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ANTHROPOGENIC CHANGES IN VEGETATION OF THE GARDNO-ŁEBA LOWLAND, N. POLAND

Preliminary report

Antropogeniczne zmiany w składzie roślinności Niziny Gardneńsko-Łebskiej

Doniesienie wstępne

INTRODUCTION

The Gardno-Łeba Lowlands are a separate, morphologically and genetically differentiated physiographic unit. Its northern part is delimited by the Baltic Sea shoreline while in the south the margin of a diluvial plateau marks its borderline (Fig. 1). Coastal lakes, the two largest of which cover 9626 ha, large areas of mires and, in the northern lowland part, coastal bar areas partly covered by migrating coastal dunes, make its relief particularly distinctive. In the lowland area, especially in its norhtern part, vegetation of unique character, with many natural features persisted in a well-preserved state. A large area of the northern part is under the supervision of the Słowiński National Park which is included into a group of world biosphere reserves.

The vegetation of the costal bar areas, composed with the other parts of the Gardno-Łeba Lowlands, is very different and little changed by man, as this large area of marshes and dunes with poor network of road and scarce settlement is very difficult of access. These facts have presumably made botanists suppose that the vegetation here is quite natural and man interference in these biocenoses minimal, if not lacking at all. The fact that the effects of ecological succession are easy to trace seems to confirm the suggestion about natural plant communities in the bar and partly peaty areas. In the bar area ecological succession includes two seres. One sere begins with nitrophilous and psammophilous plants and ends with pine forest *Empetro nigri-Pinetum*. Another sere is initiated with aquatic vegetation and ends with the development of extensive and well formed phytocoenoses (swamp alder wood — *Carici elongatae-Alnetum*).

Recently undertaken palaeobotanical studies on fossil soils, modern soil humus, and subfossil peats have shown that significant vegetational changes occurred several times on the bars and on post-Littorina surfaces lying to the south of the bar belt. Present day forest vegetation in these areas, though with

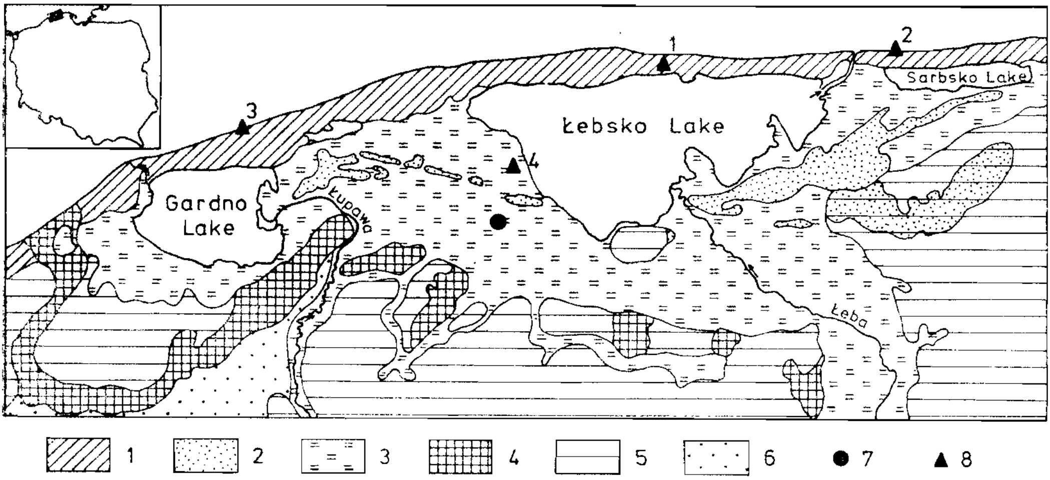

Fig. 1. Scheme of Gardno-Łeba Lowland geomorphology (according to A. Marsz, MS, simplified). 1 — coastal dunes; 2 — inland dunes; 3 — organic and mineral accumulation forms; 4 — end push moraines; 5 — moraine plateau; 6 — outwashes; 7 — reference site Kluki/74; 8 — other investigated sites

many natural features, results from at least the third turn of changes that have taken place in these geologically young areas during the last 3000 years. The studies have pointed to the influence of man's activities on the change of forests growing in the bar sector and on surfaces laying southwards. Man's activity on the bar is evidenced by numerous archaeological artifacts found recently, the oldest of which belong to the Bronze Age.

The objective of the present paper is to attempt the correlation of changes in vegetation that may be seen in the post-Atlantic part of Kluki pollen diagram which present the reference site of I.G.C.P. 158 B project, with some results from former investigations on fossil and modern soils, and some subfossil peats and gyttjas. Since all studies, especially radiocarbon datings, have not been yet accomplished, the data presented here are incomplete and should be considered as preliminary.

A BRIEF DESCRIPTION OF KLUKI REFERENCE SITE

Kluki/74 profile chosen as a reference profile lies within a vast peatbog complex extending throughout the northern part of the Gardno-Łeba Lowland. This peatbog complex, at present with partly changed vegetation (e.g. in the lowland large areas of peatbogs were transformed into meadows and fields), belongs to the coastal peatbogs extending along the shores on the southern Baltic coast. The majority of those coastal peatbogs belong to the geobotanical unit defined by Czubiński (1950) as the "Coastal Region". Kluki reference profile presented here can be regarded as representative of coastal peatbogs while the polygenetic northern part of the Gardno-Łeba Lowlands can be admitted a reference area with respect to the geobotanical unit "Coastal Region" within the Cashubian Lake District in the Western Pomerania. Studies on the Kluki profile also serve the needs of stratigraphy and correlation of the results of numerous palaeoecological researches and thus, permit the better understanding of postglacial history of vegetation and soils and of problems related to the southern Baltic history.

Sediments cores were obtained from Kluki Forestry Division area in the Słowiński National Park, 900 m southwards from the eastern part of the Kluki village (17°19' 54°40') in the forest section 77 and the southeastern part of subsection *k. Vaccinio uliginosi-Pinetum* growing on the deep peat deposit constitutes a phytocoenose. Tree stand in this bog pine forest is composed of pine of age-class V, and density of tree canopy is estimated to be 70%. Within the shrub layer *Ledum palustre* and single *Betula pubescens* specimens occur; herb and moss layers are composed of forest and high peat vegetation components. A rich stand of *Rubus chamaemorus* occurs about 500 m northwestwards from the boring site (cf. Piotrowska & Żukowski 1973). The surface of peatbog lies only 2·1 m above sea level.

The thickness of organic deposit is 6·7 m. In the bottom part of these deposits detritus gyttja occurs; a series of low peats with predominant macrofossils of *Cladium mariscus*, *Menyanthes trifoliata* and *Charales* overlie them. Greatest quantities of *Juncus subnodulosus* seeds in the peat are found at the depth of 395—275 cm. In overlying peats three layers of peat with *Cladium mariscus* alternate with two layers representing a swamp overgrown with birch forest (*Betuletum pubescentis*). Oligotrophication processes are clearly seen to affect peatbog formation from the depth of 65 cm. Palynological studies and radiocarbon datings permit inference about the beginning of organic deposition which can be assigned to the Preboreal (the depth of 655—660 cm: 9855 ± 315, Hv-9104; 660—665 cm: 9865 ± 105, Gd-548). Since then at least a few distinctive minerotrophic phytocoenoses have contributed to the deposition of various peat layers. Oligotrophication processes in the peatbog began about 1000 years ago. Bog pine forest phytocoenose growing on the peatbog is estimated to be very young. Most probably modern pine stand constitutes the first tree generation of this forest phytocoenose.

MAIN CHANGES IN VEGETATION BASED ON THE UPPER PART OF KLUKI/74 PROFILE

The description of vegetational changes is confined to the main characteristics of curves for oak, hornbeam, beech and for plant indicators of human activity. The contributions from oak and beech are of significance since, prior to pine spread, extensive forests on coastal dunes of the Gardno-Łeba Lowland bar were composed of them (Tobolski 1975, 1980).

Oak pollen curve in the upper part of the profile shows many oscillations, some of which overlap with quantitative changes in man's activity indicators. This appears to be noted at the depth of 180 cm where 18% fall in oak pollen proportions coincides with the first peak in man's activity indicators. *Secale* pollen was then found for the first time. Before that, at the depth of 230—180 cm, regular occurrence of sporomorphs from that group was concomitant with declining oak contribution which was, in turn, coincident with increasing occurrence of hornbeam. The beginning of continuous hornbeam pollen curve has been radiometrically dated to 3865 ± 70 (Gd-563) years BP. The next peak of oak pollen together with a pronounced decline in man's activity indicators is again to be noted at the depth of 95 cm. Also, the absolute maximum of oak pollen proportion in the top sample is associated with similar fall in both weed and cereal pollen. Large proportions of oak pollen in the recent spectrum of the profile reflects a sudden expansion of *Quercus robur* in the northern part of the Gardno-Łeba Lowland. This species is to be found there in diverse forest phytocoenoses including swamp forests and changed habitats lying on thick peat beds.

The beginning of a continuous beech pollen curve is to be found at the point of a decline in man's activity indicators at the depth of 120 cm. From that point up hornbeam proportions, though restricted until then, re-increase and this is accompanied by a small peak in the *Corylus* pollen curve. The process of successional changes in tree stands took place at the beginning of the Christian era; the radiocarbon date is 1750 ± 50 years BP. The depression of hornbeam pollen curve (the depth of 75 cm) with concomitant increase in indicators of man's activity follows rapidly the absolute maximum of this tree. That decline in hornbeam pollen values is not accompanied by a fall in the beech pollen curve since it occurred later on. From that point up the lack of synchronous oscillations in beech and hornbeam curves may be seen several times. These metachronous hornbeam and beech reactions to oscillations in the curve of human activity indicators may provide evidence for: (1) the spread of hornbeam and especially beech forests in the northern part of the Gardno-Łeba Lowland, (2) forests with dominant beech and dominant hornbeam were separate phytocoenoses.

Hornbeam dominated forests occupied the northern part of the Gardno-Łeba Lowlands over a period of a few hundred years only. In the recent millennium the role of that species was insignificant and was confined to very small areas. The majority of hornbeam pollen in the recent millennium seems to have been transported from plateau areas. Beech occurrence in the highest spectra is of particular significance since large areas of old beech forests are noted to occur about 2·5 km north-northwestwards from the boring locality.

The survey curve being a sum of plant indicators of man's activity can be divided into five successive parts designated A—E (Fig. 2 under the cover).

The oldest part which comprises weeds with dominant *Artemisia* and *Rumex acetosa/acetosella* type shows low values that do not exceed 1%. Besides, sporadic pollen of *Plantago lanceolata, P. maior/media* type and one *Triticum* pollen grain occur there. Part A was formed in the Bronze Age.

In the part B, the curve shows higher percentage values, always over 1%. That part includes chiefly *Artemisia* pollen (maximum values in the entire profile), *Rumex acetosa/acetosella* type, regular proportions of *Plantago lanceolata* at its absolute maximum and other weeds. The scarcity of cereals is still to be noted. That part of the curve refers to the younger part of the Bronze Age and the beginning of the Iron Age. Part C, similar to the preceding one in its floristic composition, records a decline in man's activity in nearby areas. The age of that part is 1750 $\pm$ 50 years BP.

Part D presents quite different picture. The quantity of weeds is very small but simultaneously the beginning of an almost continuous cereal curve is to be noted here. At present it is premature to conclude whether the lack of man's activity in the northern part of the Gardno-Łeba Lowland is to be recognized in that part. It cannot be excluded that cereal pollen and perhaps weeds as well, were transported from distant, presumably morainic, areas.

Part E is characterized by regular occurrence of cereals and large, but variable weed proportions. That part can be divided into three subparts with respect to different percentage of cereals.

The lower part of the curve (A—C) reflects pastoral farming while part E illustrates cereal growing dominated farming. Now it is rather difficult to explain oscillations of the cereal curve. Additional studies are required to contribute to our better knowledge of that problem. It has already been known that those changes occurred in the nearby areas. A decline of cereal proportions in the modern pollen spectrum of that profile confirms the above suggestion. That fall results from changes in agriculture in the northern part of the Gardno-Łeba Lowland.

THE ROLE OF AN ANTHROPOGENIC FACTOR IN FOREST HISTORY

The description of changes in forest cover should be now supplemented by examples of histories of particular phytocoenoses in the northern part of the Gardno-Łeba Lowland.

Palynological studies on humus horizons in fossil and modern soils, and on subfossil peats and gyttjas permitted inference about histories of particular phytocoenoses. They provided evidence of numerous changes that very frequently proceeded from disastrous destructions of forest phytocoenoses. After almost each disaster a forest community began to recover in a form quite different from phytocoenoses prior to destruction.

Changes of phytocoenose in bar areas

During the Subboreal and at the beginning of the Subatlantic eutrophic and mezotrophic oak forests grew on coastal dunes of the Łebska Bar (Fig. 1, site 1). About 1900 years ago those forests were destroyed by fires, which is evidenced by numerous charcoals in accumulation horizons of forest soils and sometimes at the contact between two different humus types. Oak charcoals found in the humus horizon and in the charcoal layer separating oak forest humus from an overlying layer of humus formed in another phytocoenose have been dated to 1920 ± 200 (Gd-W7) and 1940 ± 50 (Lu-769) years BP, respectively. After oak forests had been destroyed, beech forests with acidophilous plants dominating in the herb layer appeared in those habitats. This change resulted in the accumulation of mor humus and in soil podsolization. The destruction of oak phytocoenose and the development of beech forest on the bar were recorded in Kluki/74 profile and their age was estimated as 1750 ± 50 years BP. That date refers to the beginning of a continuous beech curve. Contemporary pine forest cover on coastal dunes records the youngest stage of forest development in that area. It is estimated to date from 1500 years ago (Tobolski 1975, 1980), and in many localities from 200—300 years ago only.

Subfossil biogenic deposits from the beach zone also record the development of local vegetation. One of the sites under investigation is located in the western part of the Sarbska Bar near Łeba (Fig. 1, site 2), another on the Lake Gardno Bar (Fig. 1, site 3).

At the end of the Atlantic on the Sarbska Bar (cf. Tobolski 1979), the plant succession started from communities of a shallow basin of brackish water. Subsequently, these communities were replaced by alder wood. In the Bronze Age (2459 ± 140, Gd-416) that alder forest underwent destruction. Shrub community of *Salici-Franguletum* type then prevailed throughout the sedimentational basin and shortly afterwards a new sere began to form, resulting finally in oak forest. Occurrence of such a forest is evidenced by humus horizons containing 62% of *Quercus* pollen and by oak wood, e. g. oak trunk 55 cm in diameter with 160 annual rings. That trunk lying horizontally, covered a depositional layer in an oak forest. Its lower part down to the depth of a few centimeters underwent carbonization. Radiocarbon dates of oak forest humus horizons yield the age of 1435 ± 140 (Gd-418) while the outermost covering of the trunk has been dated to 1220 ± 45 (Gd-573) years BP. The dating of two other wood samples from oak roots that belong to the same subfossil phytocoenose of oak forest has allowed calibration as far back as 1125 ± 45 (Gd-1006) and 1065 ± 50 (Gd- 1008) years BP (Tobolski, Pazdur et al. 1980). Oak forest, just like alder forests growing there formerly, was also destroyed by fire. Subsequently bog vegetation developed and later on, the regenerative phase of birch forest was formed. Yet, the regeneration of oak forest was inhibited. Instead, transition peatbog was formed. Its further development was interrupted by aeolian processes. On a layer of dune sand 50 cm thick, bog birch-pine forest developed and afterwards *Myrica gale* dominated community prevailed. That community was next destroyed by subsequent invasion of dune sands.

On the beach of Lake Gardno Bar (Fig. 1, site 3) a few large subfossil oak trunks were found. The majority of those oak trunks have their roots in a low peat layer. Palynological investigations upon these peats have shown that they accumulated in the Atlantic (Tobolski, M S.) while subfossil phytocoenose of oak forest occurred in the Subboreal Period and underwent destruction in the Bronze Age. The datings of wood from outermost covering of the two trunks produced the radiocarbon age of 2865 ± 55 (Gd-1006) and 2135 ± 50 (Gd-1005) BP (Tobolski, Pazdur et al. 1980).

Changes of phytocoenose on mineral surfaces outside the bars

History of beech forest in the regions 2·5 km to the north of Kluki/74 profile was reconstructed by palynological investigations on humus horizon of podsolic-mucky soils 40 cm thick (Tobolski 1975; Dzięciołowski, Tobolski 1975: Fig. 1, site 4). Unfortunately, no radiocarbon dates have been so far obtained for that site but the history of local forest vegetation can be correlated with the adjacent peat profiles. That soil formed in an area subjected to Littorina transgression. Alder wood of *Carici elongatae-Alnetum* type that changed next to a drier alder forest constituted there the first forest community. Afterwards oak forest (65% *Quercus* pollen) prevailed. Its destruction is evidence by charcoal proportions in the soil. The regeneration of forest vegetation similar to that on coastal dunes led to the development of beech forest with oak. Its destruction was subsequently followed by the regeneration of beech forest with hazel and birch, which finally resulted in beech forest that persists today.

The data obtained suggest that in the northern part of the Gardno-Łeba Lowland, especially in the bar areas and to the south of the bar, abrupt, sometimes disastrous changes in forest phytocoenoses are to be interpreted as due to anthropogenic processes. Anthropogenic genesis of these changes is evidenced by:

(1) the occurrence of charcoals, very frequently forming a clear fire layer and lying in horizons of radically changed forest phytocoenoses; fire or charcoal layers frequently separate clearly different deposits,

(2) the fact that increased and sometimes maximum pollen values of plants indicating man's activity almost always occur, in levels of change in forest phytocoenose,

(3) archaeological artifacts occurring in fossil soils or in nearby regions,

(4) chronostratigraphic correspondence between sites which record clear evidence for changes in forest cover and Kluki/74 profile where pollen of oak, beech, hornbeam and human activity indicators are allochthonous components.

In the Sarbska Bar profile, the most distant one from Kluki /74 reference site, charcoal layers are correlated with maximum or clearly increasing proportions of human activity indicators (Fig. 1, site 2). Simultaneously an abrupt decline in forest tress pollen occurred, recording a local formation of a treeless area. Those sudden changes in forest vegetation resulted in changes within a habitat and affected geographical environment by giving rise to aeolian processes and water level fluctuations.

Processes and interactions recorded in that profile were of much larger extent and also affected other bar areas and the adjacent regions within the Gardno-Łeba Lowland. That may also be apparent from humus horizons of fossil and modern soils. In those profiles changes in forest vegetation are accompanied by charcoal occurrence; in addition, proportions of human activity indicators as well as pollen of acidiphilous plants are noted to increase. The natural environment responds to anthropogenic activity which brings in advance of oligotrophication in less stabilized habitats by the expansion of acidophilous plants into the sites where forest vegetation was changing. Habitats on coastal bar dunes are particularly susceptible of far-reaching changes. During the last 3000 years the bar area has undergone many changes, with several dune changes being clearly apparent. Longitudinal dunes where oak forest grew and beech forests were next predominant belong to the oldest ones. Higher and more extensive parabolic dunes on which pinewoods grew constituted the second generation of dunes. Modern dunes with the highest and, to a large extent, mobile aeolian forms are to be included into the third generation.

CONCLUSIONS

1. Palaeobotanical studies have pointed to a clear relationship between several changes in forest vegetation and man's activity in the northern part of the Gardno-Łeba Lowlands, and especially in bar areas. The oldest traces of that activity, as revealed until now, are interpreted to belong to the Bronze Age.

2. Changes in particular forest phytocoenoses in a few localities in the northern part of the Gardno-Łeba Lowlands can be interpreted to record events with respect to Kluki/74 profile. Particular localities as well as the overall palynological image of Kluki/74 profile allochthonous components are complementary to, and chronologically consistent with one another. A greater number of datings and investigations of other localities will permit inference about more detailed correlation.

3. Vegetational changes resulted in readily apparent alterations of the entire natural environment. They involve changes in dune morphology interpreted as due to aeolian activity and water-level fluctuations followed by the formation of a temporary basin and paludification. Migration and colonization of acidophilous plants predominating in modern vegetational cover of that area occurred.

4. Changes within abiotic and biotic sectors initiated by, or intensified by, an anthropogenic factor are closely related to the fact that coastal dune environment is easily susceptible to changes. Apart from the existence of labile habitats another factor is an important clue to the intensification of man's destructive activities. It is found to be a complex of subfactors which are concomitant with climatic-edaphic telocratic stage and regressive succession.

5. Palaeobotanical data suggest that a few generally accepted views on the succession and history of vegetation on coastal dunes, and on the origin of bar coast in the Gardno-Łeba Lowland call for verification.

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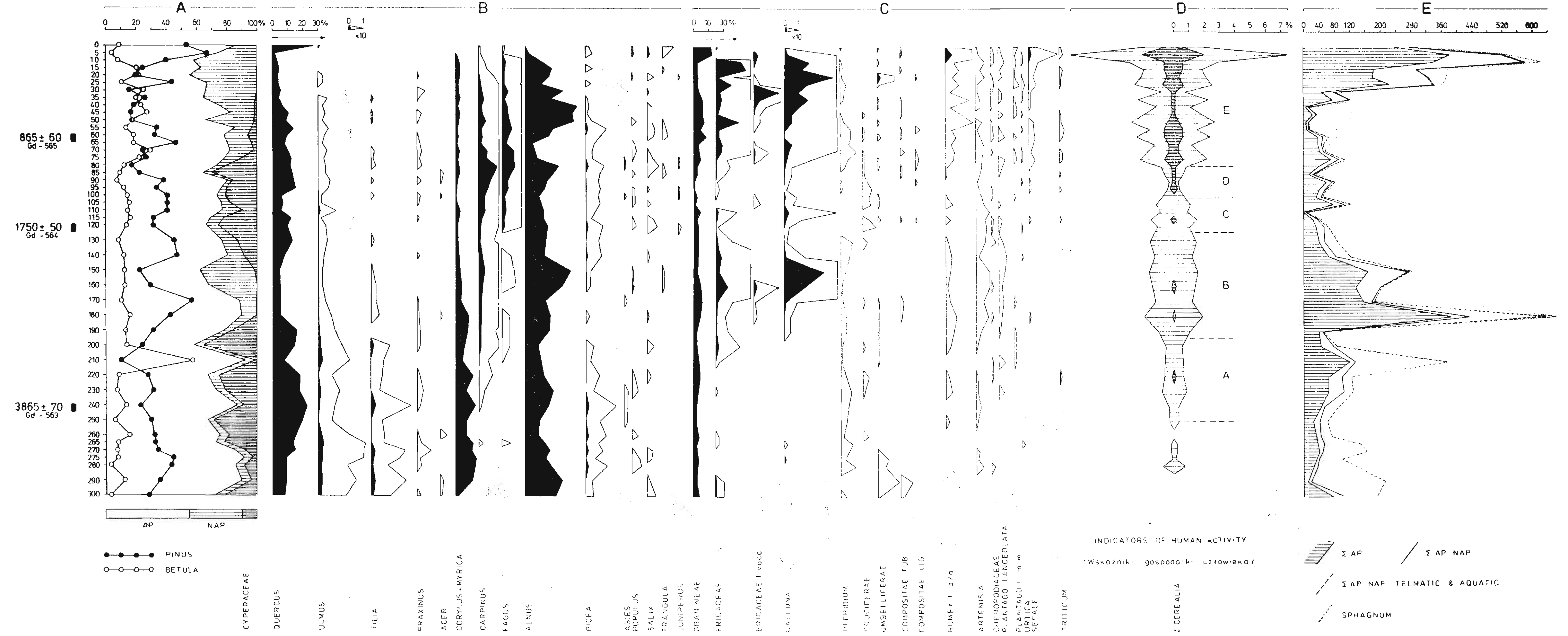

Fig. 2. Simplified pollen diagram from the upper part of the profile Kluki/74. A, C, D, — total percentages (AP+NAP = 100%), B—AP = 100%, E — absolute pollen concentration (thousands pollen grains) cm³