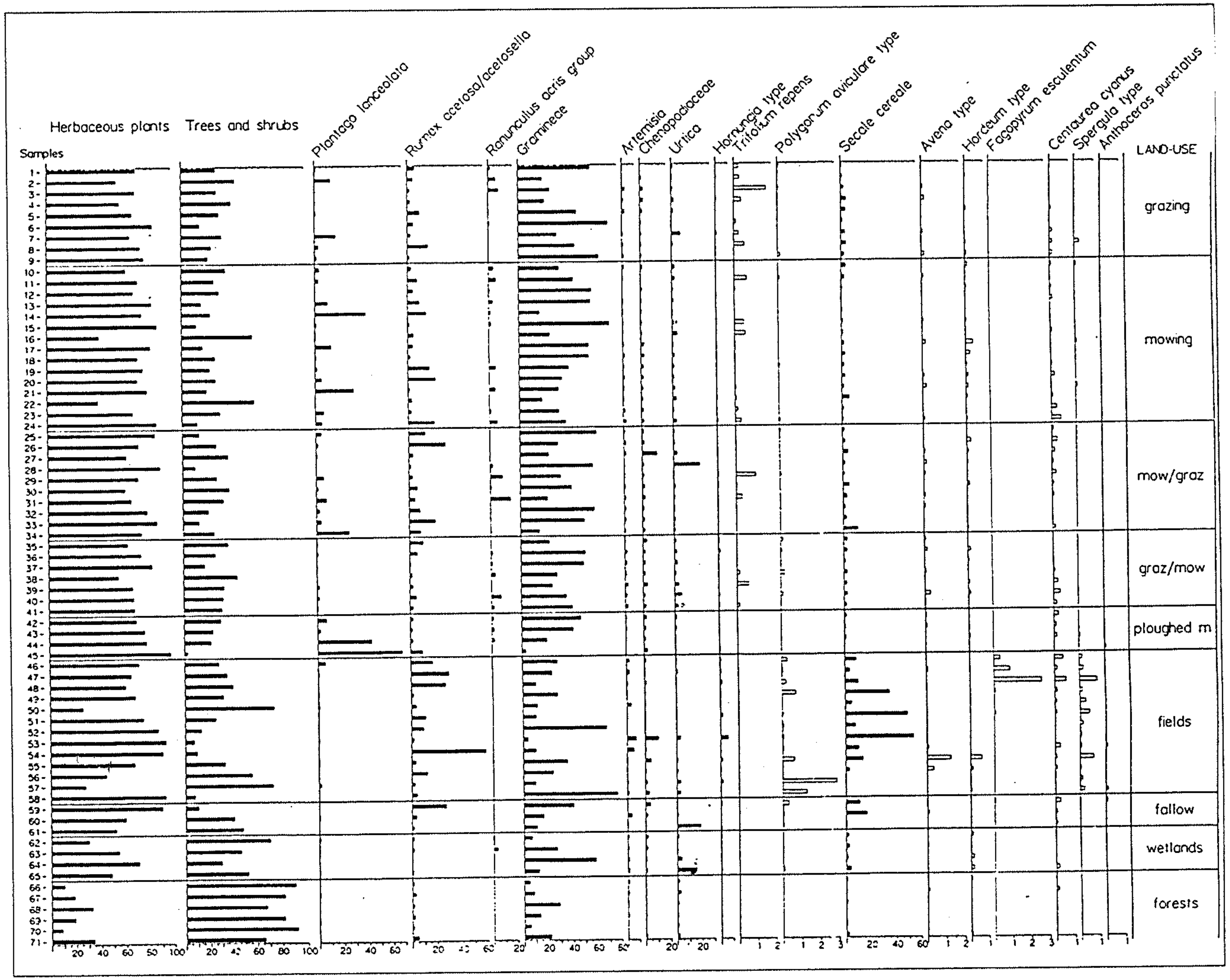


Fig. 185. Percentage pollen diagram of 71 surface samples for 17 selected taxa. The samples are grouped according to land-use. Abbreviations: (mow/graz) mowing and weak grazing, (graz/mow) heavy grazing and mowing, (m) meadow. (Makohonienko et al. 1998)

Fig. 188. Box-and-whisker plots for Plantago lanceolata pollen in three land-use classes (mowing, grazing and mowing, grazing) showing the median (wide bar), the interquartile range (solid box), and range (lines) of Plantago lanceolata percentages in the three land-use classes.

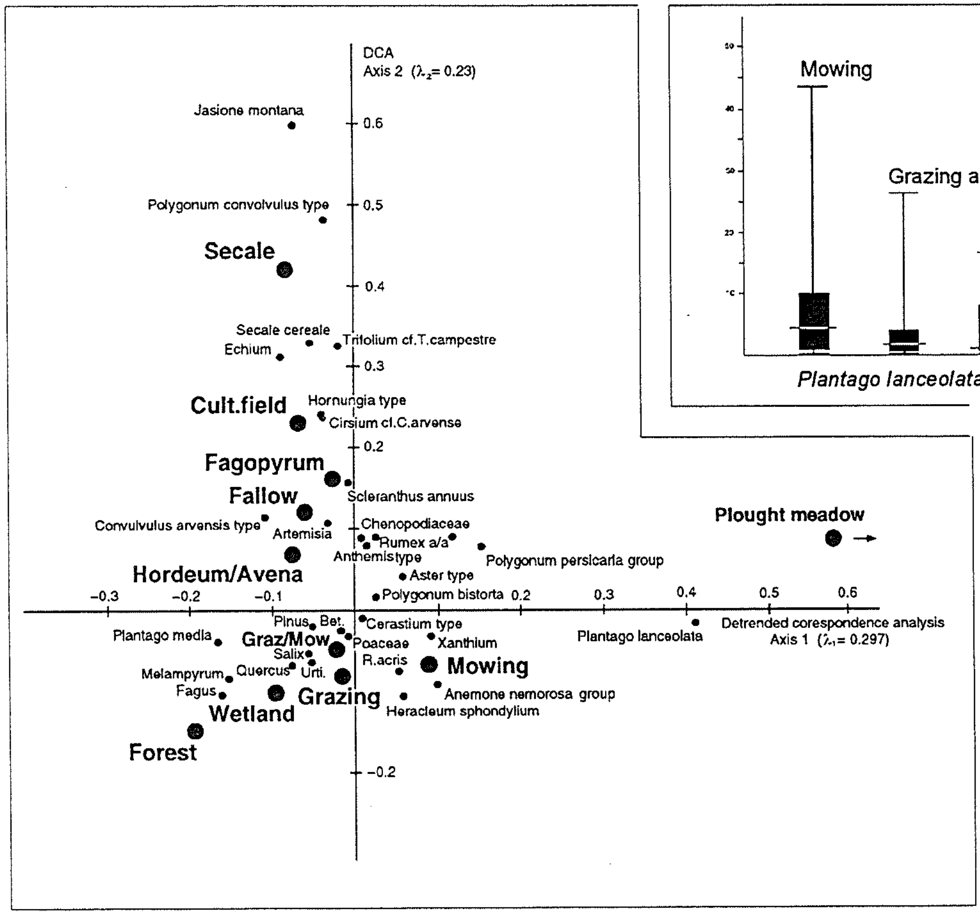


Fig. 186. DCA plot (Axes 1 and 2) of 71 surface pollen samples and 32 selected pollen and spores types in relation to 11 selected land-use variables. To avoid crowding on the plot, the position of thr 71 samples on DCAaxes 1 and 2 is not shown. The land-use variables are represented by large dots (dichotomous variables). Scores of pollen and spore taxa (dots) are weight mean sample scores. (DCA) detrended correspondence analysis, (Graz/Mow) grazing and mowing, (a/a) acetosa/acetosella, (Bet) Betula, (Urti) Urtica, (R) Ranunculus. (Makohonienko et al. 1998)

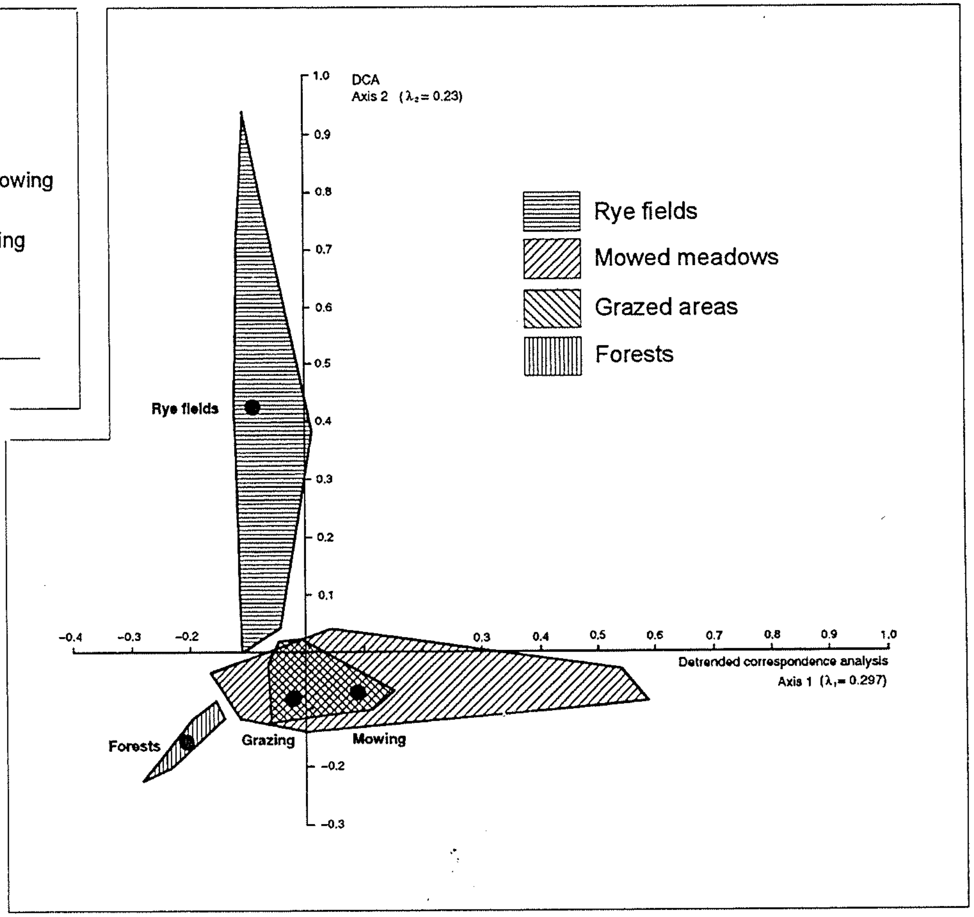


Fig. 187. DCA plot (Axes 1 and 2) showing the position of modern pollen samples from 6 rye fields, 6 forests, 19 mowed sites, and 9 grazed sites in relation to the scores for the rye fields, forests, mowing, and grazing variables. The scores for the land-use variables (large signatures) are represented by their centroid or weighted average of the site scores (small signatures) where the variable is present. The dashed areas show the distribution of individual rye fields, mowed sites, grazed sites, and forests. (Makohonienko et al. 1998)

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