Roczniki Akademii Rolniczej w Poznaniu CCCLXXXVIII

Botanika – Steciana

13, 2009, 29-36

www.up.poznan.pl/steciana

ISSN 1896-1908

RARE AND THREATENED PLANTS OF THE MIRES IN THE INTENSIVELY MANAGED LANDSCAPE OF THE GÓRY SUDAWSKIE REGION (NORTH-EASTERN POLAND)

Paweł Pawlikowski, Filip Jarzombkowski, Dan Wołkowycki, Łukasz Kozub, Piotr Zaniewski, Olga Bakanowska, Łukasz Banasiak, Katarzyna Barańska, Anna Bielska, Urszula Biereżnoj, Magdalena Galus, Marlena Grzybowska, Adam Kapler, Justyna Karpowicz, Iwona Sadowska, Rafał Zarzecki

P. Pawlikowski, Department of Plant Ecology and Environmental Conservation, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warsaw, Poland, e-mail: p.pawlikowski@uw.edu.pl
F. Jarzombkowski, Department of Nature Protection and Rural Landscape, Institute of Technology and Life Sciences, Falenty, al. Hrabska 3, 05-090 Raszyn, Poland, e-mail: fjarzomb@gmail.com
D. Wołkowycki, Department of Environmental Conservation and Management, Białystok Technical University, Wiejska 45 A, 15-351 Białystok, Poland, e-mail: d.wolkowycki@pb.edu.pl
Ł. Kozub, Department of Plant Ecology and Environmental Conservation, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warsaw, Poland, e-mail: lukasz.kozub@biol.uw.edu.pl
P. Zaniewski, Department of Molecular Plant Physiology, University of Warsaw, Miecznikowa 1, 02-096 Warsaw, Poland, e-mail: piotrzaniewski@uw.edu.pl
O. Bakanowska, Student Scientific Circle of Inter-Faculty Study Programme in Environmental Protection, Żwirki i Wigury 93, 02-089 Warsaw, Poland, e-mail: olga.bakanowska@gmail.com
Ł. Banasiak, Department of Systematics and Plant Geography, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warsaw, Poland, e-mail: lukaszbanasiak@student.uw.edu.pl
K. Barańska, Naturalists' Club, 1 Maja 22, 66-200 Świebodzin, Poland, e-mail: kasia_baranska@interia.pl
A. Bielska, Student Scientific Circle of Environmental Conservation, Białystok Technical University, Wiejska 45 A, 15-351 Białystok, Poland
U. Biereżnoj, Naturalists' Club, 1 Maja 22, 66-200 Świebodzin, Poland, e-mail: donaroza@gmail.com
M. Galus, Student Scientific Circle of Inter-Faculty Study Programme in Environmental Protection, Żwirki i Wigury 93, 02-089 Warsaw, Poland, e-mail: mggalus@wp.pl
M. Grzybowska, Student Scientific Circle of Environmental Conservation, Białystok Technical University, Wiejska 45 A, 15-351 Białystok, Poland
A. Kapler, Department of the Evaluation and Plant-Biodiversity Conservation, Botanical Garden – Center for Biological Diversity Conservation of the Polish Academy of Sciences, Prawdziwka 2, 02-973 Warsaw, Poland, e-mail: adam.kapler@obpan.pl
J. Karpowicz, Student Scientific Circle of Environmental Conservation, Białystok Technical University, Wiejska 45 A, 15-351 Białystok, Poland
I. Sadowska, Student Scientific Circle of Environmental Conservation, Białystok Technical University, Wiejska 45 A, 15-351 Białystok, Poland
R. Zarzecki, Student Scientific Circle of Environmental Conservation, Białystok Technical University, Wiejska 45 A, 15-351 Białystok, Poland

(Received: March 30, 2009. Accepted: September 28, 2009)

ABSTRACT. During the field survey of small, predominantly *Sphagnum*-dominated mires, occupying depressions in the intensively managed landscape of the Góry Sudawskie region (NE Poland, Lithuanian Lake District), the localities of 29 rare and threatened plant species were recorded. The most valuable of them were: *Baeothryon alpinum*, *Carex chordorrhiza*, *C. pauciflora*, *Cinclidium stygium*, *Dactylorhiza baltica*, *D. ruthei*, *Eriophorum gracile*, *Hammarbya paludosa*, *Lycopodiella inundata*, *Oxycoccus microcarpus*, *Pseudocalliergon trifarium* and *Salix lapponum*. Several red-listed species (like *Carex chordorrhiza*, *C. limosa*, *Drosera rotundifolia*, *Epipactis palustris*, *Scheuchzeria palustris* and *Utricularia minor*) were quite common and should not be considered threatened in the studied area. A striking feature was an abundant presence of species that are considered calciphilous (like *E. palustris*, *Carex dioica* and *Dactylorhiza* spp.). Species-rich flora of the mires is threatened first of all due to non-forest vegetation being overgrown with shrubs. It needs conservation measures (removal of shrubs). The presence of such species-rich ecosystems in highly transformed landscape is hard to explain and puts a new light on the importance of key habitats protection even in typical agricultural areas. Mechanisms protecting the mire ecosystems from external disturbances (e.g. eutrophication) are very important in this case and need detailed studies. The unique natural values of the studied area have remained undiscovered until now and are revealed for the first time.

KEY WORDS: red list species, threatened species, mire plants, distribution, eutrophication

INTRODUCTION

During recent decades, the intensification of land use (including fertilization and drainage) has increasingly threatened the remnants of natural and semi-natural ecosystems in agricultural landscapes (Agger and Brandt 1988, Boers 1996, Waldhardt et al. 2003). The leaching of fertilizers (including phosphorus, nitrogen and potassium) from agricultural fields into groundwater results in the shift in vegetation of groundwater-fed mires. This includes the replacement of species-rich, low-productive vegetation with highly productive, rare species-poor patches (Olde Venterink et al. 2002), especially when eutrophication is accompanied by hydrological disturbances (Endler and Dziedzic 1991, Bollens et al. 2001, Kołos 2004, Wilhelm 2004). In Poland, dozens of wetland species are decreasing and consequently included in the Polish red data book (Polska czerwona księga... 2001).

The Góry Sudawskie (the Sudawskie Mountains), which are situated in the north-easternmost Poland near the Lithuanian border, is an agricultural, intensively managed area. An abundance of small peatlands due to a landscape that is geomorphologically very diverse is a typical characteristic of the north-easternmost part of Poland (Żurek 1987). Peatlands in the studied area are scattered among arable fields and pastures. Agricultural management of the area includes fertilization, drainage by drains and ditches, as well as pasture grass sawing. Thus, the Góry Sudawskie region gives an excellent opportunity to observe the impact of intensive land management on the flora of mires.

The plant cover of the Góry Sudawskie region is very poorly recognised although the first information on the flora of the area was published as early as in XIX century (Rostafiński 1872). Some data on the flora and vegetation of several sites are found in the papers of Kawecka (1991) and Kawecka and Karczmarz (1993).

The aim of the study is to determine the role of the mires in the intensively managed landscape of the Góry Sudawskie region for conservation and maintenance of rare and threatened species of vascular plants and bryophytes.

MATERIAL AND METHODS

Description of the study area

According to the division of the territory of Poland into physico-geographical regions by Kondracki (2002), the Góry Sudawskie area is defined as Wiżajny Elevation microregion, where numerous glacial landforms (especially kames) are aggregated. The adjacent areas located south of the Góry Sudawskie microregion are defined as Jeleniewo Hills microregion. Both microregions are included into East Suwałki Lakeland, a mesoregion within the Lithuanian Lake District.

The Góry Sudawskie area has been largely deforested and agriculturally managed, apart from the mires, many of which escaped severe human impact. Small, scattered patches of mire vegetation are surrounded by arable fields and artificial pastures, and constitute 'habitat islands'. However, it should be noted that the majority of them used to be extensively managed in the past. Traditional, handheld peat extraction had the most important impact on the plant cover. The mires used to be irregularly affected by mowing, grazing and cranberry-picking. The last activity still takes place at some sites, as well as occasional grazing of mire margins by cows. Some of the peatlands are (or were in the past) affected by direct or non-direct draining. Apart from anthropogenic impacts, beaver activity is an important natural factor influencing mire ecosystems. On the one hand, beavers inhibit the development of trees and willow shrubs, but on the other hand, they dig canals or dam outflows which results in hydrological changes and alteration of vegetation.

Surrounded by agricultural land, the mires of the Góry Sudawskie region range in size from ca. 0.5 to a dozen of hectares. They have diverse stratigraphy and thickness of organic deposits. The majority of them developed in the place of former lakes overgrown with peat-forming vegetation. Thus, in peat profiles lake gyttjas (usually: detritus-rich) are common. At several sites, the remnants of natural or man-made reservoirs (small lakes or peat cuttings with an open water) still persist. Topogenous character and usually very limited catchment area are the common features of these peatlands. Many of them are hydrologically disturbed and overgrown entirely with forest or shrub vegetation. In some places, non-forest mire vegetation persists, which includes first of all *Sphagnum*-dominated communities. Poor fens predominate, but *Sphagnum teres*-dominated moderately rich fens are present as well. Extremely rich fens and ombrotrophic bogs are very rare in the studied area. Other vegetation types include forest, shrub, rush, tall-sedge and aquatic phytocoenoses. In the marginal zone of almost all the peatlands, a willow and birch-covered belt is developed (Pawlikowski and Jarzombkowski, unpublished data).

Field survey

Floristic data from the peatlands of the Góry Sudawskie area and neighbouring regions to the south-east were collected during the student scientific camp of the Student Scientific Circle of Geobotany, the Student Scientific Circle of Inter-Faculty Study Programme in Environmental Protection (both at the University of Warsaw) and the Student Scientific Circle of Environmental Conservation (the Białystok Technical University). The field survey took place in July 2008. Additionally, unpublished data of Paweł Pawlikowski and Filip Jarzombkowski from the years 2004-2008 were used.

The attention was paid only to species from the Polish "red book" (Polska czerwona księga... 2001) and "red lists" (Żarnowiec et al. 2004, Zarzycki and Szeląg 2006). The collected specimens of selected plant species were deposited in the herbarium of the Department of Systematics and Plant Geography of the University of Warsaw, herbarium of the Department of Environmental Conservation and Management of Białystok Technical University (vascular plants) and Bryological Herbarium of the W. Szafer Botanical Institute of the Polish Academy of Sciences (bryophytes).

Since selected peatlands of the studied area were a subject of a floristic survey in the years 1979-1987

(Kawecka 1991, Kawecka and Karczmarz 1993), it was also possible to determine the changes in the flora during the last 25 years.

Nomenclature used

The poor-rich gradient typology was applied to the mire vegetation types (e.g. Sjörs 1952, Vitt 2000). Plant names of vascular plants and mosses follow, respectively, Mirek et al. (2002), and Ochyra et al. (2003).

RESULTS

List of localities

Every locality described below was assigned to an appropriate ATPOL grid square (Zając and Zając 2001). Apart from the 10 km x 10 km squares, smaller 5 km × 5 km quarters (one-fourth of the big square) were applied. For example, letter "A" denotes north-west quarter, letter "B" denotes north-east quarter and so on. ATPOL grid square codes are given in **bold**. Numbers in brackets refer to site numbers on the map (Fig. 1).

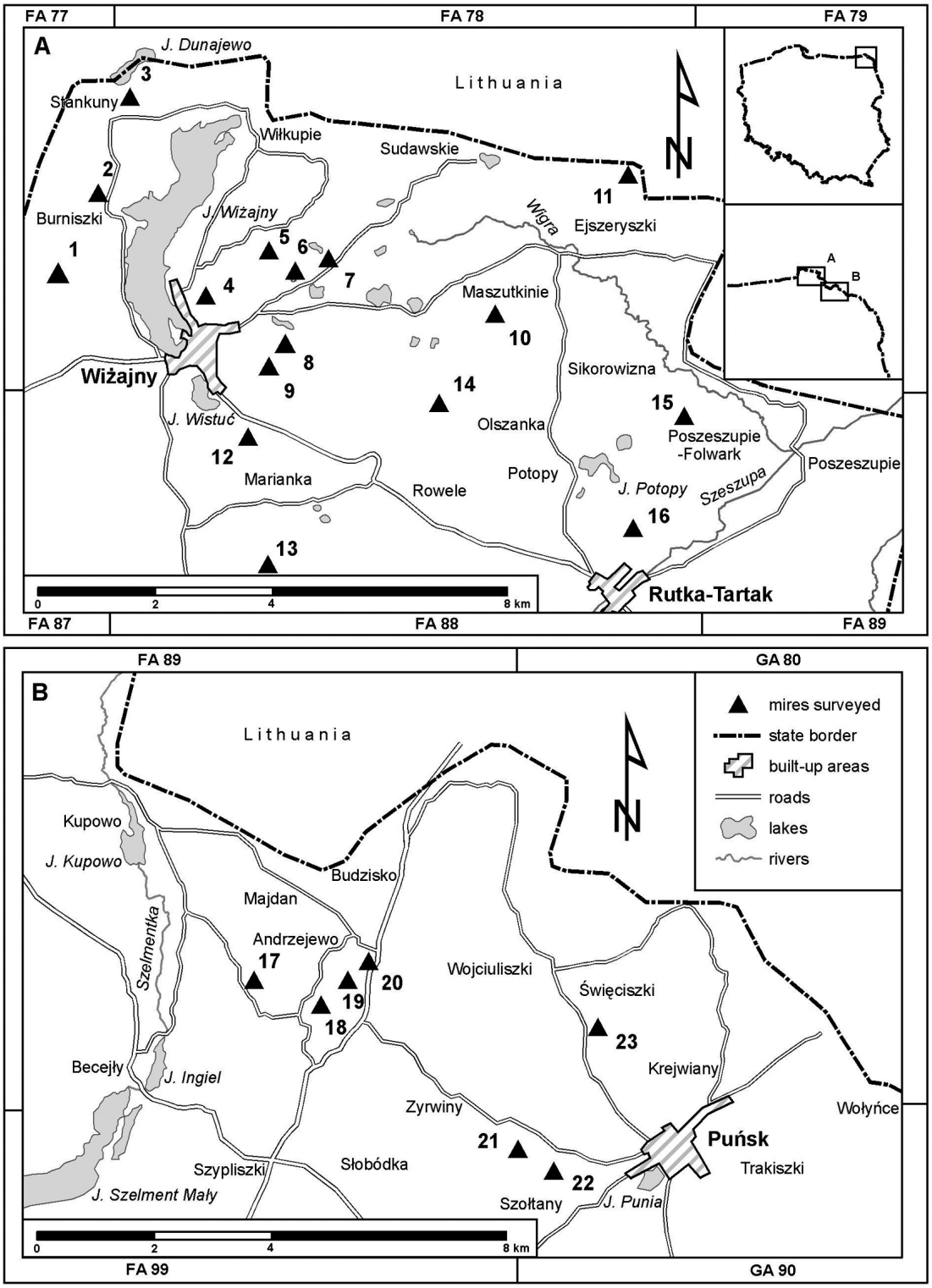

Fig. 1. Distribution of the surveyed mires in the Góry Sudawskie region and adjacent areas

[1] **FA77D**. Predominantly wooded peatland adjacent to the village of Grzybina; area of ca. 3 ha. Non-forest mire vegetation (including various patches from extremely poor fen to moderately rich fen) is restricted to small clearings. Numerous peat cuttings of various age are present.

[2] **FA77D**. Moderately drained peatland near the village of Burniszki, predominantly wooded, partially converted into meadows; area of ca. 7 ha. Remnants of non-forest vegetation (poor fen, as well as rich fen) cover very limited areas of clearings and former peat cuttings.

[3] **FA78C**. Peatland near the village of Stankuny; area of ca. 2.5 ha. Covered by well-preserved *Sphagnum*-dominated mire (from extremely poor fen to moderately rich fen) and woodland, as well as small patches of the rush vegetation.

[4] **FA78C**. Intensively drained and predominantly wooded peatland with numerous old peat cuttings, adjacent to the cemetery in the town of Wiżajny; area of nearly 15 ha. In the eastern part small non-forest ombrotrophic bog still exists.

[5] **FA78C**. Peatland bordering a small lake near the settlement of Kolonia Wiżajny; area of ca. 2.5 ha. Covered by very well-preserved *Sphagnum*-dominated mire (from extremely poor fen to moderately rich fen, including bog-like vegetation) and willow-shrubland.

[6] **FA78C**. Predominantly shrub-covered peatland bordering the northern part of Kuprelek Lake; area of nearly 1 ha. Small patches of brown moss- and *Sphagnum*-dominated rich fen are present.

[7] **FA78C**. Treeless peatland bordering the south-eastern part of Prudel Lake near the village of Podsudawskie; area of ca. 1 ha. Covered by well-preserved *Sphagnum*-dominated moderately rich fen.

[8] **FA78C**. Peatland near the town of Wiżajny, south of Staneluszki Lake; area of ca. 1 ha. Covered by willow shrubland and poor fen vegetation.

[9] **FA78C**. Predominantly shrubland-covered peatland between the town of Wiżajny and the village of Kamionka; area of ca. 3 ha. In the central part extremely poor fen develops in a former peat cuttings.

[10] **FA78D**. Treeless peatland bordering a small lake near the villages of Makowszczyzna and Maszutkinie; area of ca. 1 ha. Dominated by open poor fen (including bog-like) vegetation. On the shore of the lake and in small pools within poor fen area, brown moss-dominated patches of rich fen vegetation are present.

[11] **FA78D**. Peatland "Plinia" adjacent to the village of Ejszeryszki, next to the state border; area of ca. 2.5 ha. Covered by woodland and well-preserved *Sphagnum*-dominated mire (from extremely poor fen to moderately rich fen). Next to small pools small patches of brown moss-dominated rich fen exist.

[12] **FA88A**. Treeless peatland south-east of Wistuć Lake, near the settlement of Kolonia Wiżajny; area of ca. 0.5 ha. Covered entirely by poor fen vegetation.

[13] **FA88A**. Peatland near the villages of Marianka and Rogożajny Wielkie; area of ca. 6 ha. Covered by woodland as well as well-preserved *Sphagnum*-dominated poor fen (including bog-like vegetation) that develops mainly in former peat cuttings.

[14] **FA88B**. Sparsely wooded peatland bordering a small lake between the villages of Rowele and Makowszczyzna, next to the small forest complex; area of ca. 4 ha. Covered by well-preserved *Sphagnum*-dominated moderately poor fen and moderately rich fen.

[15] **FA88B**. Predominantly wooded peatland bordering a small lake near the village of Wingrany west of Łopuszek Lake; area of nearly 8 ha. The area situated next to the lake is covered by brown moss-dominated rich fen and rush vegetation. It is intensively flooded due to beavers activity.

[16] **FA88B**. Predominantly wooded peatland bordering the northern part of the Samanin Lake; area of nearly 5 ha. Near the lake shore small patches of brown moss- and *Sphagnum*-dominated rich fen exist.

[17] **FA89D**. Peatland adjacent to the village of Kociołki; area of ca. 5 ha. Covered by woodland and a very well-preserved non-forested mire with diverse *Sphagnum*- and (locally) brown moss-dominated vegetation (from extremely poor fen to extremely rich fen).

[18] **FA89D**. Predominantly wooded peatland between the villages of Andrzejewo and Jeziorki; area of ca. 0.5 ha. In the central part a small clearing with bog-like vegetation still persists.

[19] **FA89D**. Predominantly wooded and moderately drained peatland between the villages of Andrzejewo and Szymanowizna; area of ca. 5 ha. Non-forest mire vegetation (from extremely poor fen to moderately rich fen) is restricted to small clearings.

[20] **FA89D**. Shrub-covered and moderately drained peatland between the villages of Andrzejewo and Sadzawki; area of ca. 1.5 ha. Non-forest fen vegetation covers very small clearings only. Numerous peat cuttings are present.

[21] **GA90A**. Predominantly wooded peatland adjacent to the village of Węgielnia; area of ca. 6 ha. Non-forest mire vegetation (poor fen) develops in former peat cuttings.

[22] **GA90A**. Almost treeless peatland west of the town of Puńsk; area of ca. 0.5 ha. Covered by a very well-preserved poor fen vegetation.

[23] **GA80C**. Peatland adjacent to the settlement of Święciszki; area of ca. 5 ha. Covered by woodland and non-forest poor fen (including bog-like vegetation). Numerous peat cuttings of various age are present.

List of the species

Species are grouped into taxonomic units and listed in alphabetic order. Additional information given next to the species names includes:

- category from "red book" (Polska czerwona księga... 2001): CR – critically endangered species, EN – endangered species, VU – vulnerable species, LR – lower risk species;
- category from "red list" (Żarnowiec et al. 2004, Zarzycki and Szeląg 2006): E – species on verge of extinction, V – threatened species, [V] – threatened species at isolated stands far from the main occurrence area.

Localities of species recorded earlier by Kawecka (1991) or Kawecka and Karczmarz (1993) are indicated with an asterisk ("*").

Mosses

Cinclidium stygium – E. Brown moss-dominated rich fen: [17], moderately numerous (*leg.* 2008).

Helodium blandowii – E. Fens: [2], scarce in willow-birch shrubland in moderately drained fen (*leg.* 2004); [3], rather abundant in *Sphagnum*-dominated moderately poor and moderately rich fen, also in patches with *Salix repens* ssp. *rosmarinifolia* (*leg.* 2008); [15], moderately abundant in brown moss-dominated rich fen (*leg.* 2008); [16], moderately abundant in brown moss-dominated rich fen and in *Thelypteris palustris*-dominated vegetation.

Pseudobryum cinclidioides – E. Willow-birch thickets in moderately drained fen, also in former peat cuttings: [2], moderately abundant (*leg.* 2004).

Pseudocalliergon trifarium – E. Very wet rich fen, among *Scorpidium scorpioides* and *Limprichtia cossonii*: [15], rather scarce (*leg.* 2008).

Scorpidium scorpioides – E. Very wet fens: [10], scarce in small pools among poor fen vegetation (*leg.* 2004); [11], scarce in small pools (*leg.* 2008); [14], moderately abundant on the lake shore (*leg.* 2004); [15], very abundant in brown moss-dominated rich fen (*leg.* 2008).

Sphagnum fuscum – V. Usually in poor fens, abundant: [1], (*leg.* 2008); [3], scarce; [4], bog; [5], very abundant (*leg.* 2008); [10], (*leg.* 2008); [11], (*leg.* 2008); [13]; [17].

Tomentypnum nitens – V. Brown moss- and *Sphagnum teres*-dominated moderately rich fens: [2]*, scarce (*leg.* 2004); [17], rather abundant (*leg.* 2008).

Vascular plants

Baeothryon alpinum – EN, V. Usually rather abundant in moss-dominated non-forest mire vegetation, most frequent among calcitolerant *Sphagnum* species (like *Sphagnum teres*, *Sph. contortum* and *Sph. subsecundum*), less often among brown mosses. (e.g. *Campylium stellatum*): [1], (*leg.* 2008); [3], (*leg.* 2008); [5], (*leg.* 2008); [7]; [11], (*leg.* 2008); [17], (*leg.* 2008); [19]*, scarce (*leg.* 2004, 2008).

Carex chordorrhiza – VU, V. Usually abundant in moss-dominated non-forest mire vegetation among *Sphagnum* species (*Sphagnum teres* and *Sph. fallax* s.l.), rarely among brown mosses: [3], very abundant (*leg.* 2008); [5], (*leg.* 2008); [7], (*leg.* 2008); [8], very abundant (*leg.* 2008); [12], (*leg.* 2008); [13], scarce; [14], (*leg.* 2008); [15], (*leg.* 2008); [17]; [19]*, scarce (*leg.* 2008); [22].

C. dioica – VU. Usually abundant in moss-dominated non-forest mire vegetation, among *Sphagnum*, as well as brown moss species: [1], (*leg.* 2008); [3]; [5], (*leg.* 2008); [7], (*leg.* 2008); [11]; [17].

C. limosa – LR, V. Usually abundant in moss-dominated non-forest vegetation, among *Sphagnum* as well as brown moss species: [1]; [3-5]; [7]*; [8]; [9]; [11]; [12]; [14]; [15]; [17]; [19]*; [22].

C. pauciflora – V. Non-forest poor fen (and bog-like) vegetation, usually among *Sphagnum fallax* and *Sph. fuscum*: [1], several dozens of clumps (*leg.* 2008); [5], ca. a dozen of clumps (*leg.* 2008).

Dactylorhiza baltica – V. *Sphagnum*-dominated moderately-rich fens as well as *Salix repens* ssp. *rosmarinifolia* low shrublands; rarely in poor fens and brown moss-dominated rich fens: [1] a dozen of individuals; [2], ca. 10 individuals [3], more than 100 individuals, [4], single individual by a ditch next to the peatland margin; this site was recorded earlier by Bernacki (1990); [5], several dozens of individuals; [11], several dozens of individuals.

D. ruthei – EN. *Sphagnum*-dominated moderately rich fens as well as *Salix repens* ssp. *rosmarinifolia* low shrublands; rarely in poor fens: [3], several individuals; [5], ca. 100 individuals.

Drosera rotundifolia – V. Usually abundant in *Sphagnum*-dominated non-forest mires, rarely in shrublands and brown moss rich fens: [1]; [2]*; [3-14]; [16-18]; [19]*; [20]*; [21]; [22]; [23]*.

Dryopteris cristata – V. Scarce in willow-birch shrubs and forests at the mire edges, less often among poor fen vegetation: [2]; [4]; [9], (*leg.* 2008); [12].

Empetrum nigrum – [V]. Usually in poor fens and among bog (or bog-like) vegetation: [1]; [2]*; [4]; [5], very abundant; [8]; [9]; [17].

Epipactis palustris – V. Usually moderately abundant in moss-dominated, non-forest mire vegetation, most often along with very low *Salix repens* ssp. *rosmarinifolia* and next to the willow-birch shrublands at mire margins: [1-3]; [5]; [7]; [11]; [15]; [17].

Eriophorum gracile – CR. Brown moss-dominated rich fen: [15]: scarce (*leg.* 2008).

Hammarbya paludosa – EN, E. *Sphagnum*-dominated, non-forest moderately poor and moderately rich fens, among *Sphagnum teres*, *Sph. fallax* and *Sph. warnstorfii*: [1], ca. 30 individuals; [5], several individuals.

Huperzia selago – [V]. Birch-alder forest in drained peatland: [2], moderately abundant.

Lycopodiella inundata – V. *Sphagnum*-dominated poor fen: [13], about 200 stems within an area of 10 m^2.

Oxycoccus microcarpus – V. Poor fen and bog-like non-forest vegetation, usually in *Sphagnum fuscum* hummocks, more rarely on *Sph. magellanicum* and other species: [5], abundant (*leg.* 2008); [11], moderately abundant.

Pedicularis palustris – V. Scarce in moss-dominated, non-forest mires: [10]; [13], poor fen; [14], moderately poor fen; [15], brown moss-dominated rich fen.

Ranunculus lingua – V. Rather abundant in brown moss-dominated rich fen, rush and tall sedge vegetation: [6]; [15]; [16].

Salix lapponum – EN, V. *Sphagnum*-dominated fens (moderately poor and moderately rich) especially near the mire margins: [5], several hundreds of shoots; [7], several dozens of shoots.

Scheuchzeria palustris – E. Usually abundant in poor fens: [1]; [3]; [5]; [11-14]; [17]; [19]*.

Utricularia intermedia – V. Usually abundant in very wet depressions and small pools in moss-dominated non-forest mires: [6]; [7]; [11]; [14], very abundant; [15], abundant; [16], quite abundant.

U. minor – V. Scarce in very wet depressions in moss-dominated mires and adjacent lakes and pools: [1]; [3]; [5]; [7]; [10]; [11]; [13]; [15], abundant; [16]; [17]; [22].

Apart from the plants listed above, some other rare species were recorded at field-surrounded mires in the Góry Sudawskie region. These included: *Dactylorhiza incarnata* (sites [1-3], [5], [8], [10], [11], [14], [15], [17]), *Juncus filiformis* ([12], [13]), *Parnassia palustris* ([1], [2]*, [5], [17]), *Phegopteris connectilis* ([2]), *Platanthera bifolia*

([17]), *Rhynchospora alba* ([1], [11], [13], [17]), *Sanguisorba officinalis* ([7]*) and *Sparganium minimum* ([1], [5], [7], [10], [11], [13], [15-17], [22].

Remarks on results of the floristic survey

As a result of the field survey, 23 peatlands with localities of rare and threatened species were encountered. Among them, 16 sites belonged to the Góry Sudawskie region and seven sites were from the area located southeast of the above-mentioned area.

The localities of 29 plant species considered rare and threatened were recorded. Among them were 22 vascular plants and seven mosses. Some species considered to be endangered – *Drosera rotundifolia*, *Utricularia minor*, *Carex limosa*, *C. chordorrhiza* and *Scheuchzeria palustris* – were quite common in the studied area and were recorded in more than 1/3 of all the surveyed mires. Twelve species were found to occur in one or two localities only. The flora of six mires was strikingly rich in species of special concern. These included:

- [5] – a mire near the settlement of Kolonia Wiżajny (16 rare or endangered species);
- [1], [3], [11], [17] – mires near the villages of Grzybina, Stankuny, Ejszeryszki and Kociołki (12)
- [15] – a mire near the village of Wingrany (11).

Changes in the flora during last 25 years

After 25 years the flora of six previously investigated mires ([2], [6], [7], [19], [20], [23]) has changed only slightly, except for a single peatland where almost all the rare species were extinct (site [20]). Furthermore, the localities of new species were recorded presently. Among the species previously recorded but not confirmed nowadays are: *Baeothryon alpinum* (peatland [2]), *Viola epipsila* ([2]; only the hybrids with *V. palustris* were found), *Carex dioica* ([6]), *Tomentypnum nitens* ([7]), *Sparganium minimum* ([19]), *Utricularia intermedia* ([19] and [20]), *Carex chordorrhiza* ([20]), *Pedicularis palustris* ([20]) and *Eriophorum gracile* ([23]).

DISCUSSION

The flora of threatened species and species considered threatened

The number of rare species in the small mires of the Góry Sudawskie region is outstanding. Among the species recorded, five vascular plants are given very high IUCN categories according to the Polish red data book (Polska czerwona księga... 2001). These are endangered species (EN category: *Baeothryon alpinum*, *Dactylorhiza ruthei*, *Hammarbya paludosa*, *Salix lapponum*) and critically endangered species (CR category: *Eriophorum gracile*). The other most valuable vascular plant species are: *Carex pauciflora*, *C. chordorrhiza*, *Dactylorhiza baltica*, *Oxycoccus microcarpus*, *Lycopodiella inundata*, *Pseudocalliergon trifarium* and *Cinclidium stygium*. Up to now, several of them have been recorded in the Polish part of the Lithuanian Lake District macroregion in a few localities only (*C. pauciflora*, *E. gracile*, *S. lapponum* and *D. ruthei*), while *L. inundata* is a species new to that region. Moreover, *C. pauciflora* has not been previously recorded in the Podlasie Province (Zając and Zając 2001).

Several red-listed species (*Baeothryon alpinum*, *Carex chordorrhiza*, *C. limosa*, *Drosera rotundifolia*, *Empetrum nigrum*, *Epipactis palustris*, *Scheuchzeria palustris*, *Sphagnum fuscum* and *Utricularia minor* (Żarnowiec et al. 2004, Zarzycki and Szeląg 2006) were recorded in quite numerous localities. They do not seem to be threatened in the Góry Sudawskie region. Most of them are known to occur at numerous sites in other parts of the Lithuanian Lake District as well (see e.g. Sokołowski 1973, 1990, Kawecka 1991, Pawlikowski 2008 a, b). Their high conservation status in Poland seems to be inadequate when considering the situation in the north-easternmost part of Poland. This is particularly true of *C. limosa*, *D. rotundifolia*, *E. palustris*, *S. palustris* and *U. minor*. By contrast, *Ranunculus lingua*, a species common and beyond any doubt not threatened in the whole north-eastern Poland (especially in more fertile wetland habitats – e.g. Sokołowski 1973, 1990, Pawlikowski 2008 b), is hardly present in the studied mires.

Why do calciphilous species occur in Sphagnum-mires?

A striking feature of the flora of the studied *Sphagnum*-dominated mires is the abundant presence of vascular plant species that are considered calciphilous, such as *Epipactis palustris*, *Carex dioica* and *Dactylorhiza* spp.). The existence of species typical of calcium-rich habitats can be explained first of all by the water feeding system. Most of the described mires are of topogenous type, thus the quaternary sediments (mainly gyttja but also clay sediments), rich in lime and often located under the peat, can be in hydrological contact with surface waters used by plants. In contrast to bryophytes (which form a layer in close contact with the peat surface), vascular plants receive water through roots from the deeper peat layers. Therefore they demonstrate different responses to hydrochemical conditions in mires (see Hájková and Hájek 2004). Due to evaporation and capillary rise of water (Brehm 1971), in mires of the Góry Sudawskie region calciphilous plants can be fed by at least slightly alkaline waters, and, therefore, they can coexist with typical poor fen species on the mire surface.

Why do the threatened species persist?

Herbichowa and Jąkalska (1985) indicated that mires in forested areas of the Kaszuby Lakeland were richer in rare plant species than similar mires in an agricultural landscape. They claimed that it was due to the buffering function of the forests, protecting mires from nutrient inflow (mainly nitrogen) from agricultural land. Haraguchi et al. (2000) showed that farms could affect mires directly. They indicated three ways in which the nutrients are supplied to the mire: through drainage ditches, surface runoff and groundwater. Nutrient enrichment of agricultural areas due to wet and dry precipitation was also well described (Aerts et al. 1992, Galloway 1995, Bobbink et al. 1998).

Despite the fact that the landscape is intensively managed, in predominantly non-forested the Góry Sudawskie region the rich mire flora consisting of rare vascular plant and moss species is still present and the vegetation seems to be relatively natural. It is still unclear, why they persist. Moreover, the lack of intensive

dynamics in the flora of some of the investigated mires during the last 25 years suggests that the high species diversity in these mires is quite stable.

There are different possible explanations of the above observation. The drainage system does not exist or is not active, therefore pollution can reach the mires only through surface inflow or indirectly with groundwater. The described peatlands have a topogenous origin, where feeding with groundwater and precipitation is of minor importance (see Landschaftsökologische Moorkunde 2001). The catchments in the Góry Sudawskie region are not large (with maximum size of a few km^2) and a certain amount of fertilizers supplied with runoff is possibly trapped by shrubs forming thicket around persisting mires and in beaver pools fringing the mires as well. Another reason of the observed persistence of natural vegetation in the mires surveyed is connected with the lack of air-borne pollution. In north-eastern Poland atmospheric pollution is very low (Bok et al. 2007), thus it does not significantly affect ecosystems.

Moreover, the specific geomorphology, which includes numerous small basins and big altitude gradient has restricted intensive land use. It seems that the degree of intensification of land use and the landscape homogeneity in the described area are still lower than reported in Western and many parts of Central Europe (Agger and Brandt 1988, Boers 1996, Waldhardt et al. 2003).

Pieterse et al. (2005) showed that nutrient pollution of groundwater in agricultural land did not cause nutrient enrichment in the nearby wetland. Thus, the influence of land-use intensification on wetlands in agricultural landscapes does not seem to be unambiguous. The role of buffer zones around the mires (usually consisting of birch-alder-willow shrubland) can be of general importance in nutrients retention (see also Herbichowa and Herbich 2004), but the mechanism is unclear. From the diversity conservation point of view it is important to reveal whether polluted waters from the fields are in direct contact with mire surface waters (thus changing the nutrient status) or not. The described processes at the scale of the whole landscape and particular ecosystems demand further investigations.

Perspectives of retaining the flora of mires in Góry Sudawskie region

Mire ecosystems surrounded by agricultural land in the Góry Sudawskie region seem to remain in a relatively natural state. Biological diversity has persisted until today, but is it possible to preserve it for the future? We think the Lithuanian Lake District with intensive agriculture and private land ownership on one hand and high biodiversity concentrated in small biodiversity hot spots ("key habitats") on the other hand, can be a great case study area for implementation of nature conservation programmes dedicated to privately-owned land which often need some management. The implementation of Natura 2000 network should focus much more on local communities and their attitude towards nature conservation on their property. The removal of shrubs is among the most necessary conservation activities, as valuable non-forest vegetation is vanishing due to secondary succession.

Virolainen et al. (1998) stated that while the presence of single, more extensive mire ecosystem minimizes the probability of species extinction, the presence of several smaller patches of such vegetation maximizes overall species diversity. Järvinen (1982) showed that in order to maintain species richness no direct connection between patches is necessary. Thus, it would be advisable to follow Scandinavian examples of establishing a network of very small but species-rich and diverse protected sites on private land, which can be very beneficial in protection of biodiversity (plants, fungi, lichens, invertebrates and small birds) at a regional scale (Pykala 2007). The unique aggregation of rare and endangered species in the Góry Sudawskie region shows that this area is important for the conservation of mire plant species in Poland.

Acknowledgements

We would like to thank the local administration of the commune of Wiżajny for providing us with accommodation during the student scientific camp in Smolniki.

REFERENCES

Aerts R., Wallen B., Malmer N. (1992): Growth-limiting nutrients in *Sphagnum*-dominated bogs subjects to low and high atmospheric nitrogen supply. J. Ecol. 80: 131-140.

Agger P., Brandt J. (1988): Dynamics of small biotopes in Danish agricultural landscapes. Landsc. Ecol. 1: 227-240.

Bernacki L. (1990): On the occurrence of *Dactylorhiza baltica* (Klinge) Orlova in Poland. Acta Univ. Wratisl. 1055: 189-194.

Bobbink R., Hornung M., Roelofs J.G.M. (1998): The effects of air-borne nitrogen pollutants on species diversity in natural and semi-natural European vegetation. J. Ecol. 86: 717-738.

Boers P.C.M. (1996): Nutrient emissions from agriculture in the Netherlands, causes and remedies. Water Sci. Technol. 33: 183-189.

Bok G., Godula A., Dorochowicz A. (2007): Raport o stanie środowiska województwa podlaskiego w latach 2004-2006. Biblioteka Monitoringu Środowiska, Białystok.

Bollens U., Güsewell S., Klötzli F. (2001): Vegetation change in two Swiss fens affected by eutrophication and desiccation. Bot. Helv. 111: 139-155.

Bratli H., Økland T., Halvorsen Økland R., Dramstad W.E., Elven R., Engan G., Fjellstad W., Heegaard E., Pedersen O., Solstad H. (2006): Patterns of variation in vascular plant species richness and composition in SE Norwegian agricultural landscapes. Agric. Ecosyst. Environ. 114: 270-286.

Brehm K. (1971): Ein *Sphagnum*-Bult als Beispiel einer natürlichen Ionenaustauschersäule. Beitr. Biol. Pflanz. 47: 287-312.

Endler Z., Dziedzic J. (1991): Zmiany w składzie florystycznym rezerwatu „Torfowisko Spytkowo" koło Giżycka. Chrońmy Przyr. Ojcz. 47, 6: 71-74.

Galloway J.N. (1995): Acid deposition: perspectives in time and space. Wat. Air Soil Pollut. 85: 15-24.

Hájková P., Hájek M. (2004): Bryophyte and vascular plants responses to base-richness and water level gradients in Western Carpathian *Sphagnum*-rich mires. Folia Geobot. 39: 335-351.

Haraguchi A., Uemura S., Yabe K. (2000): Effects of nutrient loadings from catchments on Asajino mire, a small coastal ombrotrophic mire in northernmost. Jpn. Ecol. Res. 15: 107-112.

Herbichowa M., Herbich J. (2004): Conservation of biodiversity in Pomerania mires – problems against the background of hitherto practice and knowledge. In: The future of Polish mires. Eds L. Wołejko, J. Jasnowska. Wydawnictwo Akademii Rolniczej w Szczecinie, Szczecin: 149-158.

Herbichowa M., Jąkalska M. (1985): Szata roślinna torfowisk w krajobrazie rolniczym okolic Miechucina na Pojezierzu Kaszubskim. Zesz. Nauk. Wydz. Biol. Geogr. Oceanol. Uniw. Gdań. 6: 59-94.

Järvinen O. (1982): Conservation of endangered plant populations: single large or several small reserves? Oikos 38: 301-307.

Kawecka A. (1991): Rośliny chronione, rzadkie i zagrożone w Suwalskim Parku Krajobrazowym i na terenach przyległych. Parki Nar. Rez. Przyr. 10, 3-4: 93-109.

Kawecka A., Karczmarz K. (1993): Występowanie rzadkich i wyróżniających mszaków w zbiorowiskach roślinnych Suwalskiego Parku Krajobrazowego. Parki Nar. Rez. Przyr. 12, 1: 55-68.

Kołos A. (2004): Współczesna roślinność i flora rezerwatów przyrody Bagno Wizna I i Bagno Wizna II jako efekt długotrwałego odwodnienia torfowisk w dolinie środkowej Narwi. Parki Nar. Rez. Przyr. 23, 1: 61-91.

Kondracki J. (2002): Geografia regionalna Polski. Wydawnictwo Naukowe PWN, Warszawa.

Landschaftsökologische Moorkunde. (2001). Eds M. Succow, H. Joosten. Schweizerbart'sche Verlag, Stuttgart.

Mirek Z., Piękoś-Mirkowa H., Zając A., Zając M. (2002): Flowering plants and pteridophytes of Poland – a checklist. In: Biodiversity of Poland. 1. Ed. Z. Mirek. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Ochyra R., Bednarek-Ochyra H., Żarnowiec J. (2003): Census catalogue of Polish mosses. In: Biodiversity of Poland. 3. Ed. Z. Mirek. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Olde Venterink H., Pieterse N.M., Belgers J.D.M., Wassen M.J., de Ruiter P.C. (2002): N, P and K budgets along nutrient availability and productivity gradients in wetlands. Ecol. Appl. 12, 4: 1010-1026.

Pawlikowski P. (2008 a): Nowe stanowiska zagrożonych gatunków torfowiskowych roślin naczyniowych i mchów w Suwalskim Parku Krajobrazowym i jego otulinie. Fragm. Florist. Geobot. Polonica 15, 1: 43-50.

Pawlikowski P. (2008 b): Rzadkie i zagrożone rośliny naczyniowe torfowisk w dolinie Kunisianki na Pojezierzu Sejneńskim. Fragm. Florist. Geobot. Pol. 15, 2: 205-212.

Pieterse N.M., Olde Venterink H., Schot P.P., Verkroost A.W.M. (2005): Is nutrient contamination of groundwater causing eutrophication of groundwater-fed meadows? Landsc. Ecol. 20, 6: 743-753.

Polska czerwona księga roślin. (2001). Eds R. Kaźmierczakowa, K. Zarzycki. Instytut Botaniki im. W. Szafera PAN, Kraków.

Pykala J. (2007): Implementation of Forest Act habitats in Finland: Does it protect the right habitats for threatened species? For. Ecol. Manage. 242: 281-287.

Rostafiński J. (1872): Florae Polonicae Prodromus. Übersicht der bis jetzt im Königreiche Polen beobachteten Phanerogamen. Verh. Zool.-Bot. Ges. Vien 22: 81-208.

Sjörs H. (1952): On the relation between vegetation and electrolytes in north Swedish mire waters. Oikos 2, 2: 241-258.

Sokołowski A.W. (1973): Rośliny naczyniowe Suwalskiego Parku Krajobrazowego. Pr. Białost. Tow. Nauk. 19: 85-101.

Sokołowski A.W. (1990): Flora roślin naczyniowych Wigierskiego Parku Narodowego. Parki Nar. Rez. Przyr. 9, 4: 5-84.

Virolainen K.M., Suomi T., Suhonen J., Kuitunen M. (1998): Conservation of vascular plants in single large and several small mires: species richness, rarity and taxonomic diversity. J. Appl. Ecol. 35: 700-707.

Vitt D.H. (2000): Peatlands: ecosystems dominated by bryophytes. In: Bryophyte biology. Eds A.J. Shaw, B. Goffinet. University Press, Cambridge: 312-343.

Waldhardt R., Simmering D., Albrecht H. (2003): Floristic diversity at the habitat scale in agricultural landscapes of Central Europe – summary, conclusions and perspectives. Agric. Ecosyst. Environ. 98: 79-85.

Wilhelm M. (2004): Nature rarities around Lake Żelewko. In: The future of Polish mires. Eds L. Wołejko, J. Jasnowska. Wydawnictwo Akademii Rolniczej w Szczecinie, Szczecin: 195-198.

Zając A., Zając M. (2001): Distribution atlas of vascular plants in Poland. Laboratory of Computer Chorology, Institute of Botany, Jagiellonian University, Kraków.

Zarzycki K., Szeląg Z. (2006): Red list of the vascular plants in Poland. In: Red list of plants and fungi in Poland. Eds Z. Mirek, K. Zarzycki, W. Wojewoda, Z. Szeląg. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Żarnowiec J., Stebel A., Ochyra R. (2004): Threatened moss species in the Polish Carpathians in the light of a new red-list of mosses in Poland. In: Bryological studies in the Western Carpathians. Eds A. Stebel, R. Ochyra. Sorus, Poznań: 9-28.

Żurek S. (1987): Złoża torfowe Polski na tle stref torfowych Europy. Dok. Geogr. 4: 1-84.

For citation: Pawlikowski P., Jarzombkowski F., Wołkowycki D., Kozub Ł., Zaniewski P., Bakanowska O., Banasiak Ł., Barańska K., Bielska A., Biereżnoj U., Galus M., Grzybowska M., Kapler A., Karpowicz J., Sadowska I., Zarzecki R. (2009): Rare and threatened plants of the mires in the intensively managed landscape of the Góry Sudawskie region (north-eastern Poland). Rocz. AR Pozn. 388, Bot.-Stec. 13: 29-36.