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Sphagnum dominated mires and Sphagnum occurrences of North-Hungary

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ABSTRACT: This paper summarises the recent knowledge about *Sphagnum* dominated mires and other peatmoss occurrences of North-Hungary, on the basis of literature, herbarium data and skill of authors.

The invetigated area, accurately the Northern Mountain Range and the northern part of Great Hungarian Plain, contains numerous mires (bogs, intermediate mires, swamps), fens with peatmosses and other *Sphagnum* occurrences (on wet places, on acidic soil in forests). There are 12 areas, which contain *Sphagna,* some of these contain only one mire or small peatmoss patch and others contain numeros mires or *Sphagnum* occurrences. Since 1930's lot of investigations (e.g. floristical, coenological, zoological and palaeoecological) were made on these habitats and in the last decade also many new started (and partly finished). It is timely to summarise these data, results, maps etc. to initiate new researches.

Introduction

The peatmosses and their habitats are very rare in Hungary and since the 19th century they attracted a special attention. More recently, since 1986 the genus *Sphagnum* is protected by law in Hungary; since 1996 all mires are also under protection („Ex-lege" Mire Protection). At present, 24 *Sphagnum* species are recorded in Hungary (CORLEY et al. 1981, CORLEY and CRUNDWELL 1991). All of the Hungarian peatmoss occurrences are found below 600 m a.s.l. *Sphagna* live mainly in small disjunct mires usually surrounded by broad-leaved forest communities that create unsuitable habitats for them. Only in the northeastern (Zempléni-hegység region; SZURDOKI et al. 2000) and in the westernmost (Vendvidék and Őrség regions; ÓDOR et al. 1996, SZURDOKI 1996) parts of Hungary they grow also in fens and on wet, acidic soils of coniferous and broad-leaved forests.

Floristical and phytosociological investigations of mires and *Sphagnum* occurrences were in the focus of Hungarian botany (including bryology) from the 1930's. Peatmoss localities were relatively well explored until the 1970's (e.g. ZÓLYOMI 1931, 1939, SIMON 1953, MÁTHÉ and KOVÁCS 1958, 1959, BOROS and VAJDA 1960, BOROS 1964, 1968, PÓCS 1958, PÓCS et al. 1962, BARBALICS 1976). This is especially true for the mires of the Northern Mountain Range where numerous scientists investigated the mires from different points of view. Also, there is a number of floristical, coenological, zoological and palaeoecological studies. In the present study the authors, who made extensive surveys on the subject, provide a summarisation the recent knowledge about *Sphagnum* dominated mires and other peatmoss occurrences of North-Hungary.

Methods

The nomenclature of bryophytes follows CORLEY et al. (1981, 1991), GROLLE (1983), and SIMON (2000) for vascular plants and the associations.

Sphagna are investigated since 1994 by the authors. Hitherto all known *Sphagnum* localities had been visited; their species composition and vegetation types described, identification of earlier collections (specimens of the Bryophyte Herbaria at BP and EGR) have been mostly revised. The following sources were consulted during this study: publications, floristical notices of BOROS (1915-71) and VAJDA (1933-78) (preserved at BP) and the bryological collections at BP and the Bryophyte Collection of EKF Botanical Department (EGR).

Results

Among the numerous peatmoss dominated mires and peatmoss occurrences in North-Hungary the most important mires are in the northern part of the Great Hungarian Plain (in the Bereg region), in the Putnok-hills and in the Mátra Mts.

Several works have provided data on different mires (BOROS 1964, KRÖEL-DULAY 1995, LÁJER 1998a). Among these, Á. BOROS (1964) described the distribution of peatmosses known at that time. GY. KRÖEL-DULAY (1995) made a comparative study of the Hungarian bogs, on the basis of island-biogeography. K. LÁJER (1998a) made a coenological relevés from most wetland communities, from different parts of the country. He collected data on *Sphagnum* dominated mires, too. These above articles will be mentioned only if they contain new information related to the subject.

In the following part of this study we summarise the present knowledge of *Sphagnum* dominated mires and occurrences of North Hungary.

1. Csömör: Forrás- stream (150 m a.s.l.)
This location was discovered in 1976 by E. Stollmayer-Boncz at the lake of Csömör, situated near Csömör village (Pest County). At that time, *Sphagnum fimbriatum* and *S. squarrosum* occurred in the centre of the lake, on the floating island, dominated by *Salix cinerea* and *Thelypteris palustris* (STOLLMAYER-BONCZ 1982). The main communities of the lake were *Salicetum cinereae* in the outer and *Salici-cinereae Sphagnetum recurvi* in the center part, and there was open water too. This area, named Csömöri-pasture, is protected since 1977. The lake was burned in 1987, and the *Sphagnum* communities were destroyed so much that they have not come back to date (SZOLLÁT et al. 1997, Stollmayer-Boncz 1999).

E. Stollmayer-Boncz has been making floristical investigations since the 1970's. She drew a vegetation map of the peaty areas (STOLLMAYER-BONCZ 1982); she studied the algae of this lake, and found 111 taxa, of which 17 are rare (STOLLMAYER-BONCZ 1988, 1992 a, b). She mesured the pH values, too (it was relatively high: pH 5,5-6, in 1984-85, later pH 6-7. In the 1990's new floristical and coenological investigations were made in this area (Csömöri-lake and Réti-dűlő, SZOLLÁT et al. 1997). The lake now is dominated by *Scirpo-Phragmitetum*, and around of this *Calamagrosti-Salicetum cinereae* communities are growing. The investigated area, including Csömöri-lake, begun to dry up and the water regime has considerably changed. The valuable fen communities can be protected only with active intervention on part of the nature conservation.

2. Nagybárkány: Nádas-lake (360 m a.s.l.)
The swamp, named Nádas-lake, is situated near Nagybárkány (Nógrád County) in the Cserhát Mts. I. Máthé and M. Kovács discovered it in 1957, during the botanical investigation

of "Nógradense" flora district (MÁTHÉ and KOVÁCS 1958, 1959). They made the vegetation map of the area, and made floristical studies and bored the peat. They assumed that *Sphagna* must be recent establishments, because the investigated profiles contained only sedge and reed peat but no *Sphagnum*. They recorded only one peat moss, *S. squarrosum* (identified by Á. Boros) from the *Phragmites* consociatio of *Salici cinereae-Sphagnetum*. They found that this lake is situated in a shallow basin, approximately 100 m long and 40 wide in the widest part, and it has the long protrusion which is only 5-10 m wide. The total area covers about 2000 m^2 (MÁTHÉ and KOVÁCS 1959). *Sphagna* lived only in the wider part.

Megyeri studied the fauna of this swamp in 1961, and made also some chemical measurements of the water, (MEGYERI 1962). He showed the importance of presence and absence of major orders of water animals (*Rotatoria*, *Copepoda*) in the classification and characterisation of mires. He ascertained that the microfauna of the peatmoss dominated mires were strongly influenced by the main *Sphagnum* species.

Ádám Boros visited this mire in 1958 (BOROS 1915-1971). He found only a few m^2-sized *S. squarrosum* patches under willows, in the southeastern part of the lake and he also recorded some other bryophytes.

P. ITTZÉS (1996) reported bryofloristical data from the Northern Mountain Range. He found two *Plagiothecium* species (*P. curvifolium* and *P. ruthei*) not collected earlier in this swamp, but he mentioned only *S. squarrosum* among the peatmosses.

K. LÁJER (1998a) made coenological relevé in the *Salici cinereae-Sphagnetum recurvi* community, and recorded two peatmoss species, *S. squarrosum* and *S. fallax*.

Szurdoki visited this mire in 1997 with Peter Erzberger. That time the peatmosses dominated most part of the moss layer in the *Salici cinereae-Sphagnetum recurvi* community. Open water was mainly in the lagg zone.

3. Sirok: Nyírjes-lake (250 m a.s.l.)

The bog of Mátra Mts, Nyírjes-lake, situated near Sirok village, on the northern slope of Darnó-hill. This bog developed in a basin of about 9000 m^2, and has no visible surface water supply. I. Máthé and M. Kovács discovered it in 1957, during the investigation of "Mátrense" flora district (MÁTHÉ and KOVÁCS 1958, 1959). They drew a vegetation map, made floristical studies and cored the peat. The vegetation map visualised the zonation of communities. These, from outside to inside are the following: *Scirpo-Phragmitetum, Salicetum cinereae, Salici cinereae-Sphagnetum* with *Sphagnum palustre*, *S. subsecundum* and *S. recurvum s.l., Carici lasiocarpae-Sphagnetum* with *S. palustre*, *S. magellanicum S. subsecundum* and *S. recurvum s.l.* in the moss layer. Between the *Salici cinereae-Sphagnetum* and *Carici lasiocarpae-Sphagnetum* there was a small stand of Phragmites consociacio of *Salici cinereae-Sphagnetum* also.

Á. BOROS (1964) noted the occurrence of 6 *Sphagnum* species in this bog: *S. subsecundum, S. obtusum, S. recurvum s.l., S. squarrosum, S. palustre, S. magellanicum*.

I. BAKALÁR (1981) found *S. fimbriatum* in the centre of the mire, in the *Carici lasiocarpae-Sphagnetum* stand, together with *S. palustre, S. subsecundum, S. obtusum, S. recurvum s.l.* (presumably *S. fallax*) and *S. angustifolium*.

MEGYERI (1962) also investigated the micro-fauna of this mire. He explained the differences of the micro-fauna between mires, with the differences in the *Sphagnum* flora.

Penksza with his colleagues made analytical measurements in the mire (PENKSZA et al. 1994). They investigated concentrations of 26 elements in dominant herbs and bryophytes

(altogether 12 species) and in the peat under *Sphagnum recurvum s.l.* In addition to the element concentration they measured the pH values of re-wetted peat. They found high heavy metal concentrations in the mosses and in the leaves of *Salix cinerea* and *Thelypteris palustris*; the element concentration of peat changed with the depth and the pH values decreased in samples down to 50-67 cm. They assumed that their results are similar to the data found in the literature.

From this bog peat cores were retrieved by I. MÁTHÉ and M. KOVÁCS (1958). The upper 40-50 cm part of the sequence contained *Sphagnum* peat, the lower part consisted of sedge and reed peat with *Sphagnum* remnants. They ascertained that peatmosses live in this basin for a long time. Sümegi and his colleagues made borings in this bog too. They started to investigate the development of local wetland dynamics and changes of environment. GARDNER (1999), in his PhD thesis studied the impact of Neolithic agriculture on the environments, and one of his sequences came from Nyírjes-lake. In this bog from cal. 5000 BP years Sphagna and brown mosses dominated the peat and earlier only few spores of peatmosses could be found. The development of *Sphagnum* bog was dated between 5-6000 cal BP years and the lowest part of investigated peat sequences (450 cm) was about 10000 cal BP years.

The authors have been visiting this bog since 1994. At that time the bog was in bad condition. The lag zone was dry, the *Sphagna* were wet only, and the water table was low. The vegetation was similar to what was shown by the map of Máthé and Kovács, but trembling poplars and birch trees were much more dominant than at the time of the surveys for the map. The Nature Conservancy (Bükk N.P.) cut most of them in 2000. In 1994 Kröel-Dulay and his colleagues found *Drosera rotundifolia* and *Vaccinium oxycoccos* (KRÖEL-DULAY 1995, SZMORAD and BARABÁS 1999), which are new for the flora of this mire, but it seems possible that *V. oxycoccos* was planted (SZMORAD and BARABÁS 1999). In 1998-1999 the basin of the mire was filled by excess water: in early summer of these two years the water table moved 40 cm higher then the level of the peat moss but by the end of the summer (besides that the peatmoss showed a more extensive growth) the water table has also retreated. In this period, the lag zone got filled with water too, but *Utricularia bremii* and *U. minor* could not be found in the past years.

4. Egerbakta: Kis-lake (280 m a.s.l.) and Nagy-lake (290 m a.s.l.)

At the foot of Tó-hill, near Egerbakta, 3 lakes can be found, two of them containing *Sphagna*.

The first floristical data from this area date back to 1810-20's (VOJTKÓ 2001). In 1886, V. BORBÁS (1886) recorded the occurrence of *Sphagnum fimbriatum* and *Drosera rotundifolia* from Kis-lake. He visited the mire together with M. Vrabély, who collelted numerous specimens from the Bükk Mts (VOJTKÓ 2001). The first detailed floristical investigaton was made by Á. Boros in 1920's. He published some new vascular taxa, and he reported some earlier unknown bryophyte species for the area, e.g. *S. centrale*, *S. recurvum s.l.*, *Polytrichum strictum*. At that time, the water table was high, and from the markings on the tree trunks he assumed that the water level could change about one meter even in short periods of time (BOROS 1915-71). Later he classed this mire among the *Sphagnum* dominated willow-mires, which developed on floating mire (BOROS 1964).

B. Zólyomi studied the vegetation of Kis-Lake (ZÓLYOMI 1931). The mire reaches about 40 m in diameter, with a circle shaped basin. In the central part *Carex rostrata-Sphagnum recurvum* association was observed with continuous moss layer. Around this a transitional,

low-growing tree community occurred with *Salix cinerea*, *Populus tremula*, *Juncus effusus*, *Thelypteris palustris* and *Lysimachia vulgaris*. The outer, dense belt was dominated by *Salix cinerea*, with a few herbs and by a moss layer. *Sphagna* lived mainly in the central part. He considered this mire of a transitional type.

At the end of the 1950's and the beginning of the 1960's new data were published from this mire. S. Jávorka, V. Csapody and E. Kol found *Eriophorum gracile*, which was new for Hungary too (in: Boros and Bohus 1959). This was confirmed by L. Juhász (1961), who found some new and rare mushroom (Juhász 1960) and new peatmoss species, *S. capillifolium* (Juhász 1963). In the 1960's Á. Boros and L. Vajda found *Sphagnum palustre and S. obtusum* (Boros 1915-71, Boros 1964). In 1962 T. Pócs found *Lysimachia thyrsifolia* (Pócs 1963). Megyeri (1965) made also hydrological investigation on this mire.

At the end of the 1980's S. Dulai and A. Vojtkó made floristical studies and microclimatological measurements in the area (Dulai and Vojtkó 1991). They ascertained that this mire is sedge dominant transitional mire, and it is a topogenous one (after Oswald). The mire has gradually become dry, because of the dry weather of those years, although the mire was still wetter and colder then its surroundings. In the centre a *Salici-cinereae-Sphagnetum recurvi* stand existed, with *Salicetum cinereae* around it. The earlier existing marshy and lag zone have disappeared. They recorded the occurrence of eight peatmoss species (*S. fimbriatum, S. centrale, S. recurvum s.l., S. squarrosum, S. palustre, S. capillifolium, S. obtusum, S. teres*) and the absence of *Drosera rotundifolia*, *Dryopteris cristata*, *Eriophorum gracile* and *Lysimachia thyrsifolia*. They pointed out that the degradation was typical of all parts of the mire.

The origin of the mire basin is not clear. Boros (1926) thought that, the origin and development of mire could be interpreted with characteristical local conditions. The opinion of Juhász (1963) was that the basin is originated from the slip, but Dulay and Vojtkó (1991) questioned it, arguing that slipping is not typical for riolite-tuff, sandstone and quarcit bedrock.

B. Zólyomi (1931) made palynological studies of the area. The peat was 1.2 m thick, and it composed of *Sphagnum* mixed sedge-peat which built up on dy. This mire is a young one, of subatlantic age (Beech II), originating from floating mat and developed with its surface continually growing.

The authors visited this mire several times in the 1990's. In 1994 it was dry, there were only a few *Sphagna*. In 1997 it dried out, *Sphagna* have disappeared, but *Thelypteris palustris* and *Dryopteris carthusiana* still lived. By 1999 the basin of the mire got filled with water and by 2000 the water table has decreased. On the basis Clymo and Duckett (1986), it possible that *Sphagna* will colonise this basin again thanks to the still living *Sphagnum* remnants and spores.

Nagy-lake is situated near Kis-lake. The lake is surrounded by *Salicetum cinereae* and sedge communities, and in the open water *Lemnetea* can be found. Dulai and Vojtkó (1991) recorded two *Sphagna* (*S. recurvum s.l.*, *S. squarrosum*) from the *Salicetum cinereae* (Dulai and Vojtkó 1991).

5. Tarnavidék

This is a hilly area between the Mátra Mts and the town of Ózd. Bakalár and colleagues (1975) published occurrences of *Sphagna* from this area. They found a few patches of 3 peatmoss species (*Sphagnum compactum, S. palustre* and *S. capillifolium*) on the northern

slope of Futyó-valley, at the roadside bank in an acidic beech forest (*Luzulo-Fagetum*). T. Rédei saw the *Sphagna* in this valley in the 1980's (pers. comm.). The authors visited this area in 2001 (with T. Rédei), but have not found any *Sphagnum* patches.

6. Bükk Mts: Csipkéskút (800 m. a.s.l)
In the Bükk Mts, between Bánkút and Csipkéskút, on wet soil of beech forest Z. SIROKI (1961) found a patch of *Sphagnum capillifolium* with *Polytrichum commune* and *Calliergon cordifolium*. The earlier 2-3 m^2-sized patch disappeared (VOJTKÓ 2001).

7. Kelemér: Kis-Mohos (296 m. a.s.l.), **Nagy-Mohos** (294 m. a.s.l.)
These two bogs are situated in the Putnok-Hills, near Kelemér village. Many investigations were conducted in these mires, and publications appeared on the history of studies of the vascular plants (MATUS et al. 2000) and mosses (SZURDOKI et al. 2002). Recently a general work was being prepared about these mires, which contain floristical, coenological, zoological, and palaeoecologocal studies (NAGY and SZMORAD 2002). In the present article we summarise the most important results on the history of investigation and management of these mires.

General zonation of the recent vegetation is similar, as it was in the past. Both bogs are surrounded by *Quercetum petraeae-cerris* and *Querco-Carpinetum* forests which turn into a shrubby marginal zone. The bogs are surrounded by a lag zone and different willow communities, and inner *Betulo-pubescentis-Sphagnetum* community is the dominant. In the innermost part open associations (e.g. *Carici lasiocarpae-Sphagnetum*, *Eriophoro angustifolii-Sphagnetum*, *Eriophoro vaginati-Sphagnetum*) can be found.

The book of G. LÁSZLÓ and L. EMSZT (1915) contains the first scientific record of this mire, which shows the mires of Historical Hungary from the point of view of geology. They thought that the Kelemér lakes are bogs, which developed from fens, and this process has not been finished yet. They also described the main vascular genera of the mires.

In the 1920's Á. Boros described the main vascular and bryophyte species of the area: *Eriophorum vaginatum*, *Carex lasiocarpa*, *Betula pubescens*, *Sphagnum magellanicum*, *S. capillifolium*, *S. angustifolium*, *S. recurvum s.l.* (presumably *S. fallax*), *Polytrichum strictum*, and for the origin of the mires he pointed to special local conditions (BOROS 1924, SZURDOKI et al. 2002).

B. Zólyomi made detailed floristical, coenological and palynological studies at the end of the 1920's (ZÓLYOMI 1928, 1929, 1931, 1936, 1943, 1952). He found some vasculars (e.g. *Dryopteris cristata*, *Salix aurita*, *Betula x pseudo-carpatica*), and bryophytes new to Nagy-Mohos *(Sphagnum magellanicum*, *S. palustre*, *S. centrale*, *S. squarrosum*, *S. contortum),* and Kis-Mohos *(Riccia fluitans*, *Sphagnum centrale* and *S. squarrosum)*. He collected *Sphagnum subsecundum* and *S. teres,* which are also new for the area, but the annotation of specimen only mentions „Mohos-lakes" (SZURDOKI et al. 2000). He prepared a detailed vegetation maps of Kis-Mohos and Nagy-Mohos which are important even nowadays (CZENTHE 1985, LESS and MATUS 1990, MATUS et al. 1999, 2000). Zólyomi made palynological studies, too. He showed that the age of these two mires are not the same (the Nagy-Mohos is older), and that their basins have developed with sliding. The origin of Nagy-Mohos dates back to about 10 000 years (around the end of Pleistocene), and later dy, fen-peat and oligotrophic *Sphagnum* peat has deposited. It was covered by mineral layer and above this started again the developing of bog. The development of Kis-Mohos is similar. Zólyomi could make only 3 meters deep bores, because of the limitations of his technical equipment, thus the establishing of the mire's age was incorrect (MAGYARI et al. 2000).

The mires were declared as a Nature Reseve in 1952.

In the early 1980's B. Czenthe repeated the coenological works of Zólyomi and he prepared the actual vegetation map. His results were the following: the reed begun to spread aggressively in most communities of Nagy-Mohos and it endangered the survival of rare mire vasculars and bryophytes, especially *Sphagna*. However, in the Kis-Mohos important changes have not occurred, there was a species which referred to the degradation of the area and there were numerous notable species, too (CZENTHE 1985).

Since the 1980's non-governmental organisations (Association for the Nature Conservation In Borsod-Abaúlj-Zemplén County, Green Action, The Guarding Organization for Nature Conservations, The Holocen-Association for Nature Conservation, The Ecological Instititute for the Sustainable Development) made ecological investigations, regeneration experiments (GYULAI et al. 1988, HUDÁK 2000a) and conducted conservation activities (e.g. water reconstruction, lag zone cleaning, reed cutting; HUDÁK 2000a, b)

Matus with colleagues studied the flora of mires and prepared new vegetation maps in 1990 and 1998 (LESS et MATUS 1990, MATUS et al. 1999, 2000). They found *Menyanthes trifoliata* again, which disappeared in the 1980's. They pointed out that the bog vegetation went trough a quick succession. Reed control was only achieved by repeated cutting and removal by the middle of the 1990's. This process is continued recently with regard to the over-dominance of birch (*Betula pubescens*) – the areas of open communities have been decreased to a great extent. As a consequence of recent high water levels the opposite process also occurred on small scales. They mention that adequate water supply will also be essential in the future.

G. JAKAB (1997a) published the record of *Calliergon stramineum*, from these mires. It seemed to be new to the area on the basis of Hungarian literature, but in 1968 K. Karzmarz revealed from the Boros collections (SZURDOKI et al. 2002).

K. Lájer made floristical and coenological studies in the Mohos-lakes in 1990's (LÁJER 1998a,b). He published 4 relevés from Kis-Mohos and 2 relevés from Nagy-Mohos and published a new community with the name of *Sphagno flexuosi-Eriophoretum angustifolii* Lájer, and the type relevé was made in Kis-Mohos (LÁJER 1998a). He published *Sphagnum flexuosum* as a taxon new to these bogs. Earlier, Á. Boros collected it from Nagy-Mohos, but it was revised only recently (SZURDOKI et al. 2002).

Palaeoecological analyses of sedimentary sequences were made from Nagy-Mohos and Kis-Mohos; these have provided a paleoenvironmental record of the last *c.* 25300 cal years BP in the Kelemér Region, by P. Sümegi and colleagues. Pollen, plant macrofossil and humification data amplified by chemical and physical analyses of the sedimentary sequences had been used to study local wetland vegetation dynamics and upland vegetation development (WILLIS et al. 1997, 1998, JAKAB et al. 1998, MAGYARI et al. 2000).

Nagy-Mohos is about 25300 cal BP years old. That time the basin was invaded by brown mosses dominated rich fen communities, later different fen communities changed each other and the mire became much poorer in nutrients. The continuous peat sequence was interrupted by an approximately one meter thick intercalation of inorganic sediment between 14600 and 9500 cal BP years. After 9500 cal BP years started again the succession of bog through different fen and bog communities.

Hydroseral development of Kis-Mohos has not yet been fully established, only major units of the wetland development were distinguished. Between 14600-13200 cal BP years the basin was occupied by an oligotrophic lake, which was rich in macrophytes and their progressive productivity resulted in the shallow lake by *c.* 9000 cal BP years. The establishment of the

peat bog they took places *c.* 8200 cal BP years, however, reconstruction of the steps of this terrestralisation process can not be carried out until further macrofossil analysis is done (MAGYARI et al. 2000).

8. Zemplén Mts

In the northern part of the Zemplén Mts numerous *Sphagnum* occurrences are known. The first occurrences of *Sphagna* were reported in 1938 (SOÓ 1938a).

In these mountains, L. Vajda made the first overall bryofloristical study. He published the results of his 10–15-year long collecting work in 1969 (VAJDA 1969). Á. Boros also collected bryophytes in this area (and his documentation is also accessible by the way of his Floristical notices (BOROS 1915-71) and the specimens in the herbarium at BP). T. Simon carried out vegetation studies including the bryophytes, in the Zemplén Mts in the 1960's and 1970's (SIMON 1970, 1971, 1977a, b). E. Szurdoki and her colleagues studied *Sphagnum* occurrences of Zemplén Mts in the end of 1990's (Szurdoki et al. 2000).

The most beautiful valleys of the Zemplén Mts are the Komlóska and Kemence Valleys, which have a Carpathian character both in their landscapes and floristical properties. Fens and montane alder forests (*Carici brisoidi-Alnetum*) are situated along the streams (JÁRAI-KOMLÓDI and SIMON 1971). The main plant community, characterising the peat accumulating fens, is *Carici echinatae-Sphagnetum*, with its *eriophoretosum latifolii* and *molinetosum* subassociations (VOJTKÓ and MARSCHALL 1995). R. SOÓ collected the first *Sphagnum* specimens (*Sphagnum contortum* and *S. centrale*) in 1938 (SOÓ 1938a, BP), with the label containing a general location named "Kemence Valley, near Pálháza". After Soó in 1940-50' s Vajda and Boros found peatmosses in fens (BOROS 1915-71, VAJDA 1933-78), they had 6 localities of *S. palustre* and *S. contortum* in the valleys. SIMON (1970) published one new occurrence. Szurdoki with colleagues (2000) revised old specimens, and they found some *S. centrale* specimens among those labelled as *S. palustre*. They established that the three largest *Sphagnum* occurrences of peat accumulating fens along the Komlóska and Kemence Valleys, which have a good water supply, could survive in the last decades and presumably will thrive in the future too. The *Sphagnum* species of some occurrences described earlier along these valley systems have shown certain changes, there is one new occurrence and two occurrences have disappeared. *S. contortum* is the most frequent peatmoss, the quantity of *S. centrale* has been decreasing, *S. palustre* disappeared and *S. compactum* is a new to the area.

VAJDA (1969) found peatmoss occurrences in wet places outside of fens, too. Szurdoki and colleagues (2000) also found some and divided them into two groups. These occurrences can not be regarded as classifiable *Sphagnum* communities, since they appear to be recent establishments. The first group can be found along the springs and small streams. Vajda described two occurrences of *S. teres* in Ósva valley, which could presumably be classed in this group, but these seem to be disappeared. Nowadays, 4 occurrences, with 8 *Sphagnum* species (*S. fallax, S. fimbriatum, S. magellanicum, S. obtusum, S. palustre, S. sqarrosum and S. subsecundum*) form this group can be accounted (SZURDOKI et al. 2000). The second group can be found on moist roadside embankments and in temporarily wet places with occasional runoff; these are drier habitats. Vajda described two patches of *S. palustre* around Telkibánya, which presumably similar to those in the second group, but they have also disappeared. In the last years 4 new locations were found, which contained two peatmoss species (*S. fallax* and *S. flexuosum*).

A. Margittai collected peatmoss from the forest of the northern slope of Lackó hill in 1938 (SOÓ 1938a), Á. Boros identified this specimen as *S. capillifolium* (earlier name was

S. acutifolium), but later it was revised for *S. quinquefarium*. It lives on the riolite bedrock in the acidofilous forest. This occurrence was reported earlier (Soó 1938a, Boros 1953, 1964, 1968, Vajda 1933-78, 1969, Simon 1977b) as a fairly large, of several m^2 sized patch of *Sphagnum*. Today, it is very small, only a few dm^2–sized patch of *Sphagnum quinquefarium* growing on the humus covered rock, in the shade of old beech trees (Szurdoki et al. 2000). There is a new occurrence of peatmoss in the forest near Füzér. The 0.5 m^2-sized red *S. capillifolium* patch is located on the soil around the heath (Szurdoki et al. 2000).

9.Tornai-karszt

L. Somlyai and L. Lőkös (1999) made floristical investigations in "Tornense" in the 1990's. During their fieldwork they found peatmosses at the place called Lókosár, near Aggtelek village. The *S. palustre* occurs on a decayed stump, and an about 1 m^2-sized patch of *S. fimbriatum* is found on the soil of the slope of one of the carstic depressions.

10. The Bereg plain

In the Holocene, alluvial clay and silt layers were deposited onto the Pleistocene river gravel sediment of the Bereg Plain (NE Hungary). The bed of the Tisza River gradually shifted from the eastern part of the plain towards southwest leaving a labyrinth of oxbow lakes and channels behind. The river occupied its present place in the Neoholocene. This runs roughly along the border of the warm temperate and cool temperate zones. The number of sunny hours is *ca* 1950, annual mean temperature is 9.4–9.5 °C here. Yearly precipitation is 630–660 mm, of which 370–380 falls during the vegetation period (Marosi and Somogyi 1990). The distribution and amount of precipitation and the ground water level could be very uneven in different years (Nagy 2002).

There were five, *Sphagnum* dominated mires described on the Bereg-plain (Simon 1960, Nagy et al. 1998a). The name of them: Nyíres-tó, Báb-tava, Navad-patak, Zsid-tó and Bence-tó. These areas can be found at the southeastern marginal zone of the prevalence of these associations in European plains. Nyíres-tó and Báb-tava still have oligotrophic bog communities (mostly *Eriophoro vaginati-Sphagnetum recurvi-magellanici* Soó 1954 *oxycoccetosum* Simon 1960) and fen like *Carici lasiocarpae-Sphagnetum recurvi* communities, with pH 3.5-4.2 in their centre, and marshes and swamps are adjacent to their territories. The Navad-patak was similar to the above but had a fire damage in 1967, when its *Oxycocco-Sphagnatea* association has totally been destroyed. The Zsid-tó and the Bence-tó had only marshes and *Sphagnum* dominated swamps (willow and alder dominated associations). The extinction of *Sphagna* from the last three mires to the end of the 90's was caused by fire, dryness and then the quick and constant supervention of high water level above the ground. Formation of floating mires – scraws – begun immediately on them. Scraws of these mires have good chanches that new establishments of *Sphagna* will appear again on their surfaces (Clymo 1963, Clymo & Duckett 1986, Balogh 1983, Nagy 2002). The mires were discovered by T. Simon for the science in 1952, except for the Bence-tó, which was found by I.D. Pethe in 1990 (Simon 1953, Fintha 1994). Simon made detailed microclimatological, coenological and floristical studies, prepared the vegetation maps of Nyíres-tó and Báb-tava (Simon 1953, 1954, 1960, 1968) and described the changes and the protection of the vegetation of this two mires between of 1952-1989 (Simon 1992). He reported the decline or extinction of hygrophytes and the expansion of hydromesophytes and mesophytes and the acceleration of forest growth. In his opinion the most important change caused by humans

was the draining of the bogs. He assumed that the harmful processes had slight effect on the *Sphagnum* dominated associations. Before the escalation of the drying process recovery was started by blocking the draining canals, by the plantation of oak forest buffer zone, by the prohibition of using chemicals in the environments and by building a water replenisher in 1986 wich carries enough amount of good quality water from an artesian well to these two mires (SIMON 1992). E. VOZÁRY (1957) did pollen analytical research on the Nyíres-tó. He was dating the change of the oxbow lake to *Sphagnum* dominated mire to the end of the Hazel age. The artesian well was out of order from 1995 to 1996, as both Nyíres-tó and Báb-tava have dried out completely. Therefore the degradation had begun again, and was desperately fast. In 1997 they received a great amount of water, so that the peatmosses could overgrow for a couple of weeks. That time begun the artificial supervention of the Zsid-tó and Navad-patak mires where the *Sphagna* could not overgrow the high water level. The supervention of Bence-tó was natural in 1998. The Hortobágy N.P. Directorate made bush clearings on the central, *Sphagnum* dominated part of Báb-tava in 1998. Notably, all mires (exept for Nyíres-tó) need oak forest plantations in their entire surroundings.

FINTHA (1994) published floristical data from the mires and coenological reviews from the Bence-tó. KÖREL-DULAY et al. (1998) found three stools of *Hammarbya paludosa* (new records for the Hungarian flora) on the Báb-tava in 1994. K. LÁJER (1998a) published coenological data from Nyíres-tó, Báb-tava and from Zsid-tó. He described the *Sphagno flexuosi-Eriophoretum angustifolii* Lájer 1998 plant association from the Báb-tava. Z. TÓTH (1997) published an informative terse review of all the five mires. JAKAB and MAGYARI (2000) diagnosed by the analysis of two bore-sample from Báb-tava, that this mire was formed by the succession of floating mires. By their opinion unplausible that this mire is a glacial relict, as they found only 90 cm peat under of it. Nagy carried out floristical and coenological investigations on the all five mires (e.g. NAGY 1996a,b, 1999a,b,c,d, 2000a,b, 2002, and NAGY et al. 1995, 1996, 1998a,b,c,d,e, 1999). His results were based on more than 1200 temporary and permanent quadrates. By his opinion the greatest selectional pressure on the vegetation of these mires the arhythmical change of the dry and wet periods (NAGY 1999a,b, 2000a,b, NAGY et *al*. 1998*e*). He studied the flora and the vegetation of the mires and prepared their detailed vegetation maps and described the processes from the formation and development of the various floating mires to the continental raised bogs. He found *Dryopteris cristata* in 1997 and after 1995 he found again *Hammarbya paludosa* (20 flowering induviduals in 2000). He described *Thelypteridi-Typhetum latifoliae* Nagy in 1999, which is frequent in the margins of the floating mires of the Bereg-plain (NAGY et al. 1999). The details of vegetation change, state and possibilities of protection of the mires has also been described by him (NAGY 1996a, 1999c,d, 2000a). Most of his results are still unpublished.

Nyíres-tó

Nyíres-tó is a C-shaped, approx. 750 m long and (on average) 80 m wide, silted backwater. The only mire, which had no fire, damage, and already has his whole buffer zone of forest and meadow. Fourteen vegetational types were indicated on Simon's vegetation map (SIMON 1960) and fifteen on Nagy's vegetation map (1999d), which follow each other comparatively in a concentric order. There are some valuable plants in the central *Sphagnum* dominated associations: e.g. in the open *Eriophoro vaginati-Sphagnetum Eriophorum vaginatum, Eriophorium latifolium, Drosera rotundifolia, Vaccinium oxycoccos f. major* are found in the herb layer. *Drosera rotundifolia* seems totally extinct from the mire since 1989. In the moss

layer the most common peatmoss is still *Sphagnum recurvum s.l.* (SIMON 1960, FINTHA 1994). By LÁJER (1998a) most of them are identified as *Sphagnum flexuosum* with a few specimens of *Sphagnum fallax.* Nagy's results are close to the above (NAGY 1999d). *Sphagnum palustre* and *Sphagnum magellanicum* were shown equal rates of dominance (<5%) in the 1950's (SIMON 1960). *Sphagnum magellanicum* was 30% in 1988 (FINTHA 1994), and less than 5% in 1997 (LÁJER 1998a). After drying out, there were just two 20x30 cm flecks in the central part in 1997, but these increased rapidly as the total surface was more than 7 m^2 in 2001. This is less than 5% of the total amount of all *Sphagna.* The presence of *Sphagnum palustre* has been less than 5% every time we checked. LÁJER (1998a) recorded *Sphagnum centrale* also less than 5%, but we have never seen it on Nyíres-tó. NAGY (1999d) found *Sphagnum fimbriatum* to be common in the *Carici elongatae-Alnetum* in 1996 and its population seems to be increasing, while *Sphagnum squarrosum* – present in some small cushions in 1996 – seems to be decreasing. LÁJER (1998a) also found this peatmoss in 1997. The plant populations have been very responsive to the water-richness of the mire. Actually the largest problem is the treading of the mire, indicated by the high dominance of *Juncus effusus.*

Báb-tava

Báb-tava is an about 700 m long and (on average) 80 m wide, silted oxbow lake. The main damaging effect on the mire was the burning in 1967, when parts of the alder and willow bogs and reed marshes got wiped out. On their place we still find open water surface, shrinking year after year as the succession of vegetation proceeds.

Simon indicated 12 plant communities in 1959 and 10 in 1989 on his vegetation map (SIMON 1960, 1992). NAGY (1999d) indicated 25 types of vegetation on the vegetation map completed by him in 1998. These communities do not follow each other as orderly as in the Nyíres-tó. All researchers described *Sphagnum palustre* as the dominant peatmoss on this mire. SIMON (1960) and FINTHA (1994) reported about *Sphagnum recurvum* as another valuable species. In Lájer's coenological relevés *Sphagnum flexuosum* is present. NAGY (1999d) has found *Sphagnum fallax* as well. According his report *Sphagnum palustre* is the most frequent peatmoss on the centre of the mire (20-90%, Fr. 5), the second is *Sphagnum fallax* (10-70%, Fr. 5) and followed by (as the third one) *Sphagnum flexuosum* (10-20%, Fr. 2). He found some *Sphagnum squarrosum* and *Sphagnum fimbriatum* on the marginal areas of the alder, birch and willow mire. *Sphagnum magellanicum* was reported by FINTHA (1994) as having dominance equal to that of *Sphagnum recurvum s.l.* in 1990. He described some cases of occurrence with capsules. Nagy has never seen this peatmoss on the Báb-tava between 1992 and 2001. TÓTH (1997) reported *Drosera rotundifolia* from the central part of it. However, Nagy had never seen it between 1993 and 2001.

In the central open area can be observed the highest dominance of *Vaccinium oxycoccos,* and *Menyanthes trifoliata* is also there, outside the mires. The appearance of *Hammarbya paludosa* is facultative in subsequent years. There are just a few individuals of *Comarum palustre* near the lag zone. *Dryopteris cristata* is reproducing well. The Hortobágy National Park Directorate arranged clearing the excessive *Betula pubescens, Salix aurita* and *Salix cinerea* bushes from the central part of the mire every year, since 1998. Therefore, the herbaceous layer is increasing on this part, and it seems to be very useful also for the *Hammarbya* and for the peatmosses. The water replenishment has been satisfactorily assured.

Navat-patak

It is an approximately 500 m long and (on average) 80 m wide, expanded, paludificated watercourse. SIMON (1960) described it as a place where the dominance and frequence of *Drosera rotundifolia* and *Sphagnum magellanicum* was the highest, the cover of the canopy layer of the central part was the lowest outside the mires. *Vaccinium oxycoccos* and *Eriophorum vaginatum* had a high dominance as well. *Sphagnum palustre* and *Sphagnum recurvum s.l.* were also present. The dominant peatmoss was *Sphagnum recurvum s.l.,* followed by *Sphagnum palustre* and *Sphagnum magellanicum* with the approximately same cover in the *Eriophoro vaginati-Sphagnetum* association. After the fire damages only some *Sphagnum recurvum* s.l. (FINTHA 1994) could survive on tussocks and on scraws under the leaves of *Thelypteris palustris* in 20 m^2. According to TÓTH (1997) *Sphagnum palustre* has been decreasing in the willow bog. After the artificial water replenishment (1994) all peatmoss species have disappeared.

NAGY (2000a) made the first detailed vegetation map of the mire. He indicated 16 different plant communities on it in 1999, and had first explored and described the formation of „cape-mire" as a special type of scraws (NAGY 1999b, 2000a,b).

There are mostly *Salix cinerea, Typha latifolia* and *Glyceria maxima* dominated scraws in the centre of the mire with small pieces of alder bog remnants. There are *Lemnetea* associations (with some *Stratiotes aloides*) in the open water.

Zsid-tó

This is an approximately 1.3 km long and (on average) 70 m wide oxbow-lake. SIMON (1960) has investigated the mire first, and collected data from *Dryopteridi-Alnetum thelypteridetosum* (6 quadrats) and from *Caricetum elatae comaretosum, Scirpo-Phragmitetum glycerietosum urticetosum, Agrostetum albae hungaricum caricetosum vulpinae* (1-1 quadrat). He did not describe *Sphagnums* from here. Further valuable species noted by him are *Thelypteris palustris, Comarum palustre, Dryopteris chartusiana, Carex pseudocyperus, Calamagrostis canescens, Salix pentandra, Carex lasiocarpa, Peucedanum palustre* and *Cicuta virosa.* FINTHA (1994) published that *Sphagnum recurvum* s.l. was abundant in the south end of the mire and *Sphagnum teres* was abundant but scattered on the mire in 1990. He mentioned the above ferns and *Athyrium filix-femina* and supposed the presence of *Dryopteris cristata* (confirmation nedeed). TÓTH (1997) published „different types of peatmosses". After the water replenishment NAGY (2000a) could not find peatmosses. He made the first vegetation map of the area, and indicated 22 different plant associations on it. The population of *Salix pentandra* and *Comarum palustre* here builds up best out of the mires. The greatest merits of the mire are the floating isles of scenic *Cicuto virosae-Caricetum pseudocyperi* associations.

Bence-tó

This is an approximately 1.4 km long and (on average) 70 m wide oxbow lake. Earlier it had more open water surfaces with *Lemnetea* associations and scraws with three different *Sphagnum species* and ferns like *Thelypteris palustris* and *Dryopteris chartusiana.* The peatmosses were identified as *Sphagnum magellanicum* (abundant)*, Sphagnum recurvum s.l.* (frequent) and *Sphagnum squarrosum* (abundant) in the year of exploration, 1990 (FINTHA 1994). NAGY (1996b) published the presence of *Sphagnum fallax* erroneously. Those specimens, in fact, belong to *Sphagnum fimbriatum.* His records of *Sphagnum squar-*

rosum, recorded from before 1997 (the year after all peatmosses disappeared from the mire), however, are indeed correct. One data of *Sphagnum recurvum s.l.* by FINTHA (1994) seems also an error – it should be *Sphagnum fimbriatum.* If *Sphagnum magellanicum* was really there, then Bence-tó could had once *Oxycocco-Shagnetum* association. If it was not correct data, it could be *Sphagnum palustre*, which could be a remnant of a larger mire surface or just established itself on the scraw substrate. We have never seen it here.

NAGY et al. (1998b) reported on the ratio and process of decay of different peatmoss cushions between 1994 and 1996. NAGY et al. (1998a) reported about the change and status of the flora and vegetation between 1990 and 1995 and prepared the vegetation map. An artesian well was built in 1999, but then never been in use, because the mire received natural water replenishment in the extreme wet 1998 year. Since then the water level is more or less constant. The scraws are developing (NAGY 2000a). The detailed floristical and coenological data, and the vegetation maps will be available in the Ph.D. dissertation of J. NAGY (2002).

12. Nyírség

Nyírség is the second greatest shifting sandy area situated in the north-eastern part of present-day Hungary. The features of the terrain are determined by sand-formations, and very important role is played by the northern, north-eastern, southern and south-western winds. The average temperatures of the winter (-3 °C) and summer (20-21 °C) are lower than the in other parts of Great Hungarian Plain. The annual precipitation is about 550 mm, and the highest value is in July. In this region the importance of the microclimatic differences in small areas is also relevant (e.g. top and foot of sand-hills). The main water resources are drainage ditches, these were once made to drain the marshes.

Bátorliget: Bátorliget Nature Reserve

This area is situated near Nyírbátor village. In 1914 J. Tuzson discovered this area, and he recognised its subartic flora of outstanding value (MAHUNKA 1991). Later numerous scientists made floristical, coenological, faunistical, hydrological, and palaeoecological studies; soil science had also played role here. The results were published in many articles, and two general works were prepared too (SZÉKESSY 1953, MAHUNKA 1991).

After J. Tuzson new floristical studies were made by G. Lengyel and Degen (LENGYEL 1914), RAPAICS (1924), later by BOROS (1933) and SOÓ (1933, 1934). In the 1920's E. Dudich made the first faunistical studies (DUDICH 1926). ASZÓDI (1936), and SOÓ (1938b) made phytocoenological investigations. B. Zólyomi prepared the actual vegetation map of this area in 1934 and made another one as the reconstruction based on the 1909 cadastral maps (SOÓ 1953). Comparing these maps the main changes can be well observed; the valuable stands have become smaller, mires, marshes, fens got drained, the flooded-forests and oak forests were cut. In addition, rare plants have disappeared or became less frequent (SOÓ 1935). In the 1930's an overall faunistical study was initiated (SZÉKESSY 1953). The area became protected in 1938 (Bátorliget Nature Reserve), but since the flora became more and more poor. In 1979-80 T. Simon prepared a new vegetation map, which is still unpublished. At the end of the 1980's new overall (botanical and zoological) investigations begun. The zoological exploration resulted more than 5000 taxa with new species for Hungary and for the science too (MAHUNKA 1991). Also, floristical and coenological investigations were conducted (STANDOVÁR and TÓTH 1989, STANDOVÁR et al. 1991). Comparison of the results with

earlier ones have not shown drastical differences at the floristic level, but some signs of drying and degradation have been detected. They pointed out that the most valuable area is threatened, not only by overall decrease of the ground water level, but also by the regular alternation of flooded and drained periods. They emphasised that the effective water regulation and active control of succession are necessary to save this mire.

Palaeoecological investigations were also made here. The first palynological study was made by G. CSINÁDY (1953, 1954), later in the 1990's, K.J. Willis and colleagues made new palaeoecological studies (WILLIS et al. 1995, SÜMEGI 1996). They assumed that the origins of the mire go back 18-23 000 years and its development has begun in the deepest parts of sand dunes. First it was 'topogen' and 'soligen' lake, which became a 2 m-deep oligotrophic lake 13-14000 years ago. Later the water table decreased and the lake started to eutrophise and became a marsh. In the 10-11th century part of the basin was dredged for lake and it was cultivated until the 16th century. The basin filled slowly and built up the mire. Standovár with his colleagues (1991) found one small peatmoss patch (*Sphagnum recurvum* s.l.) which has disappeared in the past decade. The authors could not find it in 2000.

Piricse: Júlia-major

This mire is situated not far from the above-described Bátorliget Nature Reserve, G. Jakab and B. Lesku discovered in 1955.

The floristical and coenlogocal studies were made by Jakab and Lesku in 1990's (JAKAB and LESKU 1995). They found numerous rare plants including bryophytes (e.g. JAKAB and LESKU 1995, 1996, JAKAB 1997b) and described a number of communities from this area. The most important among these is a *Salici pentadrae-Betuletum pubescentis* stand. They prepared a vegetation map too. Sümegi with colleagues made test borings, and they emphasised that the development and age of mire is similar to those of Bátorliget (JAKAB and LESKU 1995).

There are few patches of two peatmoss species (*S. fimbriatum* and *S. squarrosum*) in this mire in the *Salici pentadrae-Betuletum pubescentis* stand (JAKAB and LESKU 1995).

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