Studia Quaternaria, vol. 28 (2011): 53–59.

THE HISTORY OF *CLADIUM MARISCUS* (L.) POHL. IN THE "KŁOCIE OSTROWIECKIE" RESERVE (DRAWIEŃSKI NATIONAL PARK). PART I

Mariusz Gałka, Kazimierz Tobolski

Department of Biogeography and Palaeoecology, Adam Mickiewicz University, ul. Dzięgielowa 27, 61-680 Poznań, Poland, e-mail: gamarga@wp.pl, tobolski@amu.edu.pl

Abstract

The objective of the paleoecological studies undertaken in the "Kłocie Ostrowieckie" reserve was mainly to reconstruct the subfossil mire vegetation at a local and regional scale. This article presents the results of palynological and plant macroremain analyses of this site, and belongs to the first published studies of such a type, made in the Drawieński National Park. Based on our studies, five phases in the history of the mire development were determined. The most pronounced feature of that history, was a decline of *Cladietum marisci* clearly concurrent with a strong yet puzzling expansion of pine stands occurring approximately 1000 years ago.

Key words: paleobotanical research, pollen analysis, plant macrofossils, *Cladium mariscus* (L.) Pohl., biogenic sediments, Drawieński National Park.

INTRODUCTION

Cladium mariscus (L.) Pohl is one of the most intriguing telmatophytes of the Middle European flora, but so far, it has been insufficiently investigated. The necessity of extending knowledge of this plant is particularly confirmed by its postglacial history, revealed to a greater extent by paleoecological research (Conway 1938, Jalas, Okko 1951, Balátová-Tuláčková 1991, Salmina 2004, Pokorný *et al.* 2010). The surveys carried out so far, particularly those undertaken in NW Poland, especially in the Słowiński National Park (Tobolski 1987, Tobolski et al. 1997), "Bory Tucholskie" National Park (Gałka, Tobolski 2006, Gałka 2006, Gałka 2007), and Suwalski Landscape Park (Gałka, Tobolski unpubl. data), have revealed facts worthy of attention. The Drawieński National Park includes sites of *Cladium mariscus*, earlier studied by Jasnowska and Jasnowski (1991a, b, c) and mentioned by Tobolski (2000). These studies were interesting especially in light of a new peat species that has been identified in sediments of the "Kłocie Ostrowieckie" reserve (cf. Jasnowska, Jasnowski 1991b). Saw sedge sites from the Drawieński National Park were discussed in a series of our references, with the objective of producing an epiontological monograph on the plant at the Middle European scale. The following paper initiates a series of surveys concerning saw sedge sites from the Drawieński National Park.

The main objective of the surveys was to determine the history of *Cladium mariscus*, both in light of palynological analyses and carpological findings. The necessity of paleoecological research is confirmed by the fact that neither this site nor any of the sites within the entire Drawieński National Park have been subject to any published survey utilizing a pollen analysis or subfossil diagrams of macroscopic findings. Thus far, the reserve has only been the subject of peat bog and phytosociological studies by the aforementioned Jasnowskis. The studies included drillings using a manual corer, analyses of selected plant macrofossils, and execution of numerous phytosociological records.

The results of the research on the history of *Cladium mariscus* in the "Kłocie Ostrowieckie" reserve provide valuable information on the history of this threatened species in the area. The obtained knowledge can be then utilised applied to for future protection of this valuable site.

STUDY SITE

The study site is located in NW Poland. The "Kłocie Ostrowieckie" reserve, including a peat bog adjoining the northwest shore of Lake Ostrowite, is situated within the Drawieński National Park (Fig. 1). The mire, which has an elliptical shape and a NS-oriented longitudinal axis, is surrounded by mineral elevations reaching up to 15 m in relation to the peat bog level. The slopes are overgrown by *Pinus sylvestris*. A major part of the area of the mire is currently occupied by *Alnus glutinosa*, being an expansive element within the object. *Alnus glutinosa* tightly surrounds an assemblage with *Cladium mariscus* L. (Pohl), occupying the middle part of the biogenic accumulation basin. At the edges, *Cladium mariscus* grows among *Sphagnum* (including *S. teres*, *S. magellanicum*, *S. palustre*), *Carex paniculata*, and *Thelypteris palustris*. The peat bog is almost entirely separated from the waters of Lake Ostrowieckie with a mineral bar.

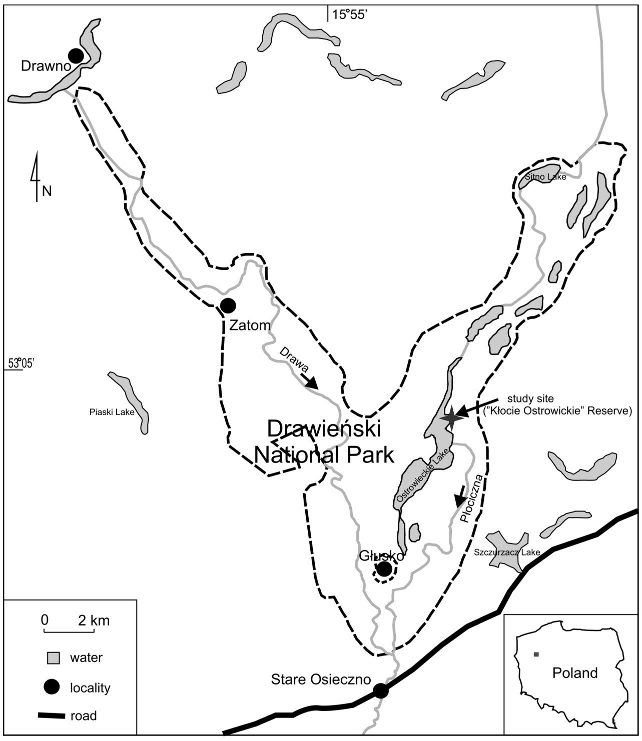

Fig. 1. Setting of the area studied in the paper.

METHODS

The material for laboratory analyses was sampled using an Instorf peat sampler with a length of 50 cm and a diameter of 10 cm.

The sediment, including the uppermost layer of lake sediments and overlying peat, with a thickness of 200 cm, was sampled in the northern part of the reserve in an alder forest, 25 m south of the mineral bar. This location of the core sampling site resulted mainly from the largest thickness of the peat deposit in that place (according to Jasnowska, Jasnowski 1991c) and the current lack of individuals of *Cladium mariscus* in that part of the reserve.

The palynological analysis, which allowed the determination of the time and nature of plant assemblage transformation, was carried out with a standard resolution of 10 cm, increased up to 5 cm in sections with a clear transition between sediment types. Analysis of plant macrofossils was carried out every 2.5 cm, with slight differences resulting from transitions between sediment types. The volume of each sample was approximately 100 cm^3.

The percentage of calcium carbonates in the biogenic sediments was determined using the Scheibler method. In total, 15 samples of lake and peat sediments were analysed.

Table 1

Radiocarbon dates of samples of the studied core

Lab. no.	Depth (cm)	Material	^{14}C age	Age AD	Age cal. BP
Poz-35954	90-92	Fruits *Betula* sp.	1000 ± 40 BP	974-1155	977-795
Poz-35955	154-156		1070 ± 40 BP	891-1024	1059-927

To determine the absolute age of the events, *Betula* fruits were selected, and two samples were sent to the Radiocarbon Laboratory in Poznań (Table 1). Both samples were calibrated using the OxCal v 4.10 program (Ramsey 2001) with the IntCal04 calibration dataset (Reimer *et al.* 2004).

RESULTS

Pollen analysis

The pollen analysis allowed for determination of four local pollen assemblage zones (LPAZ) (Fig. 2).

K.OST.1 I Pinus-Alnus LPAZ (200–175 cm)

This zone includes the first maximum of pine; the content of alder pollen grains is between 10% and 20%.

K.OST.1 II Alnus LPAZ (175–137 cm)

This zone is distinguished by the maximum percentage content of alder pollen grains, the regular occurrence of oak (approx. 10%), and a hornbeam pollen curve slightly above 5%.

K.OST.1 III Quercus-Fagus LPAZ (137–97 cm)

This zone has the maximum content of oak (15%) and beech pollen grains (5%). Among the telmatophyte sporomorphs is a regular, but low, occurrence of saw sedge pollen grains with two low culminations at the borders of the zone.

K.OST.1 IV Pinus LPAZ (depth 97–0 cm)

This zone has the maximum content of pine (reaching 90%), and a decrease in the participation of sporomorphs of deciduous trees (the continuous curve is determined only by alder pollen grains). Sporomorphs of the mire plants *Thelypteris palustris*, Filicales monolete, and Cyperaceae are found (all excluded from the NAP total; they form consecutive maxima).

Macroscopic plant remain analysis

From the macroscopic plant remain analysis, five local macrofossil assemblage zones (LMAZ) were determined in the development of the mire (Fig. 3).

KŁO I Najas LMAZ (200–142.5 cm)

In the lake sediment, only seeds of *Najas marina* were found. This phase preceded the development of the peat bog because herbaceous peat was deposited on the sediment developed during the phase. This zone includes the stage of a shallow lake, which has few elodeids and nympheids.

KŁO II Cladium LMAZ (142.5–82.5 cm)

In this period, a dense assemblage of saw sedge developed at the site analysed. Other immersion plants were *Schoenoplectus tabernaemontani* and *Typha* sp. Moreover, *Carex pseudocyperus* and *Thelypteris palustris* occurred amongst the *Cladium mariscus*. Its generative organs, deposited in herbaceous peat with a thickness of 60 cm, suggest the stability of the *Cladium mariscus* assemblage.

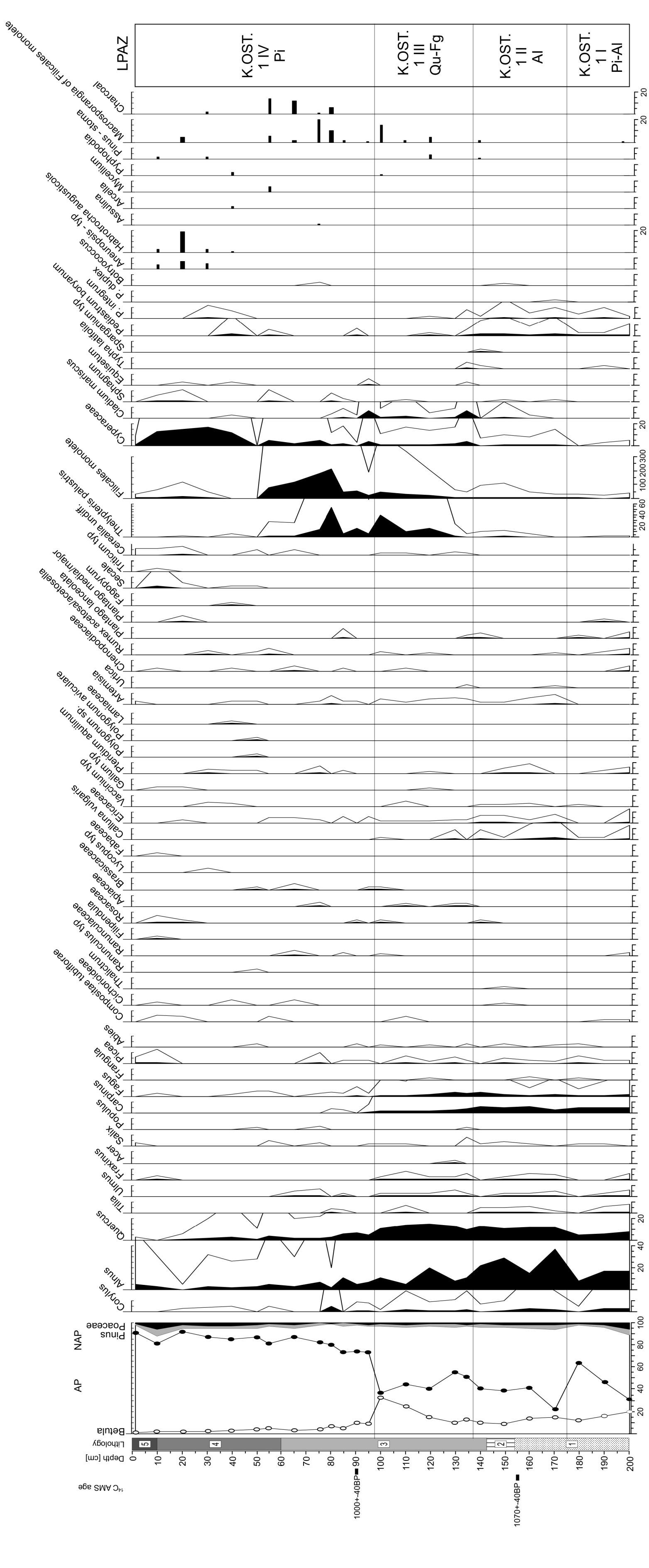

Fig. 2. Percentage pollen diagram showing regional vegetation changes in the Kłocie Ostrowieckie mire (analysis: K. Tobolski). Lithology: 1 – calcareous gyttja, 2 – detritus gyttja, 3 – herbaceous peat, 4 – brown moss-herbaceous peat, 5 – highly decomposed herbaceous peat.

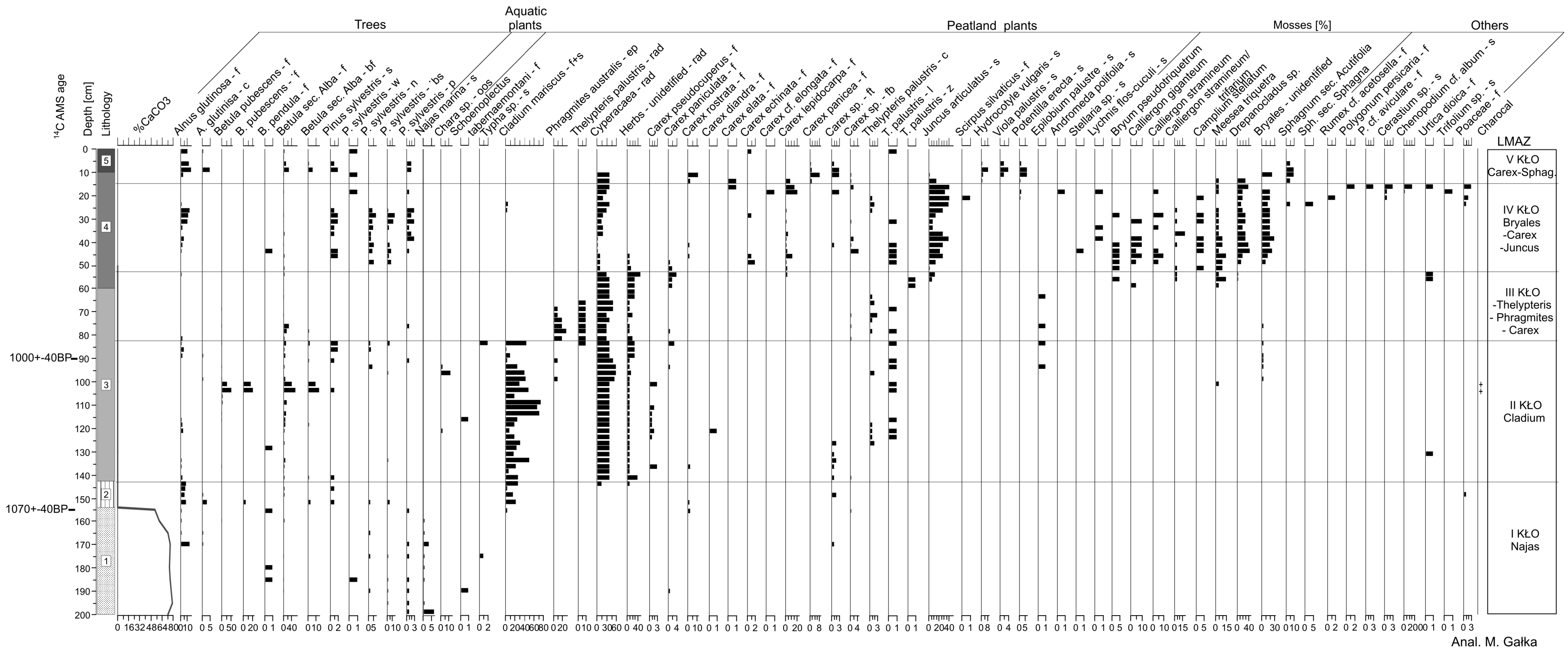

Fig. 3. Plant macrofossils diagram presenting local vegetation changes in the Kłocie Ostrowieckie mire. Lithology – description in Fig. 2. Description of plant remains: f – fruit, fb – fruit biconvex, ft – fruit trigonous, s – seed, oos – oospore, c – cone, w – wing of seed, p – periderm, rad – radicelle, n – needle, fs – fruits scale, bs – bud scale, p – pollen, ms – macrosporangia.

KŁO III Carex-Thelypteris LMAZ (82.5–50 cm)

Phragmites australis also appeared at the site analysed, as a dominating component along with *Thelypteris palustris* (the highest numbers of spores in the core analysed). *Phragmites australis* epidermises were found up to a depth of 67.5 cm. After its decline, there was an increase in the participation of sedges, mainly *Carex paniculata*. The end of this phase determines the appearance of leafy mosses: *Meesia triquetra*, *Bryum pseudotriquetrum*, *Calliergon giganteum*, and *Juncus articulatus*.

KŁO IV Bryales-Carex-Juncus LMAZ (50–15 cm)

Vast amounts of leafy mosses appeared, dominated by, among others, *Scorpidium* sp., *Meesia triquetra*, and *Calliergon giganteum*. The dead stems of these mosses constituted moss peat, including a few Cyperaceae radicelles (up to 10% of the total composition of the vegetative parts). In the moss peat in the distinguished horizon, seeds of *Juncus articulatus* were found. It is significant that *Juncus articulatus* ceased to grow at the moment of transformation of moss peat into herbaceous peat (the transition is unclear, approx. 10 cm). In this stadium, the peat bog also included sedges, and their fruits and pollen in the profile analysed are the most numerous. The amount and thickness of the layer in which nuts of one of these plants were deposited suggest that *Carex lepidocarpa* was a permanent component of local vegetation in the analysed period.

KŁO V Carex-Sphagnum LMAZ (15–0 cm)

Sphagnum sec. *Acutifolia* mosses are deposited in the uppermost peat layer. *Hydrocotyle vulgaris, Viola palustris*, and *Potentilla erecta* are also numerous in the mire. This last phase includes the period in which the surface of the peat bog was acidified.

DISCUSSION

Selected plant indicators of environmental changes show that the developmental history of the mire can be divided into four phases (Fig. 4). According to the results of the survey, no vegetative parts of mosses occur in places of the highest concentration of the subfossil *Cladium mariscus* organs (phase KŁO II *Cladium* LMAZ), mainly in the form of seeds and fruits. *Chara* sp. oospores are also found in this layer as a result of good moisture conditions. The present occurrence of *Chara* sp. amongst assemblages with *Cladium mariscus* was determined in the Lublin Macroregion (Buczek 2005, Gałka unpublished data). The horizon with subfossil mosses is located approximately 30 cm higher (in phase D – Fig. 4). Over 80%, on average, of the horizon is composed of only leaved stems of leafy mosses. Among them, hardly any generative or vegetative organs of *Cladium mariscus* occur (only single seeds at a depth of 22.5–27.5 cm). Therefore, the two fossil components creating the described *Bryalo-Cladieti* peat are located in two different horizons, being separated by a layer of herbaceous peat composed mainly of sedge radicelles, *Thelypteris* roots, and *Phragmites australis* epidermises.

In this paper, we have decided not to present the issue of the peat-forming ability of *Cladium mariscus*. We also conducted studies of *Cladium mariscus* in various parts of Poland (including Bory Tucholskie, Suwałki Region, and the Lublin Region). After completing analyses of sediments from the remaining sites, the issue of the ability of saw sedge to form peat will be published in a separate paper.

The issue of the long existence of *Cladium mariscus* at one site within the reserve (phase B or intensive peat forming), with similar results of radiocarbon dating, remains unclear. The thickness of the peat layer with generative organs of *Cladium mariscus* at one site was, therefore, not determined during the research in Bory Tucholskie (Gałka, Tobolski 2006). At a dozen or so sites studied within the Bory Tucholskie National Park, the seeds and fruits of *Cladium mariscus* were usually found only in a layer of sediment a few centimetres correlated with the stage of a shallow lake and the early development of the mire (Gałka, Tobolski 2006). The stability of *Cladium mariscus* at one site is also evidenced by the accumulation of its pollen in the sediments. The highest amount of pollen in the sediment was observed in the horizons containing also its seeds and fruits. Surprisingly, there is a lack of seeds or fruits in the uppermost sediment of the studied site, and no pollen was found there, either. This lack of pollen is puzzling because it would seem logical that there would be a greater ability to cover the area with pollen than seeds or fruits. Does *Cladium mariscus* pollen only fall within the closest vicinity of the plant? Was there a period, then, when *Cladium mariscus* was not present or constituted only a scarce component within the entire relatively small reserve? The answers to these intriguing questions can be provided only by a detailed paleobotanical analysis of several sites studied in the transect. The literature does not mention any such analyses undertaken so far.

It is significant that the decline of the saw sedge community at the place of the core sampling is basically correlated with transformations of the composition of the forest surrounding the lake analysed. In Fig. 4 (zone B/C), a clear transition is visible between the occurrence of certain components of deciduous forest with species declining (*Fraxinus*, *Ulmus*) or clearly deceasing (*Carpinus* and *Fagus*) with the suddenly increasing *Pinus* curve. From these analyses, it is difficult to determine the reason for and scale of the phenomena. The authors of this paper intend to explain these phenomena in further stages of studies carried out in the Drawieński National Park.

It is worth emphasising that the number of *Najas marina* seeds in calcareous gyttja (zone A) is relatively low. In similar sediments studied within the Bory Tucholskie National Park, the number of fossil *Najas marina* seeds was much higher (also in samples with less volume) (Gałka 2006, 2007). This high number of *Najas marina* seeds is probably related to various degrees of covering the bottom with the plant. In the studied site, calcareous gyttja was accumulating at the bottom of the former lake, and the content of calcium carbonate in that gyttja was very high (70%).

CONCLUSIONS

1. Layer of peat of the mire in the "Kłocie Ostrowieckie" Reserve consists of two main parts. The lithological distinc-

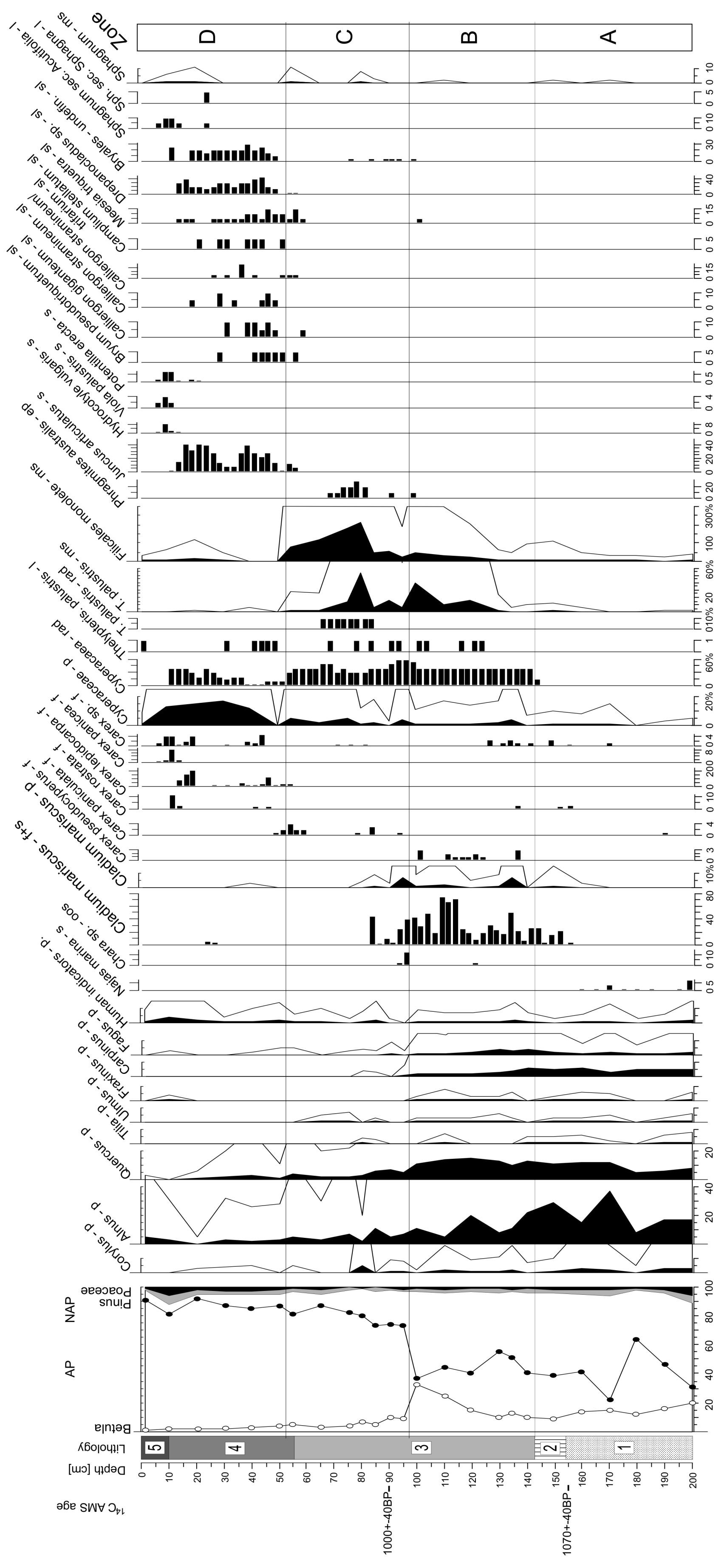

Fig. 4. Composite diagram presenting selected indicators of environmental change and phases of the Kłocie Ostrowieckie mire development. Lithology as in Fig. 2, description of plant remains as in Fig. 3.

tion between the peat with *Cladium* and the peat developed later with the dominance of leafy mosses was determined. These peats constitute two individual layers, separated by an approximately 40 cm layer of peat dominated by sedge radicelles and *Thelypteris palustris* remains. Therefore, an interesting issue of *Bryalo-Cladieti* peat arises, the genesis and taxonomic status of which should be revealed at further stages of our studies on the history of that component of water-mire flora.

2. Four stages of plant succession were determined in the development of the mire.

3. Lake-mire transformations related to the site analysed occurred only in the last millennium.

REFERENCES

Balátová-Tuláčková E. 1991. Das Cladietum marisci. Veröffentlichungen des Geobotanischen Institutes der ETH. Stiftung Rübel, Zurich 106, 7–34.

Buczek A. 2005. Habitant conditions, ecology, resources and protection of saw sedge *Cladium mariscus* (L.) Pohl. in Lublin Macroregion. *Acta Agrophysica* 9, 1–127 (in Polish with English summary).

Conway V. 1938. Studies in the autoecology of *Cladium mariscus* R. Br. Part V. The distribution of the species. *New Phytologist* 35, 312–328.

Gałka M. 2006. Fossil plants of peat bogs and lakes (original: Kopalne rośliny torfowisk i jezior). In Tobolski K. (ed.), Torfowiska Parku Narodowego "Bory Tucholskie", 119–130. Park Narodowy "Bory Tucholskie", Charzykowy (in Polish).

Gałka M. 2007. The dynamics of limnic-telmatic changes in the mouth of Seven Lakes Stream. Prace Zakładu Biogeografii i Paleoekologii Uniwersytetu im. Adama Mickiewicza w Poznaniu. Bogucki Wydawnictwo Naukowe, Poznań (in Polish with English summary).

Gałka M., Tobolski K. 2006. Materials for distribution of subfossil and current sites of saw sedge *Cladium mariscus* (L.) Pohl (original: Materiały do rozmieszczenia subfosylnych i współczesnych stanowisk kłoci wiechowatej *Cladium mariscus* (L.) Pohl. w Parku Narodowym "Bory Tucholskie" In Banaszak J., Tobolski K. (eds), *Park Narodowy Bory Tucholskie u progu nowej dekady*, 71–85. Wydawnictwo Uniwersytetu Kazimierza Wielkiego, Bydgoszcz (in Polish).

Jalas J., Okko V. 1951. Botanical and geological analysis of *Cladium mariscus* station in Joroinen. Archivum *Societatis Zoologicae Botanicae Fennicae Vanamo* 5, 82–101.

Jasnowska J., Jasnowski M. 1991a. Development dynamics of peat-forming vegetation in the "Kłocie Ostrowickie" reserve. Part I. Vegetation (original: Dynamika rozwojowa roślinności torfotwórczej w rezerwacie "Kłocie Ostrowickie". Cz. I. Szata roślinna). *Zeszyty Naukowe Akademii Rolniczej w Szczecinie. Rolnictwo* 149, 11–24 (in Polish).

Jasnowska J., Jasnowski M. 1991b. Development dynamics of peat-forming vegetation in the "Kłocie Ostrowickie" reserve. Part II. Vegetation zonation complex in the process of overgrowing of the rich in calcium bay of the lake in the "Kłocie Ostrowickie reserve (original: Dynamika rozwojowa roślinności torfotwórczej w rezerwacie "Kłocie Ostrowickie". Cz. II. Kompleks zonacyjny roślinności w procesie zarastania zasobnej w wapń zatoki jeziora w rezerwacie "Kłocie Ostrowickie"). *Zeszyty Naukowe Akademii Rolniczej w Szczecinie. Rolnictwo* 149, 25–35 (in Polish).

Jasnowska J., Jasnowski M. 1991c. Development dynamics of peat-forming vegetation in the "Kłocie Ostrowickie" reserve. Part III. Vegetation succession in the peat-forming process, history of the deposit, and current vegetation (original: Dynamika rozwojowa roślinności torfotwórczej w rezerwacie "Kłocie Ostrowickie". Cz. III. Sukcesja roślinności w procesie torfotwórczym, historii złoża i obecnej szacie roślinnej). *Zeszyty Naukowe Akademii Rolniczej w Szczecinie*. Rolnictwo 149, 37–52 (in Polish).

Pokorný P., Sáldo J., Bernardowá A. 2010. Holocene history of *Cladium mariscus* (L.) Pohl in the Czech Republic. Implications for species population dynamics and palaeoecology. *Acta Palaeobotanica* 50, 65–76.

Ramsey C. B. 2001. Development of the radiocarbon calibration program. *Radiocarbon* 43, 355–363.

Reimer P. J., Baillie M. G. L., Bard E., Bayliss A., Beck J. W., Bertrand C. J. H., Blackwell P. G., Buck C. E., Burr G. S., Cutler K. B., Damon P. E., Edwards R. L., Fairbanks R. G., Friedrich M., Guilderson T. P., Hogg A. G., Hughen K. A., Kromer B., McCormac G., Manning S., Bronk Ramsey C., Reimer R. W., Remmele S., Southon J. R., Stuiver M., Talamo S., Taylor W., van der Plicht J. and Weyhenmeyer C. E. 2004. IntCal04 terrestrial radiocarbon age calibration, 0-26 cal kyr BP. Radiocarbon 46, 1029–1058.

Salmina L. 2004. Factors influencing distribution of *Cladium mariscus* in Latvia. *Annales Botanici Fennici* 41, 367–371.

Tobolski K. 1987. Holocene vegetational development based on the Kluki reference site in the Gardno-Łeba Plain. *Acta Palaeobotanica* 27, 179–222.

Tobolski K. 2000. A guide to identification of peat and lake sediments (original: Przewodnik do oznaczania torfów i osadów jeziornych). *Vademecum Geobotanicum* 2. Wydawnictwo Naukowe PWN, Warszawa (in Polish).

Tobolski K., Mocek A., Dzięciołowski W. 1997. Soils of the Słowiński National Park in view of the history of the vegetation and substratum (original: Gleby Słowińskiego Parku Narodowego w świetle historii roślinności i podłoża). Wydawnictwo Homini, Bydgoszcz-Poznań (in Polish).