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Subfossil plant communities in deposits from the Taboły, Kładkowe Bagno and Borki mires in the Puszcza Knyszyńska Forest, NE Poland

DANUTA DRZYMULSKA

Department of Botany, Institute of Biology, University in Białystok, 15-950 Białystok, Świerkowa 20B, Poland;
e-mail: drzym@uwb.edu.pl

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ABSTRACT. This paper presents results from investigations on peat sediments from three mires (Taboły, Kładkowe Bagno and Borki) located in the Puszcza Knyszyńska Forest. Using analysis of plant remains from the peat samples, vegetative and generative finds were identified that include 109 plant taxa of different rank. Compared to syntaxa from the present time, 22 subfossil plant communities have been delimited. They belong to five plant phytosociological classes: *Phragmitetea*, *Scheuchzerio-Caricetea nigrae*, *Alnetea gutinosae*, *Oxycocco-Sphagnetea* and *Vaccinietea uliginosi*. Subfossil communities of uncertain systematic position are also described. Difficulties of phytocoenosis reconstruction are connected with the identification of some macrofossil finds, and either relate to an absence of distinct features in differentiation of some tissues within herbs or bad quality of preserved plant remains in the peat samples.

KEY WORDS: macrofossils, peat analysis, subfossil plant community, Puszcza Knyszyńska Forest, NE Poland

INTRODUCTION

In 1999 palaeobotanical studies started on peat sediments from three mires located in the Puszcza Knyszyńska Forest using plant macrofossil analysis. Radiocarbon dating of the bottom samples of sediments dated the beginning of the peat forming processes back to the Late Glacial in the Taboły and Kładkowe Bagno mires, and to the early Holocene in the Borki mire. The main goal of the present research is to reconstruct the past plant communities that grew in these mires, but development of the mires are not considered in the present contribution.

CHARACTERISTIC OF THE PUSZCZA KNYSZYŃSKA FOREST

The Puszcza Knyszyńska Forest is located in the North-Podlasie Lowland and it is assigned to two mezoregions – a larger one belonging to the Białystok Upland and a smaller one (north-eastern fragment) to the Sokólskie Hills (Kondracki 1994). The geological structure and some climatic features relate the Puszcza Knyszyńska Forest region to East European territory (Kondracki & Pietkiewicz 1967). Thickness of Quaternary cover varies from 130 to 220 m. Relief of the area was formed by the Warta glaciation (Musiał 1992) that produced an number of fluvioglacial features that include kames, kame terraces and numerous melt water forms. The Puszcza Knyszyńska Forest region is located in an immediate neighbourhood of the Vistula glaciation landscape (Pawłowska & Miodek 1993). Holocene sediments (sands, loams, fluvial gravels, and peat) fill in the river valleys and melt depressions.

Location of the Puszcza Knyszyńska Forest causes a mesothermal transitional climate. The mean annual temperature is relatively low, +7ºC, but annual amplitude is very high, up to 22ºC, and mean annual precipitation oscillates around 570 mm. The growing season is about 200 days and snow cover lasts 85–90 days, i. e., longer than in the middle and western regions of Poland (Sasinowski 1995). Polar-maritime air masses are dominant for approximately 145 days of the year. In this region brown soils predominate where they account for 60% of the forest area (Czerwiński 1995).

The Puszcza Knyszyńska Forest is located in the vicinity of the Vistula and Niemen rivers watershed in the Supraśl river basin. Specific for this area are numerous springs in the short lateral valleys passing for the Supraśl river valley.

According to the geobotanical division of Poland, the Puszcza Knyszyńska Forest belongs to the Northern Division, the Białowieża-Knyszyn Region (Szafer 1977). The characteristic feature of vegetation in this area is the distinct participation of *Picea abies* in nearly all forest associations and an absence of *Fagus sylvatica*. Except for spruce, other boreal species also occur, including *Betula humilis* or *Vaccinium oxycoccos*. Forests cover about 80% of the area of the Puszcza Knyszyńska Forest. The main tree species are *Pinus sylvestris* and *Picea abies*. *Quercus robur*, *Betula verrucosa*, *Carpinus betulus*, *Tilia cordata*, *Populus tremula*, *Fraxinus excelsior*, *Alnus glutinosa*, and *Acer platanoides* are the most important deciduous species (Żarska 1993).

CHARACTERISTICS OF THE STUDIED MIRES

Three mires under study are located within the territory of the Puszcza Knyszyńska Forest Landscape Park: Taboły and Kładkowe Bagno – in its northern part and the Borki mire – in its eastern (Fig. 1).

TABOŁY AND KŁADKOWE BAGNO

Taboły mire is situated in a melt water-basin (Fig. 2). The forest nature reserve is 307 ha. The Kładkowe Bagno peat bog is located in close proximity to this mire. It is 40 ha and consists of two depressions connected by a distinct isthmus with shallow peat of ca. 0.3 m. Both mires are surrounded by numerous kames. According to Żarska (1993) and Czerwiński (pers. com.), the Taboły mire is overgrown by *Thelypteri-Betuletum typicum*

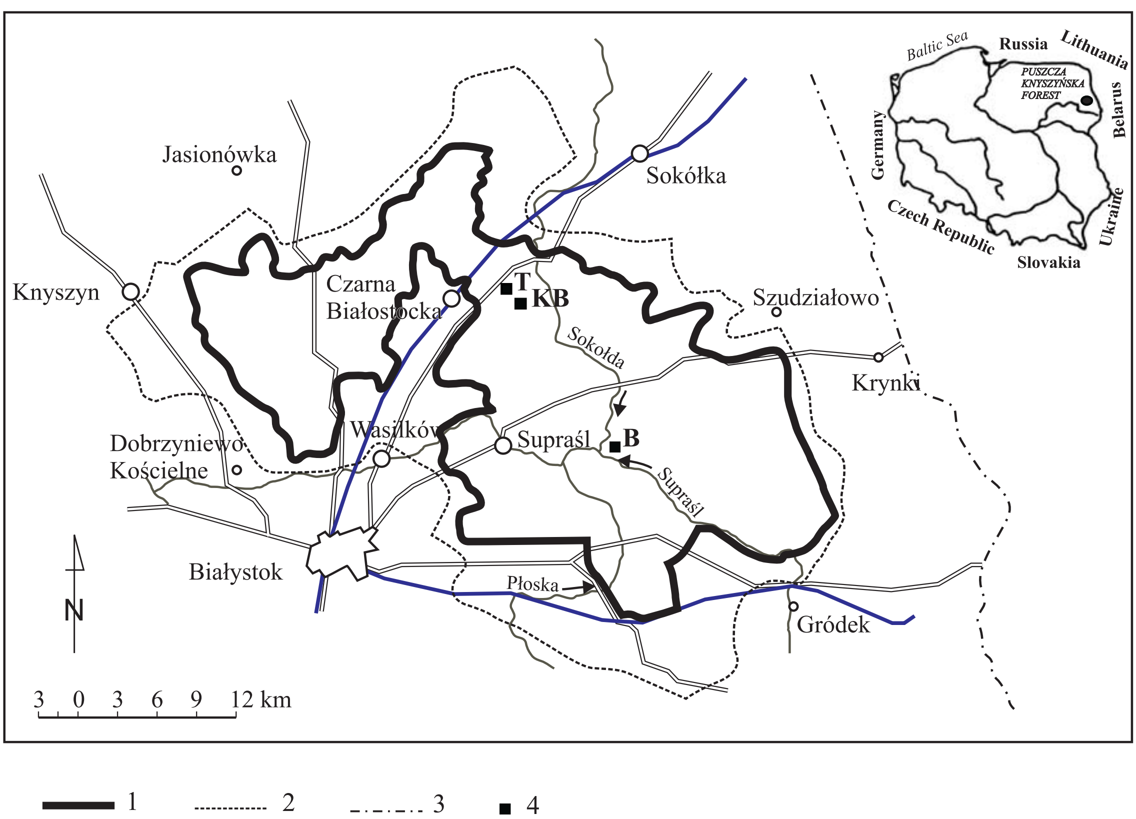

Fig. 1. The Puszcza Knyszyńska Forest Landscape Park (according to Chabros et al. 1993). **1** – border of the landscape park, **2** – border of the protected zone, **3** – state border, **4** – mire under study, **T** – Taboły, **KB** – Kładkowe Bagno, **B** – Borki

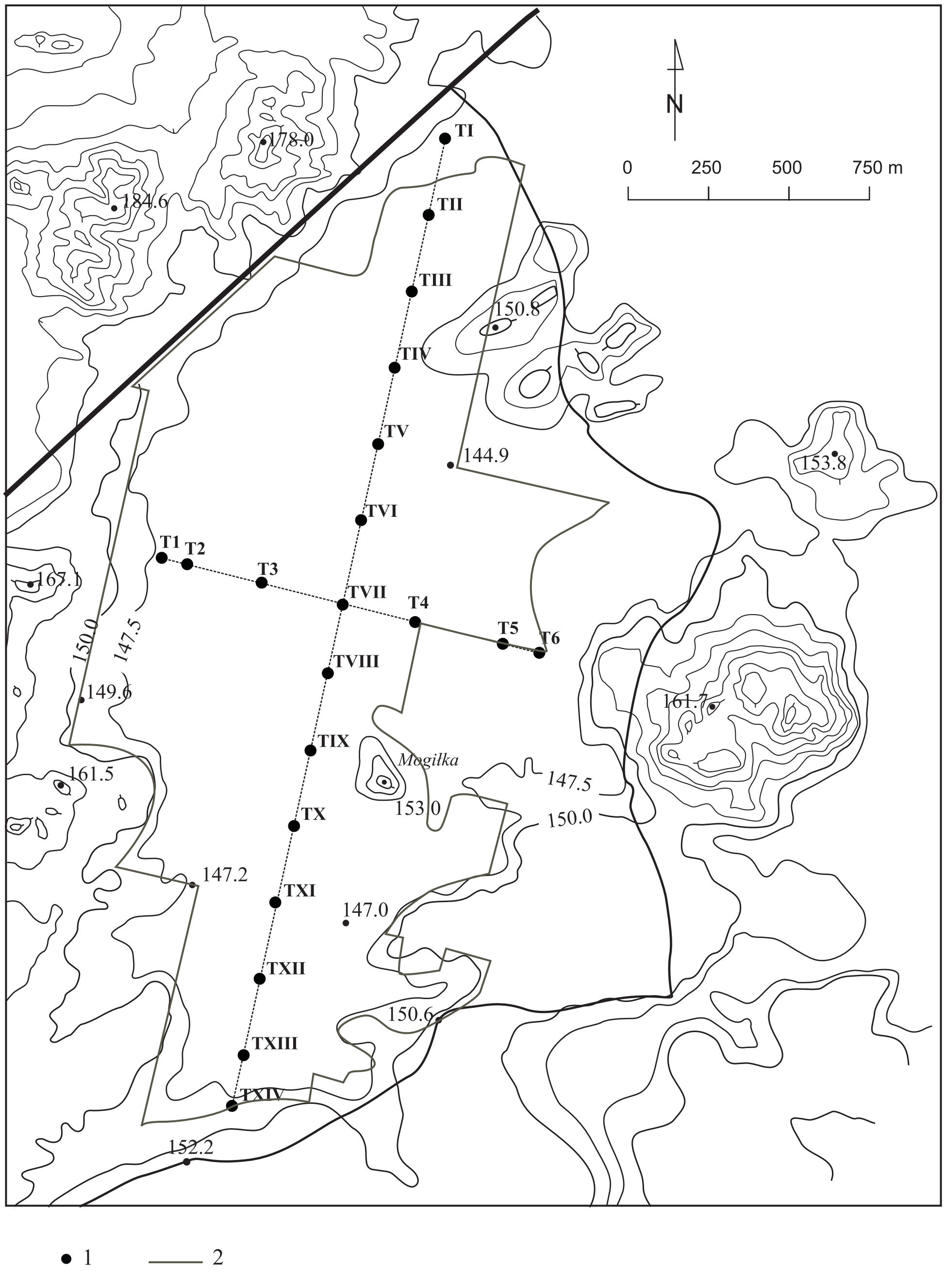

Fig. 2. Taboły mire. **1** – location of cores, **2** – border of reserve

in the north part and by *Sphagno girgensohnii-Piceetum* (3 subassociations: *Sphagno girgensohnii-Piceetum typicum*, *Sphagno girgensohnii-Piceetum caespitosae* and *Sphagno girgensohnii-Piceetum alnetosum*) in the middle part. At the periphery, there are narrow fragments of *Carici elongatae-Alnetum* sensu lato. The south part of the mire is overgrown by *Salici-Betuletum polytrichetosum strictae*.

According to Czerwiński (pers. com.), there are different hydrological patters that influence the Taboły mire. Presence of alder can be a result of surface flow from kame terraces. High river stages in the Sokołda river also can impact irrigation, especially in the northern part of the mire.

Both depressions in the Kładkowe Bagno peat bog (Fig. 3) are overgrown by *Vaccinio uliginosi-Pinetum* in the final phase of succession (Czerwiński, pers. com.). According to J. M. Matuszkiewicz (2001), this community can be defined as the *Vaccinio uliginosi-Pinetum typicum* subassociation, inland variety, subboreal subvariety. Kładkowe Bagno is a raised bog, receiving water from the atmosphere. Areas surrounding both mires

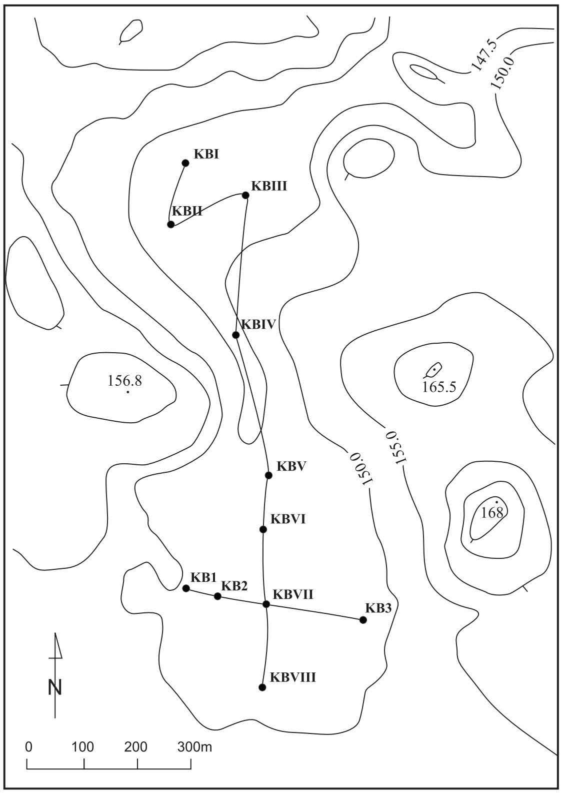

Fig. 3. Kładkowe Bagno peat bog. • – location of cores

are overgrown by *Tilio-Carpinetum*, *Melitti-Carpinetum*, *Serratulo-Piceetum*, and *Myceli-Piceetum*.

BORKI

Borki mire is situated in a large melt water-basin within the Bagno Reserve in Borki and is approximately 286 ha in area (Fig. 4). From the east, it borders with a plateau enclosed by kame terraces. At the western margin of the mire the Sokołda river occurs, separated from the mire by 300 m wide zone of mud and alluvium (Dembek 1989). The central part of the deposit is covered by *Carici chordorrhizae-Pinetum* and *Thelypteri-Betuletum* with *Betula humilis* occurring in the underwood. *Sphagno girgensohnii-Piceetum* and a narrow zone of alder appear marginally, and *Serratulo-Piceetum* and *Melitti-Carpinetum* grow in the surrounding area (Żarska 1993, Czerwiński, pers. com.). The mire is constantly and profusely irrigated by waters from deeper water-bearing horizons, lying under a clay layer (Dembek 1989, 1993).

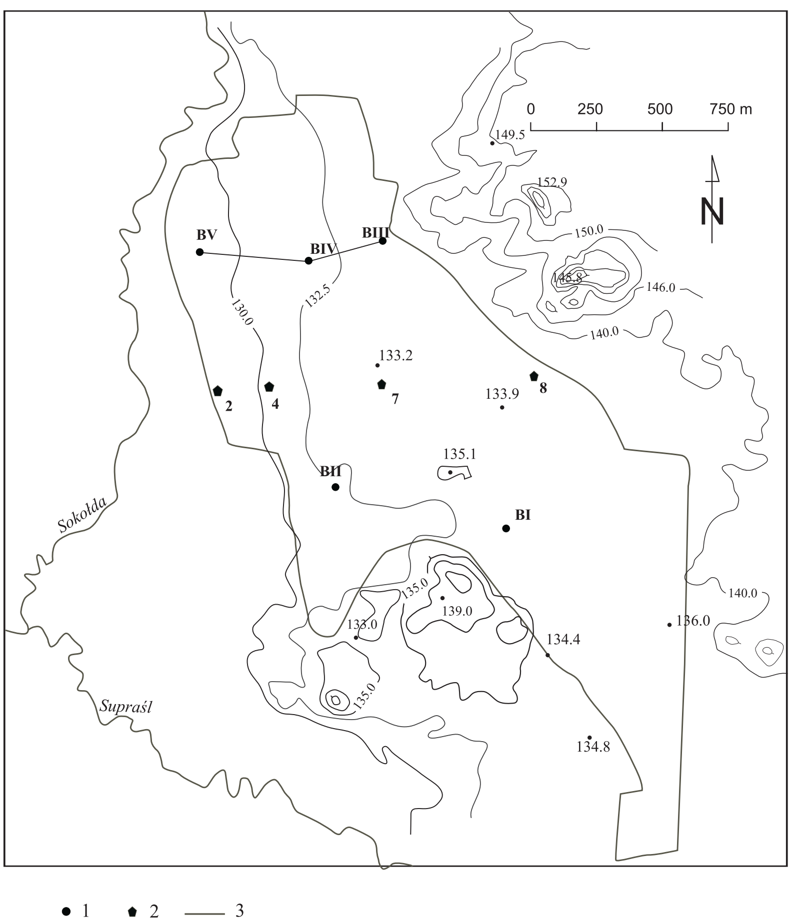

Fig. 4. Borki mire. **1** – location of cores, **2** – location of cores made by Dembek (1989), **3** – border of reserve

MATERIAL AND METHODS

Altogether 32 cores of sediments were collected using a Russian sampler of 5 cm diameter: 16 samples from Taboły, 11 from Kładkowe Bagno, and 5 from the Borki mire (Figs 2–4). Taboły deposit is ca. 6 m deep, the southern depression of the Kładkowe Bagno peat bog is ca. 5 m deep and the northern depression ca. 2.15 m deep. Thickness sediments in the Borki mire are ca. 5 m.

Reconstruction of subfossil plant communities is based on analysis of peat sediments. Fen and transitional peat sediments were found in the Taboły and Borki deposits and mainly bog peat sediments in the Kładkowe Bagno (Drzymulska 2005) mire. Peat classifications of Tołpa et al. (1967) were used and some different units were distinguished.

ANALYSIS OF SUBFOSSIL PLANT REMAINS

Altogether 667 peat samples have been studied: 407 peat samples from Taboły, 120 from Borki, and 140 from Kładkowe Bagno. Cores were divided into segments of 10–15 cm, and exceptionally 20 cm. For analysis, 50 cm^3 from each sample was used. Sediment was boiled in water with an addition of 10% KOH and then washed out through 0.2 mm sieve. Seeds and fruits were picked out and placed in glycerine-thymol mixture and an identification number added, and then studied using a stereoscopic microscope. For analysis of vegetative plant remains a light microscope (Nikon Eclipse E400) was used. Botanical composition is based on a proportion of each taxon tissues in total tissue mass. Ten selected fields of vision (objective 20×, eyepiece 20×) were estimated for every sample.

RESULTS AND DISCUSSION

PLANT REMAINS

Remains of 109 different plant taxa (species, section, genus, family) were identified in the investigated peat sediments. Among them, the following taxa are characteristic of nine vegetation classes: *Scheuchzerio-Caricetea nigrae* (30 taxa), *Phragmitetetea* (13), *Oxycocco-Sphagnetea* (13), *Potametea* (7), *Alnetea glutinosae* (4), *Bidentetea tripartiti* (2), *Charetea* (2), *Molinio-Arrenatheretea* (2), and *Litorelletea* (1).

Quantitative representation of major plant types is as follow: trees and shrubs (10 taxa), dwarf shrubs (4), herbs (51), pteridophytes (2), peat-mosses (16), brown mosses (23), and algae (3).

Sixteen of the recognized taxa are not found in the Puszcza Knyszyńska Forest region at the present time:

a) vascular plants: *Betula nana*, *Ranunculus reptans*, *Scheuchzeria palustris*, *Potamogeton friesii*, *P. filiformis*, *Cladium mariscus*, and *Hippuris vulgaris*

b) peat-mosses: *Sphagnum platyphyllum*, *Sph. angustifolium*, and *Sph. centrale*

c) brown mosses: *Meesia triquetra*, *Warnstorfia fluitans*, *Drepanocladus. sendtneri*, and *Scorpidium scorpioides*

RECONSTRUCTION OF SUBFOSSIL PLANT COMMUNITIES

Delimitation of subfossil syntaxa was based on the combination of plant remains. Criteria established for contemporary plant phytocoenology were used (Oświt 1973, Pałczyński 1975). The subfossil plant communities were arranged in synthetic tables, where degrees of frequency (I–V) represents the proportion of every past taxon within individual peat samples (Tobolski 2000).

In total 22 subfossil plant communities were reconstructed. The communities with known systematic position formed the first group (see Tab. 1). Nomenclature was either based on W. Matuszkiewicz (2001) or references to other sources of nomenclature are added where neccessary.

In the second group, there are subfossil communities of uncertain systematic position:

1. Sedge-brown moss and brown moss with scrubby birch community
2. *Sphagnum palustre-Carex* community
3. *Carex-Sphagnum* sect. *Palustria+Pinus* community
4. *Sphagnum* sect. *Acutifolia-Carex* community
5. Forest-brushwood + *Carex-Sphagnum* community

Radiocarbon dating of peat samples allowed determining the age of many subfossil plant communities delimited in three studied mires (Tab. 2).

Table 1. Systematic position and rank of subfossil communities

[1] – contemporary syntaxon according to Dierssen (1982), [2] – the class *Vaccinietea uliginosi* (according to Botsch & Smagin 1993) is an analogue of the class *Vaccinio-Piceetea* (according to W. Matuszkiewicz 2001), [3] – syntaxon noted by Botsch & Smagin (1993)

Vegetation class	Subfossil community	Syntaxonomic rank
Phragmitetea	*Magnocaricion*	alliance
	Caricetum vesicariae	association
	Caricetum rostratae	association
	Caricetum rostratae calliergonosum	subassociation
	Caricetum rostratae phragmitetosum	subassociation
	Caricetum rostratae sphagnetosum fallacis	subassociation
Scheuchzerio-Caricetea nigrae	*Scheuchzerio-Caricetea nigrae*	class
	Menyantho-Sphagnetum teretis [1]	association
	Scorpidium scorpioides	?
Alnetea glutinosae	*Sphagno squarrosi-Alnetum*-type	association
	shrubs of the alliance *Alnion glutinosae*	?
	paludal alder wood	?
Oxycocco-Sphagnetea	*Sphagnetum magellanici typicum*	association
	Sphagnetum magellanici sphagnetosum fallacis	association
	Sphagnetum magellanici eriophoretosum	association
	Sphagnetum magellanici pinetosum	association
Vaccinietea uliginosi [2]	*Sphagnetum betulo-pinosum eriophoreto fruticuletosum* [3]	subassociation

SUBFOSSIL COMMUNITIES OF THE CLASS *PHRAGMITETEA*

The tall sedge community of the *Magnocaricion* alliance, the class *Phragmitetea* (Tab. 3) contains the alliance characteristic species, including sedges (*Carex vesicaria*, *Carex* cf. *elata*, *Carex riparia*), *Equisetum limosum*, *Phragmites australis*, *Typha* sp., and *Ranunculus* cf. *lingua*. The age of that community, reconstructed in several cores from Taboły (TIII, TIV, TVIII, TIX, TXI; Fig. 2) and Borki (BII, BV; Fig. 4) is various (Tab. 2). It became a parent phytocoenosis for the *Cariceti* peat.

Tobolski (1987) described three similar subfossil communities of the *Magnocaricion* (*Magnocaricion*, *Magnocaricion* II and *Magnocaricion* III) alliance at Kluki in the Gardno-Łeba Plain. This phytocoenosis was reconstructed also in the Biebrza marginal stream valley (Pałczyński 1975) and in the Rabinówka mire (Drzymulska 2004). Sedge domination is a major feature of this association. *Thelypteris palustris* and *Menyanthes trifoliata* occurred fairly constantly in these phytocoenoses and they confirm syngenetic affinities to the *Alnetea glutinosae* and *Scheuchzerio-Caricetea nigrae* vegetation, growing sometimes in contact with *Magnocaricion* communities. Alder-birch-willow remains were also the frequent components in this association, and are similar to the sedge meadows identified by Oświt (1991) in the Biebrza valley.

The *Magnocaricion* community with *Cladium mariscus* (Tab. 3), identified as preboreal in the Taboły deposit (TVII; Fig. 2, Tab. 2), is similar to the *Magnocaricion* II community identified by Tobolski (1987) from Kluki. Both communities are characterized by regular occurrences of *Cladium mariscus*. However, because of low abundance of this species, the existence of the association *Cladietum marisci* was not probable in Taboły. On the other hand, contemporary *Cladietum marisci* (Allorge 1922, Zobrist. 1935 in. W. Matuszkiewicz 2001) occurs with four known variants: typical, acidiphilous, calciphilous and halophilous (Jasnowski 1962). In all of them, except for the typical one, *Cladium mariscus* is rare and the calciphilous variant has a brown moss layer. The *Cladietum marisci drepanocladetosum intermedii* Botsch & Smagin 1987 subassociation (cf. Botsch & Smagin 1993) and the *Drepanoclado-Cladietum* (Jasnowska & Jasnowski 1991) association, in Northwest Russia and Northwest Poland, respectively, have been recognized. Forms of *Cladietum marisci* (with brown mosses and not compact cover of swamp sawgrass) were also described by Świeboda (1968). Tomaszewska and Stepa

Table 2. Age of subfossil plant communities.
[1] – indications of cores as in Figs 2, 3, 4, **SA** – Subatlantic period, **SB** – Subboreal period, **AT** – Atlantic period, **BO** – Boreal period, **PB** – Preboreal period, **YD** – Younger Dryas, **AL** – Allerød, **OD** – Older Dryas

Subfossil plant community	Core[1]	^{14}C Date BP	Chronostratygraphy according to Mangerud et al. (1974)
Magnocaricion	TIII	10160±60	YD
	TIV	9720±50	PB
	TVIII	1635±30	SA
	TIX	8025±40	BO/AT
	TXI	5115±35	AT
	BII	2430±70	SA
	BV	5400±140	AT
Magnocaricion with *Cladium mariscus*	TVII	9080±80	PB
Caricetum vesicariae var. with Bryales	TVIII	10810±50	YD
Caricetum rostratae calliergonosum	TVII	9700±80	PB
	KBVII	8120±40	BO
Caricetum rostratae phragmitetosum	TV	10120±60	YD
Caricetum rostratae sphagnetosum fallacis var. with *Pinus sylvestris*	KB2	9635±50	PB
Caricetum rostratae sphagnetosum fallacis var. with *Phragmites australis*	KBIII	6280±40	AT
Scheuchzerio-Caricetea nigrae	TVIII	9030±50	PB/BO
	T4	5810±30	AT
	BII	1560±90	SA
	BIII	8720±140	BO
	BIV	3060±90	SB
Scorpidium scorpioides	TIV	11880±60	OD
Sphagno squarrosi-Alnetum-type	TVI	9020±50	PB/BO
	TX	9090±50	PB
	T3	9000±50	PB/BO
shrubs of the alliance *Alnion glutinosae*	TII	9100±50	PB
	TIII	7660±40	AT
	TIV	1840±30	SA
Sphagnetum magellanici eriophoretosum	KBIII	1660±45	SA
	KBVII	575±25	SA
	KBVII	2190±30	SA
sedge-brown moss and brown moss with scrubby birches	TV	11850±60	OD
	TIX	10710±50	YD
	T4	11670±50	AL
Sphagnum paluste-Carex	TX	8260±50	BO
Carex-Sphagnum sect. *Palustria+Pinus*	BIII	1850±100	SA
	BIII	3960±120	SB
Sphagnum sect. *Acutifolia-Carex*	BIII	9730±170	PB
forest-brushwood + *Carex-Sphagnaum*	TII	1915±30	SA
	TIII	1315±30	SA
	TVI	1500±30	SA
	TVII	2745±30	SB
	TIX	2100±30	SA
	TX	1900±30	SA
	BI	3900±90	SB

(1995) mentioned this kind of subfossil community in the peat deposit near Wilkowo. In addition a distinct admixture of Bryales occurred in Taboły.

Another subfossil community described in Taboły was the *Caricetum vesicariae* association. Components typical for tall sedge community with predominant *Carex vesicaria* and brown mosses (Bryales variant) were recognized (Tab. 3), opposite to the contemporary *Caricetum vesicariae* Br.-Bl. & Denis 1926, described by W. Matuszkiewicz (2001). Whereas in the subfossil *Caricetum vesiacariae* association named on Strzałowo and Zełwągi by Kloss (1993), brown mosses occurred fairly constantly and in high abundance. The pres-

Table 3. Subfossil communities of the class *Phragmitetea*

I, II, III, IV, V – degrees of frequency (Tobolski 2000), $^{+-15}$ – content (%) of vegetative remains, ^{g} – occurrence of generative remains, ^{o} – oogonium, ^{a} – aggregate, T – **T**aboły, **B** – Borki, **KB** – Kładkowe Bagno

Subfossil community	*Magnocaricion*		*Magnocaricion* with *Cladium mariscus*	*Caricetum vesicariae* variant with Bryales
Successive No	1			2
Number of botanical analyses	165	26	8	13
Mire	T	B	T	T
1	2	3	4	5
Phragmitetea				
Carex cf. *elata*	I^{+-10}	II^{+}	–	–
Carex cf. *vesicaria*	I^{g}	I^{g}	–	V^{g}
Carex cf. *pseudocyperus*	–	–	–	I^{g}
Carex cf. *gracilis*	I^{+}	–	–	–
Carex cf. *riparia*	I^{g}	–	II^{g}	–
Carex cf. *rostrata*	I^{+-5}	–	I^{+}	I^{g}
Phragmites australis	IV^{+-20}	V^{+-25}	V^{+-15}	I^{+}
Typha sp.	I^{+-10}	–	II^{+-5}	I^{+}
Cladium mariscus	I^{+}	–	V$^{+-5/g}$	–
Ranunculus cf. *lingua*	I^{g}	–	–	–
Equisetum limosum	II^{+-15}	III^{+-15}	I^{+}	II^{+-5}
Cicuta sp.	–	–	–	I^{g}
Scheuchzerio-Caricetea nigrae				
Carex cf. *limosa*	I^{+-10}	–	–	–
Carex cf. *nigra*	I$^{5/g}$	–	–	–
Menyanthes trifoliata	I$^{+-5/g}$	II$^{+/g}$	II^{+-5}	II$^{+-10/g}$
Scheuchzeria palustris	–	I^{+}	–	–
Comarum palustre	–	–	–	I^{+}
Sphagnum sect. *Subsecunda*	–	I^{+}	–	I^{+}
Sphagnum cuspidatum	I^{+}	–	–	–
Calliergon giganteum	–	–	–	I^{+}
Meesia triquetra	–	–	–	I^{+}
Helodium blandowii	–	–	–	I^{+-5}
Tomentypnum nitens	–	I^{+}	–	I^{15}
cf. *Campylium stellatum*	I^{+}	–	–	–
Drepanocladus sp.	–	–	II^{+}	I^{+}
Alnetea glutinosae				
Betula humilis	I^{g}	–	–	II^{g}
Tthelypteris palustris	II^{+-15}	II^{+-5}	I^{+-15}	III^{+-15}
Alnus sp.	I^{+-20}	I^{+}	II^{+}	–
Salix sp.	I^{+}	I^{+}	II^{+}	I^{+}
Accompanying				
Betula nana	–	–	–	II^{g}
cf. Ericaceae	I^{+-5}	–	–	II^{+}
Sphagnum magellanicum	–	I^{+}	–	–
Aulacomnium palustre	–	–	–	II^{+-5}
Betula sp.	IV^{+-10}	IV^{+-10}	II^{+}	II^{+}
Betula sect. *Albae*	I^{g}	–	–	–
Pinus sylvestris	I^{+-10}	II^{+-5}	III^{+}	I^{+}
Picea abies	I^{+}	I^{+}	–	–
Carex sp.	V$^{55-90}$	V$^{65-100}$	V$^{60-85}$	V$^{20-90}$
Cyperaceae	I^{+}	–	II^{+-10}	III^{+-15}
Scirpus sp.	I^{+}	–	–	–
Poaceae	I^{+}	I^{+}	–	–
Viola sp.	I^{g}	–	–	–
Polygonum cf. *persicaria*	I^{g}	–	–	–
Potentilla sp.	I^{g}	–	–	–
Caltha palustris	I^{g}	–	–	–

Table 3. Continued

1	2	3	4	5
Asteraceae	–	–	–	I[g]
Caryophyllaceae	I[g]	–	–	–
Myriophyllum spicatum	–	–	–	I[g]
Batrachium sp.	–	–	–	II[g]
Potamogeton friesii	–	–	–	I[g]
Potamogeton cf. *alpinus*	–	–	–	I[g]
Potamogeton filiformis	–	–	–	I[g]
Sphagnum palustre	I[+]	I[+]	–	–
Sphagnum sect. *Palustria*	I[+]	–	I[+]	–
Sphagnum sect. *Cuspidata*	I[+]	I[+]	–	–
Sphagnum sect. *Squarrosa*	I[g]	–	–	–
Sphagnum sect. *Acutifolia*	I^{+-10}	I[+]	–	–
Sphagnum sp.	I[+]	I[+]	I[+]	IV^{+-10}
Bryales	I^{+-10}	I[+]	IV^{+-20}	V^{10-25}
Nitella sp.	–	–	–	II[o]
Pediastrum sp.	–	–	–	I[a]

ence of a brown moss layer in the contemporary *Caricetum rostrato-vesicariae* association Koch 1926 (it is previous name of *Caricetum vesicariae*) was described also by Jasnowski (1962). It refers to the *Caricetum rostrato-vesicariae caricetosum vesicariae* (brown moss variant) subassociation, which occupies middle position between the *Magnocaricion* and *Caricetalia fuscae* (*nigrae*) in the recognizsed zonal arrangement of mire associations.

The discussed subfossil community that occurred in the Taboły mire (TVIII) already in the Late Glacial (Fig. 2, Tab. 2) formed two peat units: Cariceti and Cariceto-Bryaleti.

The *Caricetum rostratae* association recognized in Taboły and Kładkowe Bagno (Tab. 3) seems to be an equivalent of the *Caricetum rostratae* subfossil community that is scrubby with ferns as defined by Oświt (1991) from the Upper Biebrza Basin. Birch and willow were present in both phytocoenoses. Admixtures of ferns and brown mosses also occurred frequently. This subfossil association is similar to the contemporary *Caricetum rostratae* Rübel 1912 association (in Oświt 1973). The Cariceti peat was formed by the above described subfossil association.

The presence of a later with abundant brown moss with predominant *Calliergon giganteum* has allowed the recognition of the *Caricetum rostratae calliergonosum* subassociation (Tab. 4), as mentioned by Tołpa et al. (1967) and Tobolski (2000) as a peat-forming phytocoenosis. That subfossil phytocoenosis, connected with the early Holocene: the Preboreal period (TVII; Fig. 2, Tab. 2) and the Boreal period (KBVII; Fig. 3, Tab, 2), formed several peat units (the Cariceto-Bryaleti, Bryaleti, *Drepanocladus*-peat and *Calliergon giganteum*-peat) in the studied deposits. This community corresponds to the *Caricetum rostrato-vesicariae* (*Calliergon giganteum* facies) community described by Jasnowski (1959). Wąs (1965) recognized peat-forming phytocoenosis of the *Caricetum rostrato-vesicariae* community with *Calliergon giganteum*. However, according to Jasnowski (1959), *Drepanocladus sendtneri* is also predominant in this community. In the examined deposits, any other subassociations of the *Caricetum rosteratae* (except *Caricetum rostratae calliergonosum*) association with mosses were not distinguished, even when specimens of *Drepanocladus* genus were abundant (as observed in Taboły). According to synthetic tables of peat (Tołpa et al. 1967, Tobolski 2000), mosses of this genus (especially *Drepanocladus aduncus*) also could appear distinctly in *Caricetum rostratae calliergonosum*.

Above-mentioned, the phytocoenosis seems to be similar to the *Carex rostrata-Calliergon giganteum* subfossil association, described by Rybniček (1973), among others, in the Czech-Moravian Uplands deposits and subfossil *Calliergon giganteum* – initiator of peat-forming process in the Middle Biebrza Basin (Oświt 1991). It links also to the contemporary *Carex rostrata-Calliergon giganteum* association from Western Siberia (Liss & Beresina 1981).

The *Caricetum rostratae phragmitetosum* subfossil subassociation (Tab. 4) was indicated by a noticeable representation of common reed

Table 4. Subfossil communities of the class *Phragmitetea* cont. Legend as in Tab. 3

Subfossil community	*Caricetum rostratae*							
	typicum	*calliergonosum*		*phragmitetosum*	*sphagnetosum fallacis*			
					variant with *Pinus sylvestris*	variant with *Phragmites australis*	variant with *Sph.* sect. *Subsecunda*	variant with *Sph.* sect. *Acutifolia*
Successive No	1							
Number of botanical analyses	2	4	4	1	13	4	3	2
Mire	T	T	KB	T	KB	KB	KB	KB
1	2	3	4	5	6	7	8	9
Phragmitetea								
Carex cf. *vesicaria*	1^{g}	–	–	–	–	–	–	–
Carex cf. *pseudocyperus*	–	–	II^{g}	–	–	–	–	–
Carex cf. *riparia*	1^{g}	–	–	–	–	–	–	–
Carex cf. *rostrata*	2^{g}	IV^{g}	III^{g}	1^{g}	II^{+}	IV^{+-15}	IV^{g}	I^{+-10}
Phragmites australis	1^{5}	–	–	1^{30}	I^{+}	V^{5-20}	–	–
Typha sp.	–	–	–	1^{+}	II^{+-10}	V^{+}	–	–
Eeleocharis palustris	–	II^{g}	–	–	–	–	–	–
Equisetum limosum	2^{5-10}	IV^{g}	–	1^{+}	I^{+}	II^{+}	–	–
Scheuchzerio-Caricetea nigrae								
Carex cf. *limosa*	–	–	II^{+}	–	–	II^{+}	II^{+}	–
Menyanthes trifoliata	–	$IV^{+-10/g}$	II^{k}	–	–	–	$II^{5/g}$	–
Sphagnum cf. *platyphyllum*	–	–	–	–	–	–	IV^{+-40}	–
Sphagnum sect. *Subsecunda*	–	–	II^{15}	–	–	–	V^{+-40}	–
Calliergon giganteum	2^{+-5}	V^{10-65}	V^{5-20}	–	–	–	II^{+}	–
Calliergon sp.	–	III^{+}	IV^{+}	–	–	–	–	–
Scorpidium scorpioides	1^{+}	–	–	–	–	–	–	–
Pseudocalliergon lycopodioides	–	–	–	–	I^{+}	–	–	–
Drepanocladus sp.	–	III^{+-60}	IV^{+-5}	–	–	–	–	–
Alnetea glutinosae								
Tthelypteris palustris	2^{+}	–	–	1^{+}	I^{+}	II^{+}	–	–
Alnus sp.	–	–	–	–	–	–	–	
Oxycocco-Sphagnetea and *Vaccinio-Piceetea*								
Betula nana	–	–	–	–	–	–	–	1^{+}
cf. Ericaceae	–	–	–	–	II^{+-5}	–	V^{+-15}	–
Vaccinium uliginosum	–	–	–	–	–	–	II^{g}	–
Eriophorum vaginatum	–	–	–	–	II^{5-10}	–	V^{5-25}	2^{+-5}
Sphagnum magellanicum	–	–	II^{+}	–	IV^{+-10}	V^{+-25}	IV^{+}	1^{+}
Sphagnum fallax	–	–	–	–	I^{5}	V^{+-15}	–	1^{15}
Accompanying								
Betula sp.	2^{+}	–	–	1^{+}	IV^{+-35}	III^{+}	–	
Betula pendula	–	–	–	–	–	–	–	1^{g}
Betula sect. *Albae*	1^{g}	III^{g}	–	–	–	–	–	
Pinus sylvestris	–	–	V^{+}	–	V^{+-20}	V^{+}	–	2^{+-10}
Picea abies	–	–	–	–	–	II^{+}	II^{+}	
Carex sp.	2^{60-70}	V^{15-45}	V^{15-45}	1^{50}	V^{20-85}	V^{25-75}	V^{5-15}	2^{25-35}
Cyperaceae	1^{+}	I^{+}	–	–	–	–	–	
Poaceae	–	I^{+}	–	–	I^{10}	–	–	
Hippuris vulgaris	–	I^{g}	–	–	–	–	–	
Myriophyllum spicatum	1^{g}	–	–	–	–	–	–	
Batrachium sp.	–	–	–	–	I^{g}	–	–	
Potamogeton panormitanus	1^{g}	–	–	–	–	–	–	
Potamogeton natans	–	–	–	–	I^{g}	–	–	
Potamogeton sp.	–	–	–	–	I^{g}	–	–	
Nymphaea alba	–	–	III^{g}	–	–	–	–	
Sphagnum sect. *Palustria*	2^{+}	–	IV^{+}	–	II^{5-10}	–	–	

Table 4. Continued

1	2	3	4	5	6	7	8	9
Sphagnum sect. *Cuspidata*	–	–	III^{+}	–	IV^{+-25}	–	II^{+}	1^{10}
Sphagnum sect. *Squarrosa*	1^{+}	–	–	–	–	–	–	
Sphagnum sect. *Acutifolia*	-	–	–	–	–	II^{+-5}	V$^{10-25}$	2^{+-40}
Sphagnum sp.	–	–	V^{+}	–	I^{5}	–	IV^{+}	2^{+-5}
Polytrichum sp.	–	–	–	–	–	–	–	2^{+-5}
Bryales	2$^{10-15}$	V$^{5-15}$	V$^{45-65}$	1^{10}	I^{+}	–	IV^{+-5}	2^{+-5}
Characeae	2^{o}	–	–	–	–	–	–	
Pediastrum sp.	–	–	III^{a}	–	–	–		

remains in sediments of the *Carex rostrata* association. It existed in the Younger Dryas, in Taboły (TV; Fig. 2, Tab. 2) and formed the Cariceto-Phragmiteti peat. The peat-forming quality of that unit was noted by Tołpa et al. (1967) and Tobolski (2000). The community in question could be also identified with the subfossil phytocoenosis described by Oświt (1991) from the Upper Biebrza river valley and the Ślina river valley. There was a small admixtures of shrubs and ferns in both of these examples. While contrary to the *Carex rostrata-Phragmites australis* community reported by Kloss (2001) in Białe Ługi, the *Caricetum rostratae phragmitetosum* community from the Taboły mire was characterized by an absence of bogmosses, bogbean and pine and only contains an admixture of birch.

Caricetum rostratae sphagnetosum fallacis – the last subfossil subassociation of *Caricetum rostratae*, was found in the Kładkowe Bagno deposit (Tab. 4). Dierssen (1982) described it as the subassociation *Sphagnum fallax* contemporary community reported from the British Isles, Scandinavia and Central Europe. This subassociation is always connected with poor habitats and (especially in Central Europe) prevalent on very acid, oligotrophic moor fens. Botsch and Smagin (1993) report it in the Northwest Russian territory. Rybniček et al. (1984) described the analogous association *Carici rostratae-Sphagnetum apiculati* Osvald 1923, prevalent recently in all of Europe but mainly in Scandinavia. The above-mentioned subfossil community closely resembles the contemporary *Carex rostrata-Sphagnum recurvum* community noted by Kaule (1973) in Bavaria and the *Carex rostrata-Sphagnum fallax* community from the Western Siberia (Liss & Beresina 1981). The subfossil *Caricetum rostratae sphagnetosum fallacis* subassociation from Kładkowe Bagno is distinguished by numerous species of the class *Oxycocco-Sphagnetea*: *Sphagnum magellanicum*, *Eriophorum vaginatum* and ericaceous dwarf shrubs. The mass occurrence of bogmosses and lack of trees and shrubs was noted, both in subfossil and contemporary *Caricetum rostratae sphagnetosum fallacis* subassociations. That subassociation occurred in four variants in the examined deposits: two oligotrophic variants – the first with *Pinus sylvestris* and the second with *Sphagnum* sect. *Acutifolia,* and two mesotrophic variants – the first with *Phragmites australis* and the second with *Sphagnum* sect. *Subsesunda*. The pine variant is noted in the KB2 profile where it is dated as preboreal (Fig. 3, Tab. 2) and the common reed variant occurred in the vicinity of KBIII in the Atlantic period (Fig. 3, Tab. 2). In the variant with *Sphagnum* sect., *Subsesunda* and *Sphagnum* cf. *platyphyllum* occurred abundantly. Obidowicz (1975) recognized that very hydrophilous and mid acidiphilous species occurred in sediments from Toporowy Staw Wyżni in the Tatra Mountains. The above mentioned subassociation was a parent community of some peat units: peat-moss-sedge, the Cariceti, and Cariceto-Phragmiteti.

SUBFOSSIL COMMUNITIES OF THE CLASS *SCHEUCHZERIO-CARICETEA NIGRAE*

Subfossil phytocenoses of the class *Scheuchzerio-Caricetea nigrae* were noted in the deposits from Taboły (TVIII; T4, Fig. 2) and Borki (BII, BIII, BIV; Fig. 4). They are characterized by a clear dominance of sedges and brown mosses, and with shrubs occurring quite often (Tab. 5). The stratigraphic age of these phytocoenoses varies (Tab. 2) and they formed the Bryaleti, Cariceto-Bryaleti and Cariceti peats.

The communities listed above closely resemble the subfossil brushwood phytocoenoses of the class *Scheuchzerio-Caricetea fuscae* known from Pomieczyno in the Kartuzy Lake Region

Table 5. Subfossil communities of the class *Scheuchzerio-Caricetea nigrae*. Legend as in Tab. 3

Subfossil community	*Scheuchzerio-Caricetea nigrae*		*Menyantho trifoliatae-Sphagnetum teretis*	*Scorpidium scorpioides*
Successive No	1		2	3
Number of botanical analyses	39	40	5	2
Mire	T	B	T	T
Scheuchzerio-Caricetea nigrae				
Carex cf. *limosa*	II^{+-5}	I^{+}	–	–
Carex sect. *Paniculatae*	I^{g}	–	–	–
Menyanthes trifoliata	III$^{+-10/g}$	I^{+}	II^{+-5}	–
Scheuchzeria palustris	–	II^{+-5}	–	–
Eriophorum angustifolium	–	I^{+}	–	–
Comarum palustre	I^{g}	–	–	–
Sphagnum cf. *teres*	–	I^{+}	V$^{60-90}$	–
Calliergon giganteum	I^{+}	I^{20}	–	1^{+}
Scorpidium scorpioides	I^{+}	–	–	2$^{40-65}$
Meesia triquetra	II^{+-5}	I^{+-5}	–	–
Helodium blandowii	I^{+-30}	–	I^{10}	–
Tomentypnum nitens	II^{+-25}	–	–	–
Paludella squarrosa	I^{+-15}	–	–	–
Hamatocaulis cf. *vernicosus*	I^{+-40}	–	–	–
Drepanocladus cf. *aduncus*	I^{5}	–	–	–
Drepanocladus cf. *sendtneri*	–	I^{5}	–	–
Drepanocladus sp.	II^{+-5}	I^{+-5}	–	1^{+}
Phragmitetea				
Carex cf. *elata*	I^{+}	I^{+}	–	–
Carex cf. *vesicaria*	I^{g}	–	–	–
Carex cf. *gracilis*	I^{+}	–	–	–
Carex cf. *riparia*	I^{g}	I^{g}	–	–
Phragmites australis	II^{+-5}	III^{+-10}	–	–
Typha sp.	–	I^{+}	–	–
Equisetum limosum	II^{+}	II^{+-5}	V^{+-5}	2^{+}
Scutellaria galericulata	–	I^{+}	–	–
Alnetea glutinosae				
Betula humilis	I^{g}	–	–	–
Thelypteris palustris	III^{+-20}	III^{+-5}	I^{+}	1^{+}
Alnus sp.	I^{+}	II^{+-5}	–	–
Salix sp.	I^{+}	II^{+-5}	I^{+}	–
Accompanying				
Betula nana	I^{g}	–	–	–
cf. Ericaceae	I^{+}	I^{+}	I^{+}	–
Andromeda polifolia	–	I^{+}	–	–
Sphagnum magellanicum	–	I^{+-5}	–	–
Aulacomnium palustre	I^{+-10}	–	–	–
Polytrichum strictum	–	I^{+-5}	–	–
Betula sp.	II^{+-5}	III^{+-10}	–	1^{5}
Betula sect. *Albae*	I^{g}	I^{g}	I^{g}	–
Pinus sylvestris	I^{+}	II^{+-15}	–	–
cf. *Picea abies*	–	I^{+-5}	–	–
Carex sp.	V$^{10-90}$	V$^{30-100}$	V$^{5-35}$	2$^{25-30}$
Cyperaceae	II^{+-10}	II^{+-5}	–	–
Poaceae	I^{+}	–	–	–
Caryophyllaceae	I^{g}	–	–	–
Sphagnum palustre	I^{+-5}	II^{+-45}	I^{15}	–
Sphagnum sect. *Cuspidata*	–	I^{+}	–	–
Sphagnum sect. *Squarrosa*	I^{+}	–	–	–
Sphagnum sect. *Acutifolia*	I^{+}	I^{+-10}	I^{+}	–
Sphagnum sp.	I^{+-5}	I^{+}	–	–
Polytrichum sp.	–	I^{+}	–	–
Bryales	V$^{5-70}$	III^{+-45}	I^{+}	2$^{5-10}$
Climacium dendroides	–	I^{+}	–	–
cf. *Bryum* sp.	I^{+}	–	–	–

(Marek 1991a), Kramarzyny (Marek 1991b) and the Rabinówka mire (Drzymulska 2004).

A noteworthy fact is the presence of *Scheuchzeria palustris*, *Carex* cf. *limosa* and *Meesia triquetra* connected with the order *Scheuchzerietalia palustris* (cf. W. Matuszkiewicz 2001).

The association of the class *Scheuchzerio-Caricetea nigrae*, recognized in Taboły, was *Menyantho trifoliatae-Sphagnetum teretis* with predominant *Sphagnum teres* (Tab. 5). It formed a unit of *Sphagnum teres*-peat. Contemporary *Menyantho trifoliatae-Sphagnetum teretis* Warén 1926 (in Diersen 1982), connected with the order *Caricetalia nigrae*, occurs in Northwest Europe (Dierssen 1982) while according to W. Matuszkiewicz (2001), *Sphagnum teres* is a characteristic species of the alliance *Caricion lasiocarpae* – order *Scheuchzerietalia palustris*. The *Menyantho trifoliatae-Sphagnetum teretis* subfossil association noted in Taboły, can be identified as the subfossil phytocoenosis described by Kloss (2001) in the deposit of Białe Ługi. The absence of *Cuspidata* section peat mosses in the community reconstructed in Taboły is the most important difference. In the present time, an analogous association of *Menyanthes trifoliata-Sphagnum teres* occurs in Western Siberia (Liss & Beresina 1981). It is characterized, like the phytocoenosis from Taboły, by a noticeable admixture of oligotrophic elements: Ericaceae dwarf shrubs, *Carex limosa* and peatmosses of *Acutifolia* section.

The *Scorpidium scorpioides* phytocoenosis was also recognized among communities of the class *Scheuchzerio-Caricetea nigrae* (Tab. 5). It was described in the T4 profile (Fig. 2) as a parent community for the Cariceto-Bryaleti and *Scorpidium scorpioides*-peat. Jasnowski (1959) described this phytocoenosis in details, pointing at not certain sociological position. Its peat-forming importance was noted by Tołpa et al. (1967) and Tobolski (2000). The discussed community present in Taboły, is closely related to the *Scorpidium scorpioides* subfossil phytocoenosis described by Oświt (1973, 1991) in the Lower Biebrza Basin. Moreover, both communities existed in the Late Glacial (Tab. 2). The absence of identified sedge species impedes connection of this community from Taboły deposit with others noted in literature, like subfossil *Carex rostrata-Scorpidium scorpioides* (Rybniček 1973) described in Central Europe and in the present-day occurring in Scandinavia and Scotland.

SUBFOSSIL COMMUNITIES OF THE CLASS *ALNETEA GLUTINOSAE*

Two subfossil types of alder woods and one community named by Oświt (1973) as shrubs of the *Alnion glutinosae* alliance were recognized in the examined deposits.

Subfossil *Sphagno squarrosi-Alnetum*-type (Tab. 6) described in Taboły and Borki, is characterized like its contemporary analogue *Sphagno squarrosi-Alnetum* Solińska-Górnicka (1975) 1987 by a mass contribution of *Sphagnum squarrosum* and a noticeable admixture of species connected with oligotrophic habitats. The abundant occurrence of peat mosses distinguish that phytocoenosis from the *Carici elongatae-Alnetum* Koch 1926 association, as previously noted by numerous authors (Marek 1965, 1991a, c, Oświt 1973, 1991, Pałczyński 1975, Obidowicz 1990, Oświt 1991, Kloss 1993). The discussed community is related closer to the subfossil *Carici elongatae-Alnetum sphagnetosum* community recognized by Kloss (2001) on Białe Ługi. However, among bog mosses, *Sphagnum fallax* and *Sphagnum girgensohnii* were the most significant whereas in deposits of Taboły and Borki, *Sphagnum squarrosum* and *Sphagnum palustre* are the most significant. The *Sphagno squarrosi-Alnetum*-type community seems to be connected with the contemporary *Alnetum glutinosae sphagnosum squarrosi* Łopatin 1954 association, occurring in the Northwest Russia (Botsch & Smagin 1993). Three radiocarbon dates (TVI, TX, T3 profiles) evidence the occurrence of the above-mentioned community in the early Holocene (Tab. 2).

The second subfossil community, named the paludal alder wood (Tab. 6), described in the eastern part of the Taboły deposit, can be identified with subfossil *Carici elongatae-Alnetum*, as previously noted in literature. Peat mosses played a minor role there. The community in question seems also to be similar to subfossil paludal alder wood association characterized in Machnacz by Żurek (1992).

Shrubs of the *Alnion glutinosae* alliance (Tab. 6) recognized in Taboły, could firstly be identified with the *Salicetum pentandro-cinereae* subfossil association. Oświt (1973, 1991) noted this association in the Lower Biebrza Basin and in the Narew river valley,

Table 6. Subfossil communities of the class *Alnetea glutinosae*. Legend as in Tab. 3

Subfossil community	*Sphagno squarrosi-Alnetum*-type		Shrubs of the alliance *Alnion glutinosae*	Paludal alder wood
Successive No	1		2	3
Number of botanical analyses	26	1	59	5
Mire	T	B	T	T
Alnetea glutinosae				
Betula humilis	–	–	I^{g}	–
Thelypteris palustris	II^{+-10}	1^{+}	IV^{+-15}	III^{+}
Sphagnum squarrosum	I$^{5-35}$	–	–	–
Alnus sp.	IV^{+}	1^{+}	I^{+-5}	V^{+-20}
Salix sp.	II^{+}	1^{+}	III^{+}	I^{5}
Scheuchzerio-Caricetea nigrae				
Carex cf. *limosa*	I^{+}	–	II^{+}	II^{+}
Carex cf. *nigra*	–	–	I^{+}	–
Carex diandra	–	–	–	II^{g}
Carex sect. *Paniculatae*	–	–	–	I^{g}
Menyanthes trifoliata	–	1^{+}	I$^{+-5/g}$	II^{+}
Scheuchzeria palustris	–	–	I^{+}	–
Sphagnum sect. *Subsecunda*	–	1^{+}	I^{+}	–
Calliergon giganteum	–	–	–	IV$^{5-10}$
cf. *Campylium stellatum*	I^{+}	–	–	–
Phragmitetea				
Carex cf. *vesicaria*	–	–	I^{g}	–
Carex cf. *elata*	I^{+-5}	–	I^{+}	–
Carex cf. *rostrata*	–	–	II^{+}	I^{g}
Carex cf. *pseudocyperus*	–	–	–	I^{g}
Phragmites australis	IV^{+-10}	–	V^{+-25}	III^{+}
Typha sp.	–	–	I^{+}	–
Ranunculus lingua	–	–	I^{g}	–
Equisetum limosum	III^{+}	–	III^{+-10}	II^{+}
Accompanying				
Betula nana	–	–	I^{g}	–
(cf.) Ericaceae	I^{+}	–	I^{+}	I^{5}
Sphagnum magellanicum	I^{+}	1^{+}	I^{+}	–
Betula sp.	IV^{+-15}	1^{+}	V^{+-25}	V^{+-10}
Betula sect. *Albae*	–	–	I^{g}	I^{g}
Betula pubescens	–	–	I^{g}	–
Pinus sylvestris	II^{+-5}	1^{10}	I^{+-15}	III^{+}
Picea abies	II^{+-5}	–	I^{+}	II^{+}
Carex sp.	V$^{20-95}$	1^{55}	V$^{35-95}$	V$^{20-60}$
Cyperaceae	I^{+}	–	–	III^{+}
Scirpus sp.	–	–	I^{g}	–
Poaceae	I^{+}	–	I^{+}	I^{+}
Luzula sp.	–	–	–	I^{g}
cf. *Juncus* sp.	–	–	–	I^{g}
Ranunculus reptans	–	–	–	I^{g}
Comarum palustre	–	–	–	I^{g}
Potentilla sp.	I^{g}	–	–	–
Apiaceae	–	–	–	I^{g}
Sphagnum palustre	II$^{5-35}$	1^{15}	–	–
Sphagnum sect. *Palustria*	II^{+-30}	–	–	–
Sphagnum sect. *Cuspidata*	–	–	–	I^{+}
Sphagnum sect. *Acutifolia*	I^{+}	–	–	–
Sphagnum sect. *Squarrosa*	III^{+-15}	1^{5}	–	III^{+}
Sphagnum sp.	I^{+-5}	–	I^{+}	–
Bryales	I^{+}	–	I^{+}	IV^{+-5}

Pałczyński (1975) in the Biebrza marginal stream valley, and Kloss (1993) noted it in the Masurian Lakeland. Its distinctive feature is a minor contribution of alder, and presence of birch (common white?) and willows. The second possible connection refers to the *Betuletum humilis* (*Betulo* (*humilis*)-*Salicetum repentis*) with *Betula humilis* subfossil association, which was described by Oświt (1973, 1991) and Pałczyński (1975). In the present-day, this community occurs as a variant with *Betula nana* (Botsch & Smagin 1993). That birch species was identified in subfossil shrubs from Taboły. The age of that subfossil community was quite different in three neighbouring profiles (TII, TIII, TIV; Fig. 2, Tab. 2).

Both above-mentioned contemporary associations are similar in their floristic composition despite having different characteristic species (Oświt 1973). In the subfossil state, when identification of many plant remains is impeded, similarity increases. Hence Oświt (1973) only identified the general occurrence of this subfossil phytocoenosis, identifying only the shrubs of the alliance *Alnion glutinosae*. A mass occurrence of sedges in this community, reconstructed in Taboły, is similar to stands recorded in Pałczyński's work (1975). The three above mentioned communities of the class *Alnetea glutinosae* were the parent phytocoenoses of cf. Alnioni and Cariceti peat units.

SUBFOSSIL COMMUNITIES OF THE CLASSES *OXYCOCCO-SPHAGNETEA* AND *VACCINIETEA ULIGINOSI*

The association *Sphagnetum magellanici*, reconstructed in the Kładkowe Bagno deposit, was marked by a prevailing representation of species of the class *Oxycocco-Sphagnetea*. It resembled contemporary *Sphagnetum magellanici* (Malc. 1929) Kästn. & Flöss. 1933 (in W. Matuszkiewicz 2001). Differences in floristic combination of this community allow four past subassociations to be distinguished.

The *Sphagnetum magellanici typicum* subassociation (Tab. 7) can be identified with subfossil *Sphagnetum magellanici* recognized by Pałczyński (1975), Obidowicz (1990), Marek (1991b) and the *Sphagnetum magellanici typicum* subfossil association described by Kloss (1993, 2001). Its distinctive feature is a minor role of species of the class *Scheuchzerio-Caricetea nigrae*. It was a parent community of Eusphagneti and *Sphagnum magellanicum*-peats.

The subassociation *Sphagnetum magellanici spahgnetosum fallacis* (Tab. 7) is characterized by a dominance of *Sphagnum fallax* and lower constancy of *Sphagnum magellanicum*, than in former subassociation (peat units of Cuspidato-Sphagneti and *Sphagnum fallax*-peat, in studied deposits). It shows a close similarity to the contemporary phytocoenosis studied by Jasnowski (1962) and to the contemporary *Eriophoro vaginati-Sphagnetum recurvii* Hueck 1925 association (Rybniček et al. 1984), for which a peat-forming role was noted by Obidowicz (1990). There is also similarity to the contemporary *Eriophorum vaginatum-Sphagnum fallax* Hueck 1928 (W. Matuszkiewicz 2001) association and to the subfossil *Eriophoro-Sphagnetum apiculati* community recognized by Pacowski (1967) in the Wieliszewo peatbog. Peat-forming character of *Sphagnetum magellanici spahgnetosum fallacis* (= *recurvii*) was reported by Tołpa et al. (1967) and Tobolski (2000).

Third *Sphagnetum magellanici eriophoretosum* subfossil subassociation is marked by a large contribution of remains of *Eriophorum vaginatum* in the Eriophoro-Sphagneti peat (Tab. 7). This kind of community was noted by Pacowski (1967) and Kloss (1993, 2001). Pałczyński (1975) described it as *Sphagnetum magellanici sphagnetosum recurvii* var. *Eriophorum vaginatum* in the Biebrza marginal stream valley. According to Obidowicz (1990), the phytocoenosis is an analogue of the *Eriophoro vaginati-Sphagnetum recurvii* Hueck 1925 association. In genetic classification of peats this association was named the *Sphagnetum magellanici sphagnetosum recurvii* var.i *Eriophorum vaginatum* association, and is a peat-forming community (Tołpa et al. 1967, Tobolski 2000). In Kładkowe Bagno, the occurrence of the *Sphagnetum magellanici eriophoretosum* subassociation in the Subatlantic period was confirmed by radiocarbon dates from two profiles (KBIII, KBVII; Fig. 3, Tab. 2).

The *Sphagnetum magellanici pinetosum* subassociation (Tab. 7) could be related to subfossil communities described by Pacowski (1967) and Kloss (1993, 2001). It is indicated by high abundance of *Pinus sylvestris* and frequently by an abundance of tussock cotton-

Table 7. Subfossil communities of the classes *Oxycocco-Sphagnetea* and *Vaccinietea uliginosi*. Legend as in Tab. 3
[1] – name according to Botsch & Smagin (1993)

Subfossil community	*Sphagnetum magellanici* typicum	*Sphagnetum magellanici sphagnetosum fallacis*	*Sphagnetum magellanici eriophoreto-sum*	*Sphagnetum magellanici pinetosum*	[1] *Sphagnetum betulo-pinosum eriophoreto fruticuletosum*
Successive No	1				2
Number of botanical analyses	38	14	34	12	5
Mire	KB				KB
Oxycocco-Sphagnetea					
Andromeda polifolia	I$^{+-25/g}$	I^{g}	I^{g}	II$^{+/g}$	I^{g}
(cf.) *Oxycoccus quadripetalus*	I^{+}	I^{g}	–	I^{+}	–
Ericaceae	IV^{+-50}	III^{+-5}	III^{+-30}	I^{+}	II^{+}
Eriophorum vaginatum	V^{+-45}	IV$^{+-20/g}$	V$^{55-90}$	V$^{5-55/g}$	V$^{5-20}$
Sphagnum magellanicum	V$^{10-85}$	III$^{5-30}$	V^{+-25}	V^{+-30}	IV^{+-5}
Sphagnum fallax	I^{+-15}	I^{80}	I^{+-15}	I^{5}	I^{10}
Sphagnum angustifolium	–	–	–	I^{5}	–
Polytrichum strictum	I^{+-5}	–	I^{+}	I^{+}	–
Scheuchzerio-Caricetea nigrae					
Menyanthes trifoliata	I^{+}	–	–	I^{+}	–
Sphagnum cuspidatum	–	–	–	I^{+}	–
Sphagnum sect. *Subsecunda*	I^{5}	I^{+}	I^{5}	I^{+}	–
Sphagnum sect. *Squarrosa*	–	II^{+-10}	–	I^{5}	–
Warnstorfia cf. *fluitans*	–	I^{+}	–	–	–
Polytrichum commune	–	I^{+}	–	–	–
Accompanying					
Carex cf. *rostrata*	–	–	I^{+}	–	–
Phragmites australis	I^{+}	–	–	–	I^{+}
Equisetum limosum	I^{+}	–	I^{+-5}	–	II^{+}
Betula sp.	I^{+-25}	I^{+}	II^{+-5}	III^{+-10}	V$^{20-45}$
Betula sect. *Albae*	–	I^{g}	–	–	–
Betula pendula	–	I^{g}	–	–	–
Salix sp.	–	–	–	–	III^{+}
Pinus sylvestris	V^{+-10}	V^{+-10}	V^{+-30}	V$^{15-70}$	V$^{10-30}$
Picea abies	I^{+-5}	I^{g}	I^{+}	I^{20}	I^{+}
Carex sp.	I^{+}	II$^{+-10/g}$	I^{+}	I$^{15/g}$	–
Poaceae	–	–	I^{+-10}	–	–
Potentilla sp.	–	–	–	–	II^{g}
Sphagnum cf. *centrale*	I^{+}	–	–	–	–
Sphagnum sect. *Palustria*	II$^{5-55}$	I^{30}	I^{+-20}	–	–
Sphagnum sect. *Cuspidata*	V^{+-45}	V$^{60-95}$	V^{+-20}	V^{+-30}	III^{+-10}
Sphagnum sect. *Acutifolia*	II^{+-5}	III$^{5-10}$	I^{+}	I^{+-5}	–
Sphagnum sp.	II^{+-25}	II^{+}	I^{+-5}	II^{+-15}	–
Bryales	I^{+-5}	II^{+-5}	I^{+}	–	–
Pediastrum sp.	–	–	I^{a}	–	–

grass. *Sphagnum magellanicum* and *Sphagnum fallax* are a noticeable admixture, as also observed in the subassociation described by Kloss (1993, 2001). Pacowski (1967) and Obidowicz (1990) pointed only a minor role of *Sphagnum magellanicum*. According to the last author, this subfossil community could be identified with contemporary *Eriophoro vaginati-Pinetum silvestris* Hueck 1931 em. Neuhäusl (Rybniček et al. 1984). The peat-forming role (in studied deposits from Kładkowe Bagno – Pino-Sphagneti peat) of *Sphagnetum magellanici pinetosum* was noted by Tołpa et al. (1967) and Tobolski (2000).

Sphagnetum betulo-pinosum eriophoreto fruticuletosum was recognized in the northern Kładkowe Bagno basin (Tab. 7) and formed the Pino-Betuleti peat. Identification of that subfossil phytocoenosis was possible basing on previously published data referring to the contemporary plant communities in Northwest Russia (Botsch & Smagin 1993). Among them, the *Sphagnetum betulo-pinosum* Filatov et Yurev 1913 (in Botsch & Smagin 1993) association was named. There are minimal data about subfossil communities with predominant birch, pine and tussock cottongrass. Obidowicz (1990) related them to contemporary *Betuletum pubescentis* Tüxen 1937.

Botsch and Smagin (1993) noted transition character of the subassociation *Sphagnetum betulo-pinosum eriophoreto fruticuletosum*.

SUBFOSSIL COMMUNITIES OF UNCERTAIN SYSTEMATIC POSITION

The community of sedge-brown moss and moss with scrubby birches (*Betula nana* and *Betula humilis*, Tab. 8) could be connected with a few plant classes. Characteristic species of several higher syntaxa were found: of the *Magnocaricion* (*Carex vesicaria*, *Carex pseudocyperus*) alliance, the *Alnetea glutinosae* (*Betula humilis*, *Thelypteris palustris*) class, the *Scheuchzerio-Caricetea nigrae* (*Menyanthes trifoliata*, *Calliergon* cf. *giganteum* and *Drepanocladus* sp.) class and also of the *Oxycocco-Empetrion* (*Betula nana*) alliance. That community existed in Taboły during the Late Glacial (TV, TIX, T4; Fig. 2, Tab. 2) and was the parent community for the Cariceti, Cariceto-Bryaleti and Bryaleti peat units.

The community of sedge-brown moss with scrubby willows and birches (*Betula humilis* only) were recognized by Marek (1991b) in the deposit of Pomieczyno and classified as the *Scheuchzerio-Caricetea nigrae* class. The phytocoenosis in question from the Taboły mire could rather be identified with the shrubs-sedges-brown mosses associations described by Liss and Beresina (1981) in the Western Siberia territory.

There are several possible classification positions for the *Sphagnum palustre-Carex* subfossil community (Tab. 8), recognized in Taboły. It could be connected either with the association *Betula nana-Oxycoccus quadripetalus-Sphagnum palustre*, noted in the Western Siberia territory (Liss & Beresina 1981) or with alder woods. However, a minor role of trees and shrubs speaks against these ideas. It could also be related to the order *Scheuchzerietalia palustris*. According to Wąs (1965), *Sphagnum palustre* should be typical just for this order, namely for *Caricetum diandrae* and *Caricetum limosae*. Because of low numbers of determinable remains in peat, the presence of these sedge communities could not be confirmed.

The subfossil community *Sphagnum palustre-Carex* formed some peat units: cf. Alnioni, Cariceti and *Sphagnum palustre*-peat. Radiocarbon dating evidences its occurrence in the Boreal period (TX; Fig. 2, Tab. 2).

The *Carex-Sphagnum* sect. *Palustria+Pinus* community (Tab. 8) has been described from the roof of the Borki deposit (BIII – preboreal and boreal deposits; Fig. 4, Tab. 2). Its characteristic feature is a high proportion of *Sphagnum magellanicum*. This subfossil phytocoenosis can be related to the Western Siberian pine-birch-sedge-peat moss associations (Liss & Beresina 1981). However, birch has a minor share in the community as reconstructed from Borki. The two peat units formed by this phytocoenosis are the Cariceti and wood peat-moss-sedge units.

Connection of the *Sphagnum* sect. *Acutifolia-Carex* community (Tab. 8) with any phytosociological syntaxon seems to be impossible, because of difficulties in species identification of sedges and peat mosses of the *Acutifolia* section. However, its floristic composition is very specific. Coexistence of plants of ombro- and minerotrophic habitats implies attachment to the *Scheuchzerio-Caricetea nigrae*. It was a parent community of the *Cariceti*, *Sphagnum* sect. *Acutifolia*-peat and the *Sphagnum* sect. *Acutifolia-Carex*-peat, and it existed in the early Holocene (BIII; Fig. 4, Tab. 2).

The last of this group is the forest-brushwood + *Carex-Sphagnum* subfossil community (Tab. 8), reconstructed in Taboły (TII, TIII, TVI, TVII, TIX, TX; Fig. 2) and Borki (BI, Fig. 4). It is marked by the presence of specific plant combination from which peat mosses of *Acutifolia*, *Palustria* (*Sphagnum palustre* mainly), *Subsecunda* and *Squarrosa* sections, ericaceous dwarf shrubs, common reed and swamp horsetails have been recognized. Trees and bushes (spruce, pine, birch, alder and willow) accompany the above components. The subfossil community in question occurred during the Subboreal and Subatlantic periods (Tab. 2) and can be related to the contemporary *Thelypteri-Betuletum* and *Sphagno-Piceetum* associations. According to Czerwiński (1978), tree from these associations consist of only the above-mentioned components. However, in the subfossil state, it seems to be impossible to tell them apart, if the characteristic species of *Sphagno-Piceetum* are not recognized, like *Sphagnum girgensohnii* (absence of charac-

Table 8. Subfossil communities without certain systematic position. Legend as in Tab. 3

Subfossil community	Sedge-brown moss and brown moss with scrubby birches	*Sphagnum palustre-Carex*	*Carex-Sphagnum* sect. *Palustria + Pinus*	*Sphagnum* sect. *Acutifolia-Carex*	Forest-brushwood + *Carex–Sphagnum*		
						with *Sph.* sect. *Subsecunda*	
Successive No	1	2	3	4	5		
Number of botanical analyses	20	10	26	13	47	1	10
Mire	T	T	B	B	T		B
1	2	3	4	5	6	7	8
Scheuchzerio-Caricetea nigrae							
Carex cf. *limosa*	–	–	–	–	I^{+}	–	–
Carex cf. *nigra*	–	–	–	–	I$^{+–5}$	–	–
Carex sect. *Paniculatae*	–	–	I^{g}	–	–	–	–
Menyanthes trifoliata	II$^{+–5/g}$	I^{10}	II$^{+/g}$	–	I$^{+/g}$	–	II$^{+–5}$
Sphagnum cuspidatum	–	–	–	–	I^{+}	–	–
Sphagnum teres	–	I$^{+–15}$	–	III$^{+–5}$	I^{25}	–	–
Sphagnum cf. *contortum*	–	–	–	–	I^{5}	1^{55}	–
Sphagnum sect. *Subsecunda*	I$^{+–5}$	–	I^{+}	–	I$^{+–10}$	1^{5}	–
Calliergon giganteum	I^{+}	–	–	–	–	–	–
Tomentypmum nitens	–	–	I^{+}	–	–	–	–
Warnstorfia cf. *exanulata*	–	–	I^{+}	–	–	–	–
Drepanocladus sp.	I^{+}	–	I^{+}	–	–	–	–
Phragmitetea							
Carex vesicaria	I^{g}	–	–	–	–	–	–
Carex cf. *elata*	–	–	–	–	I$^{+–5}$	–	I^{+}
Carex cf. *rostrata*	–	–	–	–	I$^{+–5}$	–	–
Carex cf. *pseudocyperus*	I^{g}	–	–	–	–	–	–
Phragmites australis	I^{+}	II$^{+–10}$	V$^{+–10}$	II$^{+–5}$	IV$^{+–20}$	–	II$^{+–5}$
Equisetum limosum	II$^{+–5}$	V$^{+–5}$	–	IV$^{+–5}$	I^{+}	–	IV$^{+–20}$
Alnetea glutinosae							
Betula cf. *humilis*	I^{g}	I^{g}	I^{g}	–	–	–	–
Lycopus europaeus	–	–	–	–	I^{g}	1^{+}	–
Thelypteris palustris	IV$^{+–10}$	II^{+}	II^{+}	IV$^{+–5}$	III$^{+–5}$	–	III^{+}
Sphagnum squarrosum	–	II$^{+–5}$	–	–	–	–	–
Alnus sp.	–	–	I^{+}	–	II^{+}	–	I$^{+–20}$
Salix sp.	I^{+}	I^{+}	I^{+}	II$^{+–5}$	I^{+}	1^{+}	II$^{+–5}$
Oxycocco-Sphagnetea and *Vaccinio-Piceetea*							
Betula nana	II^{g}	I^{g}	–	I^{g}	I^{+}	–	II$^{+–5}$
Andromeda polifolia	–	–	I^{+}	–	–	–	I$^{+–5}$
cf. Ericaceae	I^{+}	II^{+}	IV$^{+–10}$	II^{+}	I^{+}	–	–
Sphagnum magellanicum	–	–	IV$^{5–50}$	I^{+}	–	–	–
Aulacomnium palustre	I^{+}	–	–	–	–	–	–
Polytrichum strictum	–	–	–	IV$^{+–5}$	–	–	–
Pleurozium schreberi	–	I$^{+–15}$	I^{15}	–	–	–	–
Accompanying							
Betula sp.	IV$^{+–10}$	I^{+}	III$^{+–5}$	IV$^{+–10}$	IV$^{+–30}$	1^{+}	IV$^{+–10}$
Betula sect. *Albae*	I^{g}	I^{g}	–	–	I^{g}	–	–
Betula pubescens	–	–	–	–	I^{g}	–	–
Pinus sylvestris	II^{+}	III$^{+–5}$	V$^{5–45}$	V$^{+–15}$	V$^{+–30}$	1^{10}	IV$^{+–15}$
cf. *Picea abies*	–	–	I^{+}	–	III$^{+–55}$	1^{+}	II^{+}
Carex sp.	V$^{5–75}$	V$^{15–60}$	V$^{10–65}$	V$^{+–70}$	V$^{+–95}$	1^{20}	V$^{10–90}$
Cyperaceae	II$^{+–5}$	–	II^{+}	I^{+}	I^{+}	–	II^{+}
Scirpus sp.	I^{5}	–	–	–	–	–	–
Poaceae	–	I^{+}	–	–	I$^{+–5}$	–	I^{+}
Luzula sp.	–	–	–	–	I^{g}	–	–
Lychnis flos-cuculi	–	–	–	–	I^{g}	–	–

Table 8. Continued

1	2	3	4	5	6	7	8
Stellaria sp.	–	–	–	–	I^{g}	–	–
Ranunculus acris	–	–	–	–	I^{g}	–	–
Ranunculus sceleratus	I^{g}	–	–	–	–	–	–
Alchemilla sp.	–	–	–	–	I^{g}	–	–
Polygonum cf. *hydropiper*	–	–	–	–	I^{g}	–	–
Polygonum sp.	–	–	–	–	I^{g}	–	–
Caryophyllaceae	–	–	I^{g}	–	I^{g}	–	–
Potamogeton sp.	I^{g}	–	–	–	–	–	–
Sphagnum palustre	–	V^{5-70}	III^{+-40}	II^{+-35}	I^{+-40}	–	I^{+}
Sphagnum sect. *Palustria*	I^{+}	–	III^{+-30}	II^{+}	III^{+-40}	1^{+}	I^{+}
Sphagnum sect. *Cuspidata*	–	–	I^{+-20}	IV^{+-5}	I^{+-5}	–	I^{+}
Sphagnum sect. *Acutifolia*	II^{+-5}	II^{+-10}	I^{+-20}	V^{5-80}	I^{+-10}	–	I^{+}
Sphagnum sect. *Squarrosa*	I^{+}	–	–	–	–	–	–
Sphagnum sp.	III^{+-5}	I^{5}	I^{+-5}	III^{+-5}	II^{+-5}	–	II^{+}
Polytrichum sp.	–	I^{+}	I^{+}	–	–	–	–
Bryales	V^{5-80}	II^{+-5}	II^{+-5}	IV^{+}	II^{+-5}	–	III^{+-5}
Nitella sp.	I^{o}	–	–	–	–	–	–

teristic species for the association *Thelypteri-Betuletum*) in the North-Podlasie Lowland (W. Matuszkiewicz 2001). The forest-brushwood + *Carex-Sphagnum* community could be also identified with subfossil spruce-trees described by Żurek (1992) in the area neighbouring the Machnacz mire.

The community discussed above formed four peat units, namely the *Cariceti*, cf. *Alnioni*, *Sphagnum* sect. *Subsecunda*-peat and forest-herbaceous peat.

CONCLUSIONS

An attempt to reconstruct using macrofossil analyses the subfossil plant communities in three peat deposits of north-eastern Poland were made. Phytocoenoses of different rank were described. Lower syntaxa, as variants and subassociations as well as units of higher ranks were determined. Subfossil communities with uncertain phytosociological position were also recognized. Difficulties of reconstruction arose in connection with small quantity of determinable plant organs in examined deposits.

Recognition of sedges was very important for describing many subfossil communities. If vegetative and carpological remains were named only as "*Carex* sp.", their importance in palaeophytosociological work was minimal. Hence, there is frequent identification of general syntaxa only (e.g. alliance – *Magnocaricion*, class – *Scheuchzerio-Caricetea nigrae*). A sizeable contribution of sedges to communities without certain phytosociological position was also noteworthy.

Reconstructed peat-forming communities were related to contemporary phytocoenoses known from Central, Eastern and North-western Europe and Siberia. These connections are the result of climate changes in the past (in the Late Glacial and the Holocene), with this impacting vegetation distribution. Discoveries of floral remains of plants that are not present in the territory of the Puszcza Knyszyńska Forest nowadays are evidenced through their occurrences in the past.

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