Report from realization of the projects
Conservation of alkaline fens (7230) in young-glacial landscape of northern Poland
(LIFE11 NAT/PL/423)
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(LIFE13 NAT/PL/024)

VOLUME I

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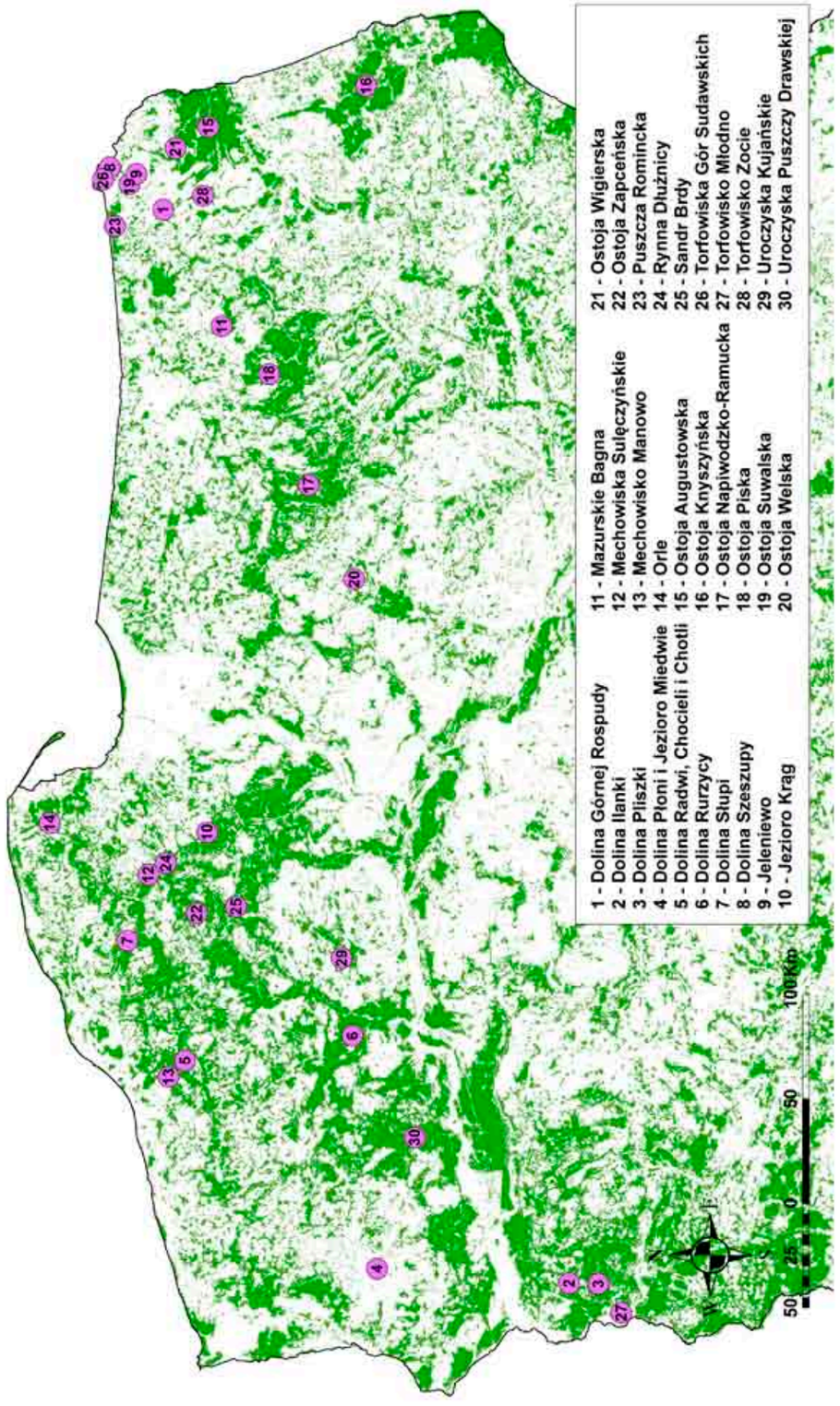

Localisation of Natura 2000 sites, where project activities were implemented

Conservation of alkaline fens (7230) in Poland

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Photo on front page: Pliszka Valley upstream of Pliszka (town) – R. Stańko

Volume I

„Dolina Ilanki" reserve - a complex of alkaline fens south of Pniów lake (photo R. Stańko).

I. Introduction

Lesław Wołejko, Robert Stańko

1.1. General characteristics

According to definition of the habitat provided by the Interpretation Manual of European Union Habitats (European Commission 2007), alkaline fens are mires overgrown largely by sedge and moss communities capable of peat or tufa accumulation. These wetlands show permanently high groundwater level with the water table oscillating around the ground level. They are supplied by soligenous or, more rarely, topogenous waters rich in alkali and often in calcium ions. Peat accumulation occurs below the groundwater level.

In the "Manual for Conservation of Habitats and Species Natura 2000" (ed. Herbich J. 2004), the habitat designated by code 7230 is defined as "alkaline fens in the form of flush fens, sedge fens and sedge-moss fens" and is described as "mesotrophic and meso-oligotrophic, weakly acidic, neutral or alkaline flush fens, spring fens and percolating fens of low type, supplied by groundwater rich or very rich in alkali, occupied by diverse, geographically diversified, peat-producing moss and low sedge communities, partially with prevalence of calciphilous plants, including those growing outside of their geographical range or on its edge (Herbichowa & Wołejko 2004). In Poland they occur in lower mountain locations, in the highlands and lowlands, mostly in northern Poland (Koczur 2011, Wołejko et al. 2012, Stańko et al. 2015b).

Based on the regional diversity of topographic, geological and hydrogeological conditions related to landscape age, dominating geomorphological processes and character of human impact, habitat 7230 was proposed, to be divided in Poland into three subtypes: 7230—1 flush fens, 7230—2 alkaline fens of southern (excluding mountains) and central Poland, and 7230—3 spring and percolating fens of northern Poland (Herbichowa & Wołejko 2004). It is partially reflected by the diversity of vegetation in these ecosystems.

1.2. Hydrology, development paths and typical vegetation of alkaline fens

Traditionally, habitat 7230 is identified principally based on vegetation. However, in the light of earlier experiences, this criterion is not sufficient to identify all alkaline fens existing in our country. A part of the typical syntaxa and species is common with other types of Natura 2000 habitats. For instance, species characteristic of the *Caricion davallianae* alliance indicated as typical of alkaline fens (Herbichowa & Wołejko 2004, Koczur 2011) are also fundamental components of calcareous fens (code 7210) and can be found in the flora of petrifying springs (code 7220) and in *Molinia* meadows (6410). On the other hand, species characteristic of different higher syntaxa of low sedge fens and transitional mires of the *Scheuchzerio-Caricetea fuscae* alliance are constant components of vegetation of well-preserved alkaline fens, especially in northern Poland. Classification of these units in relation to the diverse vegetation of European low sedge fens is currently the subject of intensive discussion (cf. Peterka et al. 2017).

The vegetation of live alkaline fens is dominated by species characteristic of the *Caricion davallianae* alliance. Similar well-developed natural communities also occur in the Polish part of the Carpathian Mountains rich in limestone, e.g., in the area of the Czarna Orawa River catchment (Kiaszewicz & Stańko 2010), Pieniny Mountains and Gorce Mountains (Stańko & Horabik 2015), and also in the area of the Nida Basin (Przemyski & Wołejko 2011), Lubelszczyzna region (Dobrowolski et al. 2016), Low Beskids (Magurski National Park) (Stańko unpubl.).

Paleoecological studies examining the developmental stages of fens representing currently habitat 7230 have demonstrated their developmental links with other habitats, most of all petrifying springs (Mazurek et al. 2014), hard water lakes, and calcareous fens (Waloch 2012). In an extreme case, the development of an alkaline fen was documented on top of a raised bog with *Sphagnum fuscum* (Hajkova et al. 2012, Madaras et al. 2012). Alkaline fens develop much more rarely in humid dune slacks (Wołejko et al. in preparation). Montane flush fens—which are a type of floating spring fens—are the dominating

form of alkaline fens in foothills and mountainous terrains.

Due to succession, alkaline fens are transformed into transitional mires of moss bog type and raised bogs, tall sedge swamps, and forest swamps.

At present, fen complexes are dominated by meadow ecosystems with different land use type (or more often abandoned) which quickly transform into tall herb communities, secondary reeds, and forests (Fig. 1).

In a majority of alkaline wetlands analyzed in recent years, fen complexes harbor patches of wet meadows, reeds, calcareous fens, and communities related to transitional mires of moss bog type, reeds and aquatic spring or scrub vegetation, and transitional forms leading to these types of vegetation.

For the above reasons, "typical" sedge-moss fen plant communities are considered herein as important indicators of occurrence of this habitat, but the entire habitat 7230 is not limited to the reach of this patch of vegetation. Also other factors such as stratigraphic structure, hydrological regime, hydrochemical parameters, and location of the fen in landscape should be taken into account for identification of these habitat patches. It is very important for the planning and implementation of a conservation strategy aimed at preserving the ecosystem integrity, especially its stages impaired and transformed by humans.

Compared with other mire ecosystems (e.g., transitional mires and raised bogs), alkaline fens are distinguished by an exceptional richness of valuable species with great conservation value and a narrow ecological amplitude (Wołejko et al. 2012). This natural habitat belongs to the most endangered with extinction. In several regions of Poland, this habitat is almost practically extinct and extremely endangered in the majority of locations (Stańko et al. 2015).

The area covered by an individual alkaline fen in Poland is very diverse, ranging from several ares to several tens—or in exceptional circumstances—several hundred hectares which depends on local topographic and hydrogeological conditions. However, a pattern can be noticed that in mountainous terrains these objects are abundant but of a small size and isolated, while their size increases northwards where vast valley and lake complexes are still preserved. They include the most famous Central European sedge-

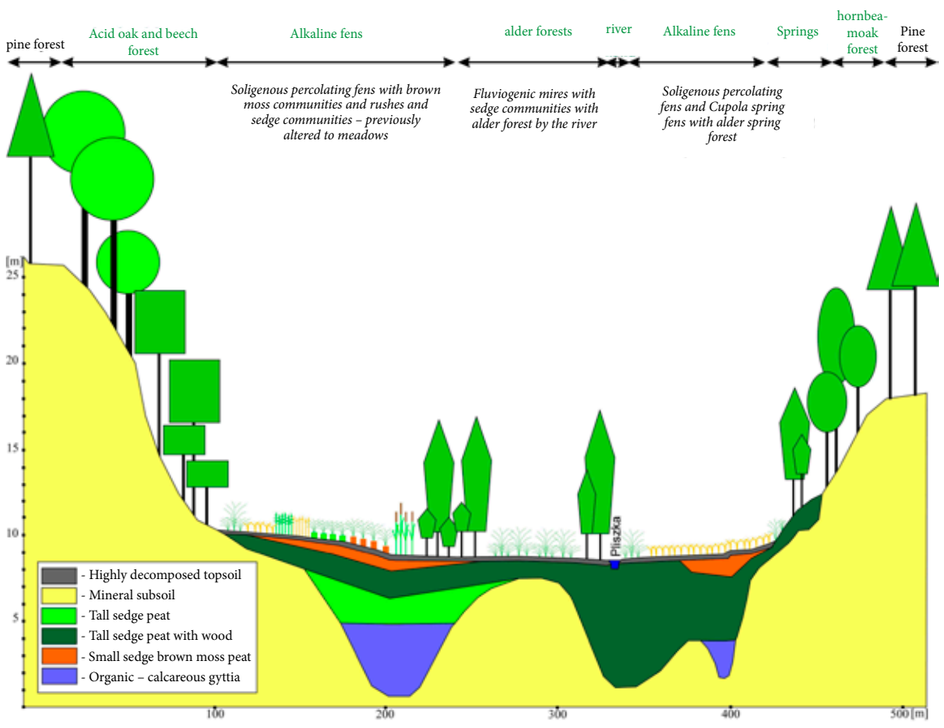


Fig. 1. A cross-section of fens situated in the upper Pliszka River valley.

Photo 1. A mountainous flush fen with broad-leaved cotton grass *Eriophorum latifolium* in the Gorce National Park (photo R. Stańko).

moss fens located in the Biebrza River (Pałczyński 1988, Wassen et al. 1990, 1996, Jarzombkowski 2010) and Rospuda River (Jabłońska et al. 2011, 2014) valleys, where no artificial drainages systems have been constructed.

Alkaline fens in Poland are often parts of larger peatlands and are components of heterogeneous landscapes in terms of water regime, trophic status, and vegetation. However, usually hydrological studies allow for identification of soligenous water supply (from groundwater), of their best developed parts. Groundwater that has long remained in contact with mineral substratum is highly saturated with soluble mineral nutrients. In terms of water outflow intensity, location in landscape, type of accumulated formations, and other diagnostic features, soligenous wetlands can be divided into percolating fens and spring fens (cupola and hanging spring fens). This division refers to the so-called ecological-landscape classification of wetlands (Succow & Jeschke 1989, Żurek, Pawlaczyk et al. 2002).

Flush fens are usually small wetlands with characteristics intermediate between floating spring fens and open springs. In the strict crenological sense, flush fens are a type of spring characterized by surface, scattered seepage of groundwater. Since they are usually situated on slopes where there are not good conditions for the formation of a deeper peat layer, only shallow peat-gleyey soils are created. Flush fens are the most common type of fens in mountainous terrains (Photo 1).

Spring fens occur in different topographic situations that ensure long-standing, uniform groundwater supply usually driven by hydrostatic pressure. This water outflow is confined and spatially limited. Point outflow of a large amount of mineralized groundwater is often associated with tectonic fractures (as in the Lubelszczyna region – in the south-eastern part of Poland) or the so-called hydrological windows, i.e., more permeable patches in the midst of less permeable geological formations. These fens form cupolas or banks that developed as a result of alternate or concurrent accumulation of peat or calcareous sinters (travertines and tufaceous limestones) built, apart from calcium salts, of iron and magnesium compounds. Precipitation of mineral compounds out of the waters is termed "petrification".

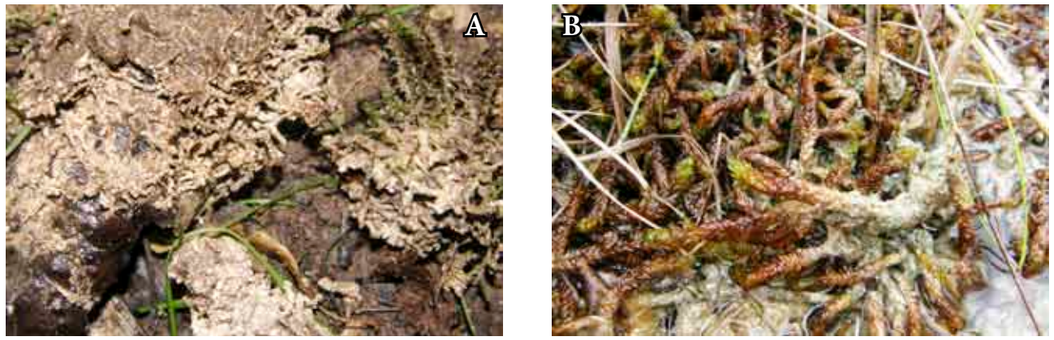


Photo 2. A) Petrification of brown mosses. B) *Scorpidium scorpioides*. (photo A. Szafnagel-Wołejko).

Cupola spring fens are also relatively common in lowland Poland, however currently they are almost always represented by more or less degraded forms. "Spurgle", the deepest known fen of this type in north-eastern Poland, reaches the depth of ca. 16 m of sediments dominated by travertines (Łachacz A., 2000). In north-western Poland, a series of spring sediments with the depth of ca. 8 m was recorded in the spring fen in the Chociela River valley (Wołejko 2001, Pidek et al. 2012).

Often eroded travertine beds or blocks are the only trace of earlier existence of peat-accumulating spring cupolas (Photo 3). Numerous spring fens in the Masurian Lake District are similarly transformed (Łachacz 2006). In many regions of northern Poland, the changed hydrological conditions currently preclude the accumulation of calcareous sinters (Grootjans et al. 2015).

Soligenous percolating fens are formed when water outflow from aquifers assumes a diffuse pattern. It can be observed on the margins of river valleys or lake basins. Percolating alkaline fens are formed most often in a varied landscape of glacial origin. In contrast to flush fens or relatively small spring fens, percolating fens are usually characterized by peat beds of a considerable depth often underlain by aqueous sediments gyttjas.

Photo 3. Vegetation on travertines. Czarna Orawa (photo R. Stańko).

In growing fens, water percolates slowly under the peat layer from the mineral side towards the watercourse or lake. The fen surface is sloping, sometimes very markedly. In wide river valleys in old glacial terrains (e.g., in the Biebrza River valley) this sloping can be slight and difficult to detect without land surveying. With a slight slope and blocked drainage, the contribution of rainfall to the hydrological balance of the fen increases. It initiates a succession of peat-producing vegetation towards the moss bogs, and can be a cause of difficulties in the proper identification of the ecological character of the fen and natural habitat type.

Photo 4. Percolating fens in the lower Rospuda River. On the left, woodless open sedge-moss fens can be seen near slopes on the edge of the valley. The fen is supplied mostly by groundwater flowing from below the scarp, which then percolates through the peat bed towards the river channel (photo K. Brzezińska).

Photo 5. A percolating fen with mass occurrence of bogbean *Menyanthes trifoliata*, bog sedge *Carex limosa*, and marsh helleborine *Epipactis palustris*. The Borsuki fen located in the terrestrialized lake basin with steep slopes in the Augustów Primeval Forest (photo P. Pawlikowski).

1.3. Anthropogenic transformations of alkaline fens

Analysis of historical maps (see Chapter 2) indicates that the areas covered by fens, including alkaline fens, have been of great interest to humans for at least several hundred years. Compared with sphagnum bogs, peats deposited in alkaline fens have not been so intensively exploited, probably due to their lower energy value and disadvantageous hydrological conditions (deeper excavation was not possible due to drainage difficulties). The situation is different when we look at it from the perspective of agricultural land use. In contrast to bogs, fens, including alkaline ones, have been under agricultural pressure almost all over their area; for ages, even the least accessible fens have been used as a source of biomass, utilized mostly as litter for livestock. At the beginning human pressure in these terrains was insignificant because it was limited to sporadic mowing of already dead biomass — sometimes only in winter — from the frozen soil surface. With economic development, a considerable part of the fens was converted into meadows and pastures that required a significant interference, not only in their hydrological conditions. In many regions, along with artificial drainage, the fen surface was covered by a dozen or so centimetre-thick layer of sand in order to allow for the use mechanical horse mowers. Over time, when the human pressure constantly increased, a part of the fens—the most severely dried and located closest to the mineral edges — was transformed into arable land and irrecoverably lost.

Since interest in using wetlands or fens declined at the end of 20th century (mostly for economic reasons), some of them have been undergoing spontaneous regeneration. A significant area of fen-meadow complexes extensively used in the past, after cessation of use, has been quickly transforming into scrubs and swamp forests, principally due to the disturbed hydrological conditions; some meadows and fens were also subjected to intentional afforestation.

While extensive use of alkaline fens consisting in occasional gathering of dry biomass from their frozen surface appears to be an insignificant human pressure (although significantly contributing to the preservation of the open character of the habitat), the transformation of fens into typical meadows and pastures was associated with substantial interference with the hydrological conditions. In spite of the abandoning of agricultural use of the fens, thousands of kilometers of drainage ditches were constantly maintained, thus fens are strongly exposed to the negative impact of drainage infrastructure. A majority of fens is not only adversely affected by local drainage systems, but also by changes in the water supply to their groundwater catchments. A spontaneous improvement of water conditions (related mostly to increased grundwater level) due to overgrowing of drainage ditches and blocking water outflow by beavers can be observed in some fens. In spite of that, the parallel improvement of habitat 7230 characteristic vegetation can be observed only in a few cases and on a small scale. It appears that only the filling of the drainage ditches by organic sediments and their complete overgrowth will render their impact on the vegetation negligible. Unfortunately this process will need to continue for the next several decades. It seems unlikely that over this time the alkaline fens left for spontaneous restoration will preserve their open character. Based on studies conducted with the use of automatic monitoring systems (Pawlaczyk & Kujawa-Pawlaczyk 2017), the dynamic nature of these changes does not allow for drawing unequivocal conclusions regarding long-term trends.

Photo 6. A part of an alkaline fen in the direct vicinity of the Mechowisko Radość Nature Reserve, used as a pasture, however with a well-preserved species-rich moss layer. A good example of an alkaline fen which underwent only slight anthropogenic transformation (photo R. Stańko).

In addition, the flow rate and chemical composition of the groundwater supplying the alkaline fens are important for their development. These factors have been undergoing modifications for centuries, first after the initiation of agricultural land use (the permanent deforestation of huge areas), and also due to forest management (large scale felling that totally changes the conditions of rainfall infiltration) within the groundwater catchment areas. Characterizing anthropogenic changes in fens, the impact of mining and large agglomerations, for different purposes that exploit the groundwater resources should also be mentioned. For these reasons, currently in Poland there are probably no areas with undistorted hydrological conditions.

It is difficult to estimate what was the overall extent of damage caused by the construction of dam reservoirs, connected with the excavation or flooding of the fens. Some alkaline fens were also lost due to the development of fish ponds.

In the near future, global climate change may be another factor significantly affecting the conservation of alkaline fens. It is difficult to determine how climate warming and related changes in the annual pattern of rainfall and temperature will influence hydrological conditions and consequently flora.

1.4. Conservation status of alkaline fens in Poland — reasons for undertaking the project

Attempts to estimate the abundance and distribution of alkaline fens in Poland were undertaken several times in the last decade or so (e.g. Sefferova-Stanova et al. 2008, Wołejko 2012). In 2012, Poland's alkaline fen resource and conservation status were evaluated based on field inventory (Wołejko et al. 2012). The field studies carried out by the Naturalists' Club within the framework of the project "National Alkaline Fen Conservation Program (7230)" indicated that at present the area covered by alkaline fens in our country amounts to ca. 15,000 hectares. Based on different data (e.g., GIS Wetlands), it can be assumed that this habitat originally covered from between 50,000 to 100,000 hectares. It means that the hectarage occupied by the fen habitat declined considerably over the last ca. 100 years. More detailed analysis of the data acquired within the National Alkaline Fen Conservation Program (Wołejko et al. 2012) shows that currently the alkaline fen resource with preserved characteristic vegetation (which is a classification criterion for the habitat 7230) can be estimated at ca. 7,000—8,000 hectares.

Inventorizing the national alkaline fen resource involved the assessment of the conservation status of each site according to the parameters and indicators accepted by the Chief Inspectorate of Environmental Protection for monitoring of natural habitats and species. A global assessment was based on three parameters, i.e. "area of the habitat", "structure and function", and "conservation prospects". The parameter "structure and function" was evaluated based on the following partial data:

- occurrence of characteristic species,
- area and species structure of bryophytes,
- occurrence of foreign invasive species,
- occurrence of expansive herbaceous plant species,
- appropriate water availability
- structure of fen surface
- peat excavation
- drainage systems
- presence of trees and shrubs.

The results of the global assessment in the different regions are presented in Table 1. Countrywide, 9% of fens are in favorable status (FV), 48% are in unfavorable-inadequate status (U1), and 43% are in unfavorable-bad status (U2). In terms of the number of objects, mountainous fens situated in the Carpathian Mountains are the best preserved; however, it should be mentioned that they cover a total area of only several tens of hectares (Wołejko et al. 2012).

The results obtained for individual parameters are presented in Table 2. They unequivocally confirm a decline of the overall area of the habitat, and the inadequate and poor conservation status of a vast majority of alkaline fens in Poland (Wołejko et al. 2012).

Dramatic changes and a fast rate of extinction of this habitat to some extent is reflected in the results of the inventory of chosen plant species conducted under this project. For instance, the number of stands of yellow marsh saxifrage (ca. 25) — the species strongly associated with alkaline fens in good conservation status — represents only 10% of the historically known stands of this plant (Pawlikowski & Jarzombkowski, 2012)!

The role which alkaline fens play in the conservation of biodiversity of wetland ecosystems (a huge number of highly specialized rare, protected, and endangered species), and their services in the landscape (stabilization of water balance, carbon accumulation) in connection with their dramatic loss and deterioration, were the basic premises justifying realization of the project "Conservation of alkaline fens in young-glacial landscape of northern Poland" and its counterpart project encompassing the remaining area of Poland.

Magdalena Makowska, Dorota Horabik

1.5. Project LIFE11 NAT/PL/423 "Conservation of alkaline fens in young glacial landscape of northern Poland" — planned actions and actual results

The project based on the assessment of the conservation status of alkaline fens, described in the preceding chapter, was financially supported by the Financial Instrument for the Environment LIFE+ (50%), National Fund for Environmental Protection and Water Management (45%), and was realized by beneficiaries (5%): the Naturalists' Club (leading) and the Regional Directorates of Environmental Protection in Gdańsk and Olsztyn (partners) from September 2012 to June 2018. The aim of the project was to curb the degradation of the alkaline fens and to improve or preserve their conservational status at 30 Natura 2000 sites situated in northern Poland, as a habitat harbouring many rare, protected, and endangered with extinction plant species, especially those listed in Annex II of the Habitats Directive (yellow marsh saxifrage *Saxifraga hirculus*, yellow widelip orchid *Liparis loeselii*, and slender green feather moss *Hamatocaulis vernicosus*). The chosen areas include 89 of the most valuable and best preserved alkaline fens in the country, e.g., the Rurzyca River valley, Augustów Primeval Forest, Kaszuby Lake District, Słupia River valley, that are situated in 6 voivodeships: Lubuskie, Greater Poland, West Pomeranian, Pomeranian, Warmian-Masurian and Podlaskie.

The detailed objectives of the project were as follows:

- to limit excessive water outflow and to increase the groundwater level in the chosen alkaline fens;
- to limit mineralization and eutrophication of the alkaline fen surface, resulting from excessive drying out;
- to halt the reduction of biodiversity of alkaline fens caused by the expansion of species characteristic of less humid habitats, e.g., grasses, trees, shrubs;
- to purchase the most valuable and the most endangered fragments of alkaline fens in order to secure their long-term existence by establishing nature reserves;
- to popularize alkaline fen conservation methods based on good conservation and management plans supported by solid scientific evidence, with special consideration given to hydroecological aspects;
- to strengthen regional populations of the extremely endangered with extinction species *Saxifraga hirculus* by its propagation and reintroduction into specific sites;
- to promote the conservation of alkaline fens as areas capable of CO_2 accumulation which provide support to actions aimed at reducing the consequences of the greenhouse effect, and to assemble a group of persons interested in alkaline fen conservation in the future, acting to make the project results sustainable.

Such a design of the project created an opportunity for preserving the good conservation status or to improve the status of the most valuable areas where habitat 7230 can be found, which constitute 70% (on area basis) of the alkaline fen resources occurring in northern Poland (30% of the country's resources), currently harboring characteristic sedge-moss vegetation. In addition, the project realization contributed to strengthening and preservation of ca. 90% of yellow marsh saxifrage stands in Poland, ca. 50% of yellow widelip orchid and slender green feather moss stands, and ca. 50% of stands of other very rare plant species, e.g. fleshy starwort *Stellaria crassifolia* or bryophytes: *Meesia triquetra, Pseudocalliergon trifarium* and *Cinclidium stygium*.

1.5.1. Actions

The following actions were carried out within the framework of this project:

A1. Preparation of design and technical documentation and obtaining all necessary consents and administrative decisions authorizing the construction of dam barriers and implementation of other non-technical measures aimed at improving water conditions in the fens. This action also included arrangements related to the purchase of land.

A2/A3. Preparation of draft management plans for existing and planned nature reserves along with plans of conservation measures for Natura 2000 areas within the boundaries of the objects. This action was performed by the Partner, i.e. the Regional Directorate of Environmental Protection in Gdańsk, or in close cooperation with it. This action also comprised the establishment of new nature reserves and the development of management plans for newly established but also existing reserves. Appropriate care was taken to ensure that the plans of conservative measures for the Natura 2000 areas, where the project was realized, included appropriate recommendations for habitat 7230 to secure its proper conservation.

A4. Preparation of simplified documentation for habitat management plans, including plans of conservation measures for Natura 2000 areas within the boundaries of the objects. Wherever management plans were not prepared (i.e., where fens were not situated within the boundaries of new or existing reserves), a "compendium of knowledge" about the habitat in a given area was developed. This documentation was prepared in order to assemble knowledge on the local habitat and to hand it to local (but not only) stakeholders so that they can use it in their work, e.g., in forest protection, issuing administrative decisions and changes in local law, including management plans. These documentations were prepared so as to encourage their use as the basis of application for inclusion of a given fen area into an agricultural-environmental-climatic program.

Table 1. Conservation status of the alkaline fen habitat in different regions of Poland (project results; Wołejko et al. 2012).

Region	Conservation status						
	FV		U1		U2		
	Number	%	Number	%	Number	%	Total
Young glacial	40	9	184	43	205	48	**429**
Old glacial	2	1	88	55	70	44	**160**
Uplands	5	9	30	55	20	36	**55**
Mountains	32	15	104	50	73	35	**209**
Total	79	9	406	48	368	43	853

Table 2. Assessment of specific parameters of the inventoried alkaline fens in the whole country (project results; Wołejko et al. 2012).

Parameter	Assessment							
	FV		U1		U2		XX	
	Number	%	Number	%	Number	%	Number	%
Area of the habitat	85	10,0	292	34,2	264	30,9	212	24,9
Specific structure and function	136	15,9	328	38,5	384	45,0	5	0,6
Conservation prospects	168	19,7	460	53,9	213	25,0	12	1,4

B1. Purchase of land for nature conservation. The aim of the land purchase was to prevent destruction of the most valuable patches of the habitat resulting from the lack or incorrect conservation management by private owners, and incorporation of the purchased areas into the nature reserve conservation system.

C1/C2. Construction of dam barriers. This action was executed together with the Partner, i.e., the Regional Directorate of Environmental Protection in Olsztyn. The aim was to construct simple, small and maintenance-free wooden barriers in drainage ditches present in the fen. They were constructed in order to increase groundwater level and its stabilization at 10—15 cm below ground level. Owning to the improvement of water conditions, the encroachment of species preferring drier habitats was halted.

C3/C4. Preparatory mowing. This action was performed in cooperation with the Partner, i.e., the Regional Directorate of Environmental Protection in Olsztyn. The aim was to restore extensive use of the areas of the project that were used for haymaking several decades ago, but this form of land use was then abandoned. In consequence, reeds, tree, and shrub species began to encroach on the dried fens, exacerbating the drying problem.

C5. Optimization of water conditions disrupted by beavers. Conservation of habitat 7230 often clashes with the conservation of species (e.g., beaver) habits which oppose the habitat conservation measures. In an attempt to strike a fair balance between conservation of habitat 7230 which does not tolerate long-lasting flooding with surface waters, and conservation of the protected species, i.e., beaver *Castor fiber* L., perforated PVC tubing protected by a steel basket was installed in several beaver dams that permanently decreased water level (earlier impounded by the dam). It prevented permanent submersion of the habitat by surface waters without destruction of the beaver lodges.

C6/C7. Removal of trees and shrubs. This action was performed in cooperation with the Partner, i.e., the Regional Directorate of Environmental Protection in Olsztyn. As in the case of preparatory mowing, this action also aims to restore extensive land use. When traditional hand mowing was abandoned many years ago, to be able to restore it in many fens it is required first to remove tree and shrub undergrowth and then to perform the first preparatory mowing.

C8. Strengthening of the *Saxifraga hirculus* population. This partly experimental action is described in detail in Chapter 3.5 of this Report. It aimed to develop a procedure for the harvest, propagation, cultivation, and reintroduction of *Saxifraga hirculus* plants so as to strengthen the existing populations, or to reintroduce the population into areas were its stands were previously documented but it withdrew due to negative habitat changes.

D1. Phytosociological and hydrological monitoring. In order to assess the impact of the implemented conservation measures and to provide the basis for further actions, every conservation project requires monitoring of species composition and water conditions.

D2. Assessment of carbon accumulation potential of alkaline fens. This low-cost and narrow-scope action involved only an attempt to assess the significance of alkaline fens as a CO_2 store and to perform a cost estimation of this ecosystem service based on the literature data. Unfortunately, with a minimal budget it was only possible to perform a general comparison of the literature reports and to draw conclusions about the specificity of alkaline fens. More detail is available on the project website http://alkfens.kp.org.pl/pliki/ and in the Guidelines on Best Practice in Conservation of Habitat 7230 in Poland and Europe where the function of fens in the landscape is described more broadly.

E1/E2. Information and promotion actions. These included the development of the project website (www.alkfens.kp.org.pl), preparation of promotional materials, organization of a series of training courses/seminars, and Guidelines on Best Practice in the Conservation of Alkaline Fens.

1.5.2. Results

The level of achievement of the different actions within this project, with the division into planned and actually carried out actions, is presented in Table 3 below.

It can easily be seen that the plan often significantly differs from the actual achievements. It is not the consequence of unrealistic planning but results from the fact that nature does not wait and has its own demands. Three to six years have elapsed between planning and execution of the conservation actions. Therefore, many conditions have significantly changed and the scope of the conservation measures had to be rethought. Other reasons include obstacles encountered during implementation of the project (lack of consents, lengthy procedures, etc.) or, on the contrary, unexpected opportunities (the initiative of owners or managers to sell land). Therefore, nature—like a live organism—should be approached with much flexibility and in a dynamic manner. We have tried to act in this way with a view to achieving the objectives set in the planning and implementation of this project. Unless we had met with the understanding of the institutions providing financial support to the project, we would not have been able to carry out many important, in our opinion, actions.

A detailed description of each action and the experiences acquired during their execution and results can be found in the next chapters of this Report.

Photo 7. „Gogolewko" reserve – aerial view after conducting restoration measures (trees and shrubs removal). To partially block the drainage ditches the biomass from cutting was used. (photo R. Stańko).

Table 3. Presentation of the planned and actually carried out conservational actions within the framework of this project.

Name of LIFE project site	Name of the fen	Name and code of Natura 2000 site	Dams and other objects to improve hydrological conditions [pcs]		One-off mowing [ha]		Trees removal [ha]		Devices to optimalize water conditions disrupted by beavers [psc]		Conservation plans for nature reserves [pcs]		7230 habitat management plans [pcs]		Plots bought strictly for nature protection purposes [ha]		Metaplantation of *Saxifraga hirculus* [new subpopulations]		Newly established nature reserves/ proposed – not established
			P[1]	R[2]	P	R	P	R	P	R	P	R	P	R	P	R	P	R	
Dolina Pliszki	Konotop	Dolina Pliszki (PLH080011)							1	1			1	1					
	Kosobudki						0,70	0,93	0	1			1	1					
	Kosobudki 2			21		1,00	0,22				1	1				12,5			„Mechowisko Kosobudki”
	Kijewo 2						1,59	1,59					1	1					
	Kijewo					1,6	0,38	0,38					1	1					
	Torfowisko Pliszka					4,00	2,89	2			1								„Torfowisko Pliszka”
	Ratno						0,20				1	1	1	1					„Jezioro Ratno”
	Jezioro Wielicko					2,2	2,22	2,2					1	1					
Dolina Ilanki	Ilanka 3	Dolina Ilanki (PLH080009)											1	1					
	Ilanka 1						3,85	3,86					1	1					
	Ilanka 2							3,03					1	1					
	Ilanka 5												1	1	14,00				
	Ilanka 4				2,05	2,07	2,04	2,06	1				1	1					
	Ilanka 7				1,00	0,97	1,00	0,97	1				1	1					
	Ilanka 8												1	1					
	Ilanka 6										1	1			7,00				„Dolina Ilanki II”
Młodno	Młodno	Torfowisko Młodno (PLH080005)			5,58	5,67	4,13	4,21	1				1	1					
Wierzchołek	Wierzchołek	Uroczyska Kujańskie (PLH300052)			1,16	1,10	1,16	0,96	1	1			1	1	0,50	2,65			„Jezioro Wierzchołek”
Torfowiska Sandru Brdy	Bagno Stawek	Sandr Brdy (PLH220026)			6,13	5,77	5,00	7,06					1	1			1	2	
	Jezioro Głuche Małe 1						0,96	0,97					1	1					
	Jezioro Głuche Małe 2						0,20	0,20					1	1					
	Jezioro Głuche Małe 3						1,60	1,58					1	1				2	
	Zapceń 1						0,60						1	1	0,50		1		
	Zapceń 2		1	1		3,05							1	1			1		
Zapceńskie Mechowiska	Torfowisko Radość	Ostoja Zapceńska (PLH220057)			2,00	2,04	3,00	3,69			1	1			0,50		1	1	„Torfowisko Radość”
	Jezioro Kruszyńskie				1,50	1,69	1,00	1,35			1	1							„Kruszynek”
Jezioro Małe Długie	Jezioro Małe Długie	Rynna Dłużnicy (PLH220081)			2,00	1,10	1,00	0,25	3	4	1						1		„Jezioro Małe Długie”
Sulęczyno	Sulęczyno	Mechowiska Sulęczyńskie (PLH220017)			5,00	8,24	5,00	9,41			1	1			20,00	6,7	1	2	„Mechowiska Sulęczyńskie”
Jezioro Krąg	Jezioro Krąg	Jezioro Krąg (PLH220070)			1,30		1,30				1	1			5,00		1	3	„Mechowisko Krąg”
Manowo	Manowo	Mechowisko Manowo (PLH320057)		5	9,80	9,79	8,65	21,75			1	1*							„Mechowisko Manowo”
Torfowiska Radwi i Chocieli	Zgniła Struga	Dolina Radwi, Chocieli i Chotli (PLH320022)											1	1					
	Lubowo		1				2,00						1	1					
	Kwiecko						0,50				1								„Kwiecko”
	Drzewiany		3	8	3,00	2,35	1,00	0,78					1	1					
	Dolina Łęcznej		10		6,00	3,7							1	1					
Dolina Płoni - Żydowo	Dolina Płoni - Żydowo	Dolina Płoni i Jezioro Miedwie (PLH320006)	15	7	5,00	2,00	3,00						1	1	25,00				„Dolina Płoni”

Dolina Rurzycy	Diabli Skok	Dolina Rurzycy (PLH300017)			1,50	5,7	1,00	5,60					1	1					
	Wielkopolska Dolina Rurzycy				7,00	9,61	2,30	4,43					1	1					
	Smolary				0,80	2,15	0,50	1,30					1	1					
Uroczyska Puszczy Drawskiej	Mielęcin Bukowo	Uroczyska Puszczy Drawskiej (PLH320046)	5	6	2,13	2,13		2,13					1	1					
	Stara Korytnica		5	5									1	1					
	Nowa Studnica		10	10	0,13	0,12					1								„Nowa Studnica”
	Jez. Bukowo Długie i Małe								0	1	1	1							
	Nowa Korytnica 2				1,00	0,92							1	1					
	Nowa Korytnica 3		13	3									1	1					
Orle	Orle	Orle (PLH220019)	15		20,00		20,00				1								
Puszcza Knyszyńska	Stare Biele	Ostoja Knyszyńska (PLH200006)	3		6,98		5,85						1	1					
	Łosiniany				1,50	4,19	1,00	3,22					1	1					
Puszcza Augustowska	Augustów - ogródki	Ostoja Augustowska (PLH200005)			1,46	1,46	0,80	0,78					1	1					
	Kobyla Biel				8,00	4,45	5,00	4,45			1				8,00				„Kobyla Biel”
	Kalejty				0,20		0,10						1	1					
	Przewięź				0,60		0,40						1	1					
	Płaska				2,30		0,50						1	1					
	Jazy				0,40	0,68	0,40	0,68					1	1					
	Borsuki				4,50		3,50				1								„Borsuki”
	Perkuć				8,50	9,02	5,00	9,02					1	1					
	Sawonia - Mostek		3		1,60		0,50				1						1	1	„Sawonia-Mostek”
	Żyliny				1,50		0,60						1	1					
	Dolina Rospudy				3,00		3,00				1				5,00	36,22			„Dolina Rospudy”
	Sarnetki				5,00	22,06	2,00	19,42					1	1					

Wigry	Jez. Kruszyn	Ostoja Wigierska (PLH200004)	3	3	0,15		0,10						1	1					
Poszeszupie	Wingrany	Dolina Szeszupy (PLH200016)	1		1,00	1,89	1,00	1,27					1	1					
	Rudawki		10	18	5,00	18,00	4,00	14,53					1	1	7,00	3,53			
	Poszeszupie		1		2,00	2,11	1,10	1,64					1	1			1		
Rowelska Góra	Rowele	Torfowiska Gór Sudawskich (PLH200017)	5		1,00	1,05	1,00	1,03					1	1	1,00				
Jeleniewo	Dziabel	Jeleniewo (PLH200001)			0,40	0,32	0,40	0,32					1	1					
	Sumówek		1		0,30		0,30						1	1					
	Jez. Purwin	Ostoja Suwalska (PLH200003)			0,20	0,27	0,20	0,27					1	1					
Dolina Czarnej Hańczy	Hańcza	Ostoja Suwalska (PLH200003)	4		2,00	0,38	1,50	0,27					1	1					
	Linówek				0,50	0,32	0,40	0,32					1	1					
	Czarnkowizna	Jeleniewo (PLH200001)	1		2,00	1,47	1,20	1,23					1	1	2,50				
	Stara Wieś		1		1,80	1,07	1,80	0,94					1	1	1,80				
	Morgi				3,00	2,62	2,00						1	1	3,20				
	Rutka				3,00	3,41	1,00	1,67					1	1					
	Stara Pawłówka				3,00	3,42	2,80	3,42					1	1					
Żytkiejmska Struga	Żytkiejmska Struga N	Puszcza Romincka (PLH280005)			0,30		0,10						1	1					
	Żytkiejmska Struga S		15		0,50	0,78	0,20						1	1			1	1	
Bagno Parchacz	Bagno Parchacz	Dolina Górnej Rospudy (PLH200022)			3,00	1,62	2,30	1,36					1	1	3,00		1		
Zocie	Zocie	Torfowisko Zocie (PLH280037)	8		2,00	8,62	2,00	8,62					1	1	2,00				
Drozdowo	Drozdowo	Mazurskie Bagna (PLH280054)	4		2,00		0,80						1	1					
Głógno	Głógno	Ostoja Piska (PLH280048)			1,50	1,37	1,00	1,37					1	1	2,00				

Trępel	Trępel	Ostoja Napiwodzko-Ramucka (PLH280052)	3	2	3,00	3,10	1,50	2,47					1	1					
Kopaniarze	Kopaniarze	Ostoja Welska (PLH280014)	3	6	1,50	1,86	1,00	1,47					1	1			1	1	
Torfowiska Doliny Słupi	Gogolewko	Dolina Słupi (PLH220052)	16	18			35,00	32,53			1	1							„Gogolewko”
	Skotawskie Łąki		26	17							1	1							
	Mechowisko Czaple										1	1							
	TOTAL:		**186**	**130**	**169**	**175**	**170**	**195**	**8**	**8**	**21**	**12**	**66**	**66**	**32 ****	**61,5**	**12**	**13**	**8/11**

* - the conservation measures plan was elaborated for Natura 2000 site that overlaps with proposed reserve „Mechowisko Manowo"

** - from the 108 ha 1/3rd (so ca. 32ha) was planned to be buy out

1 Planned scope
2 Realised scope

2. Characteristics of alkaline fens protected by the project and the results of conservation measures and monitoring

Robert Stańko, Lesław Wołejko (North-West Poland)
Filip Jarzombkowski, Katarzyna Kotowska, Ewa Gutowska (North-East Poland)

The material presented in the next section concerns the characteristics of all sites covered by the project along with a brief description of the activities undertaken and an attempt to evaluate the obtained results. Since the period of observations (from a few to 20 years), as well as the range of research conducted at the time in particular sites was very diverse, the characteristics of individual areas differ significantly. This applies to both vegetation and hydrological surveys as well as other elements which, depending on local conditions, natural values, as well as technical and financial possibilities in a given time, were subjected to analyses. The most detailed and extensive data concern the most valuable areas, usually existing or designed nature reserves, whose values have been known to the authors of this report for at least several, and sometimes several dozen years. In these areas, in addition to other activities in the field of active protection, the implementation of the project has enabled the continuation of observations conducted in previous years (eg hydrological and phytosociological – see chapter 4.1 and 4.2).

Due to the extremely valuable (in the opinion of the authors) long-term nature of those research, going beyond the time frame of the project, it was decided to present all the results obtained despite the disproportions in individual areas' characteristics. By providing information contained in the characteristics of individual sites along with the evaluation of results, several elements were considered especially important (according to the authors) affecting the development of alkaline fens, their conservation status and the possibilities of protection. These are: geological structure of the neighbourhood (or more appropriate: the type of soil determining the nature of physico-chemical parameters of water feeding the mire), peat deposit stratigraphy helpful in understanding the history of its development, condition (in terms of mineralization) of the surface layer of the peat deposit having a significant impact on the trophy of the habitat and vegetation's abilities to response to water level fluctuations, amplitude of fluctuations of the groundwater level in relation to the fen surface, as well as the history of management. Considering the above elements and the scope of conservation measures carried out, based on the observed changes in the vegetation, an attempt was made to assess the effectiveness of the protective measures applied so far and to formulate the conclusions presented in the chapter 4.1 and 4.2 resulting from this analysis.

SITES IN NORTH-WEST PART OF POLAND
Natura 2000 site "Dolina Ilanki" PLH080009

Site covers a part of the upper and middle courses of the Ilanka River with sections linked to mountain and foothill rivers. The river is a small tributary of the Oder River and intersects the sandy surfaces of the Pliszka sandur (Żynda 1967), covered mostly by pine forests. The natural value of the mire ecosystems of this area were discussed, among others, in the studies by Lipka & Frankiewicz (1980), Stańko et al. (1996), Wołejko & Stańko (1998), Wołejko et al. (2012) and Stańko & Wołejko (2016). Until 1945, the mires in the Ilanka River Valley (except for small, wettest parts) were used as hay meadows after they had been drained. The agricultural use was gradually abandoned in the following years to finally cease completely in the 1970s. In 2000, the Dolina Ilanki nature reserve with a surface area of nearly 240 ha was established on the land leased, among others, by the Naturalists' Club. In 2016, the Dolina Ilanki II reserve was established with a surface area of 11.32 ha thanks to the efforts made as part of the project. The area's alkaline mires occur mostly in the form of segde fen with a small proportion of characteristic species, including swamp sawgrass *Cladium mariscus*.

The area is distinguished by the numerous large patches of blunt-flowered rush *Juncus subnodulosus*, whose population is one of the largest in the country.

Eight sites (Ilanka I–VIII) have been identified in the area for the purposes of the project, which are either parts of larger mire complexes (Ilanka I, II, V, VI) or independently functioning mires (e.g. Ilanka III).

Active protection measures in the area focused mainly on mowing the mires (see section 1.6). Hydrological monitoring was carried out within selected sites by means of automated measuring devices and phytosociological monitoring was conducted on designated transects, as well. On the basis of the information obtained as part of the project and the research conducted at earlier times, the effects of the undertaken protective measures and the changes

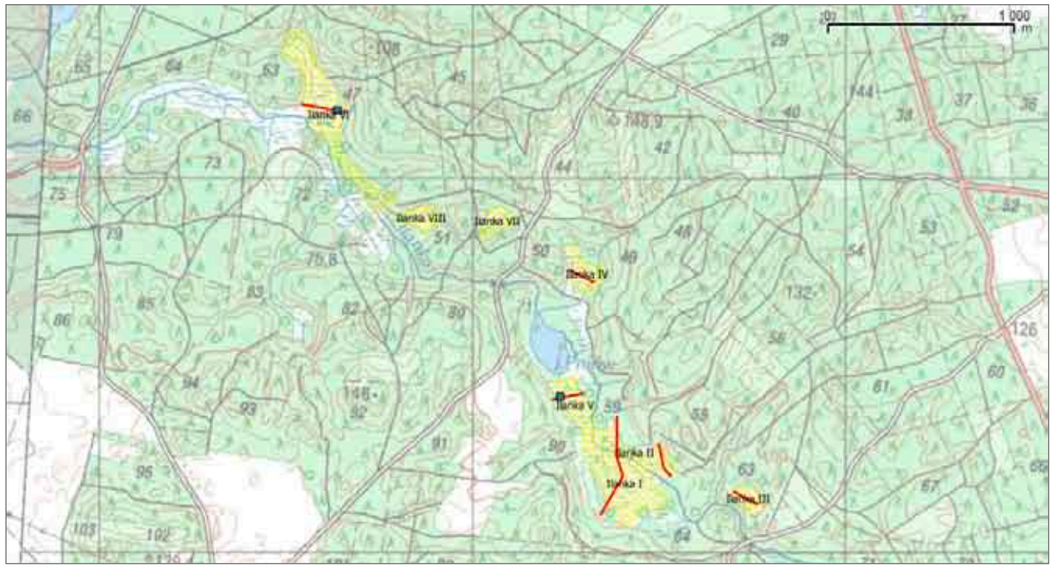


Fig. 2. Location of individual sites in the Dolina Ilanki area together with the distribution of research transects and hydrological monitoring points.

Photo 8. Blunt-flowered rush meadows in the Ilanka II site (transect I) (photo R. Stańko).

Photo 9. Central part of transect D (photo R. Stańko).

Photo 10. Fen in Ilanka IV before trees removal (photo R. Stańko).

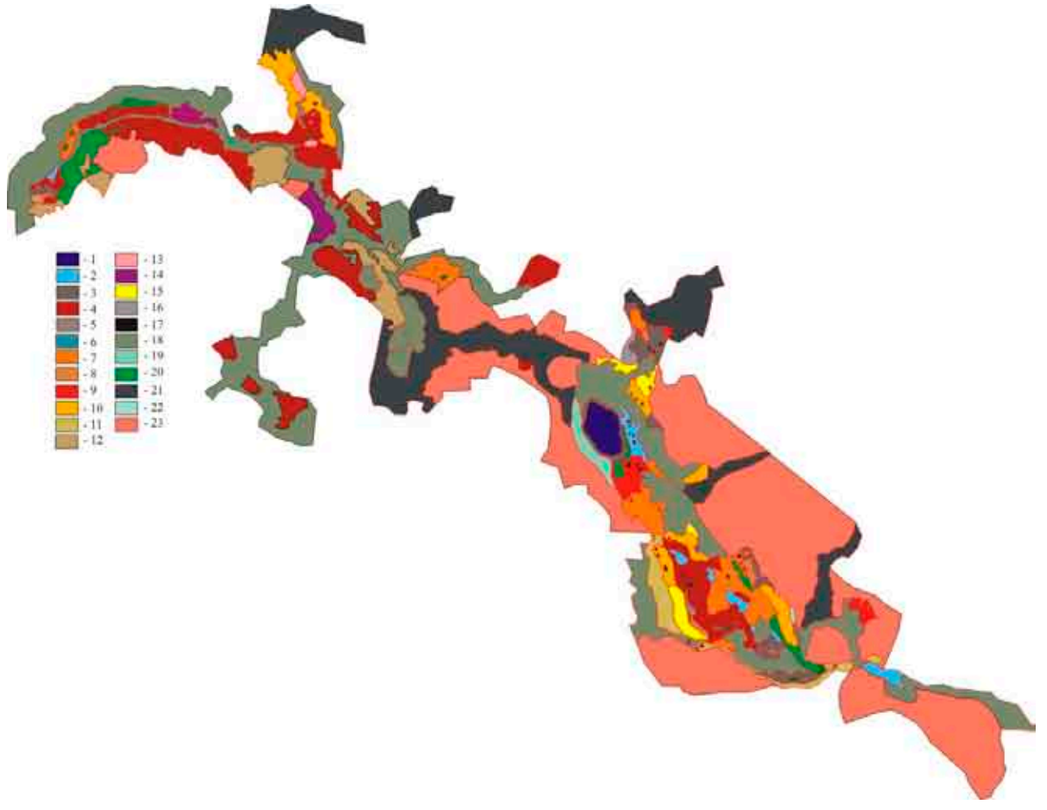


Fig. 3. Map of actual vegetation of the Dolina Ilanki and Dolina Ilanki II reserves on the basis of studies on vegetation between 1994 and 1995. 1 – lake, 2 – *Glycerietum maximae*, 3 – community of *Carex paniculata* and *Carex acutiformis*, 4 – Caricetum acutiformis, 5 – *Cladietum marisci*, 6 – *Acoretum calami*, 7 – reed bed (*Phragmitetum* communis, *Thelypteridi-Phragmitetum*), 8 – *Juncetum subnodulosi*, 9 – community of *Helodium blandowii* and *Carex rostrata*, 10 – communities of *Phragmitetum australis* and *Carex acutiformis* on spring mires, 11 – wet meadow communities on the border between peat and mineral substrates, 12 – wet meadows on peats, 13 – *Molinietum coeruleae*, 14 – nitrophilous communities with the predominance of nettle and elements of rushes and meadow vegetation, 15 – thermophilous vegetation, 16 – arable land, 17 – single trees and groups of trees and shrubs, 18 – alder forests, 19 – poplar plantations, 20 – willow scrub, 21 – broadleaved forests on mineral slopes and edges of the valley, 22 – sloe scrub, 23 – pine and mixed forests (source: Wołejko & Stańko 1998).

that had occurred in the area over the last 20 years have been assessed. The location of individual sites and selected monitoring components (including research transects) is presented in Fig. 2.

Ilanka VI, Transect B

The mire covers a side valley of a small stream flowing into the Ilanka River. A significant part of the site is covered by terrestrialisation mires. Along the mineral edges, there are numerous domes of spring mires, degraded quite strongly by drainage works that had been conducted in the past. Lesser pond-sedges (*Caricetum acutiformis*) and Phragmitetum australis covering mainly drained spring domes are the dominant vegetation within the boundaries of the site. Numerous patches of blunt-flowered rush are the most valuable element of the vegetation of the site.

The site was taken under protection as a nature reserve based on the project documentation and the protection plan prepared as part of the project. The area requires protective measures consisting mainly in blocking the drainage ditches that degrade the spring domes. At the beginning of the 2000s, three gates (dams) were built in the reserve, two of which have been operational to this day thanks to the beaver dams built on top of them, which significantly raise the water level in the adjacent mires.

Photo 11. A beaver dam on a former gate which maintains a high water level within a part of the mire (photo R. Stańko).

Ilanka VII

A site completely flooded since 2011 as a result of beaver activity. Previously, it had been an open mire with a large share of patches of reed in a mosaic with elements of meadow vegetation and some moss-sedge patches. Due to the appearance of numerous species of birds that are relatively rare in the region (e.g. goldeneyes), the measures aimed at the removal of the resulting reservoir were ceased.

Photo 12. Ilanka VII. A mire completely flooded due to beaver activity as a place particularly attractive for wetland birds (photo R. Stańko).

Ilanka VIII

A site completely overgrown with *Phragmitetum australis*. Due to the protective measures undertaken in the past which consisted in the construction of dams the measures within the project were limited to monitoring the condition of the existing gate and the observation of changes occurring within the vegetation after the abandonment of any other protective measures.

For the purposes of this report, the characteristics of the measures and their results in the area have been made on the basis of selected transects: "A" (Ilanka V), "B" (Ilanka VI), "D" (Ilanka I), and "E" (Ilanka II) – located in the vicinity of the Pniów lake, and "F" (Ilanka III) in the vicinity of the so-called Trzeci Młyn. The analysis of the evolution of vegetation on the transects was based on the data collected between 1994 and 2014. This is the longest period of time among all the analyzed areas. Protection activities included mainly the felling of tree wildings and mowing, along with the removal of biomass. No protection activities were carried out on the transects "B" and "D". In the case of transect "F", as part of the protective measures in the early 2000s, the water level was raised by means of a dam in the drainage ditch. Since the construction of the dam, the water level has been steadily raising as a result of the impact of the beaver-built dam. Within transect "A", the groundwater level was also influenced by the beaver dam on the Ilanka River, which simultaneously raised the water level in the Pniów Lake. In the case of the research transects "D" and "E", no significant changes in hydrological conditions were observed during the period of the study (Fig. 4). The observations carried out within the Ilanka VI site indicate periodic strong fluctuations in the water level, probably related to temporary damage to the beaver dam on the mire drainage watercourse (Fig. 5).

Photo 13. Ilanka VIII. Alkaline mire dominated by *Phragmitetum australis* (photo R. Stańko).

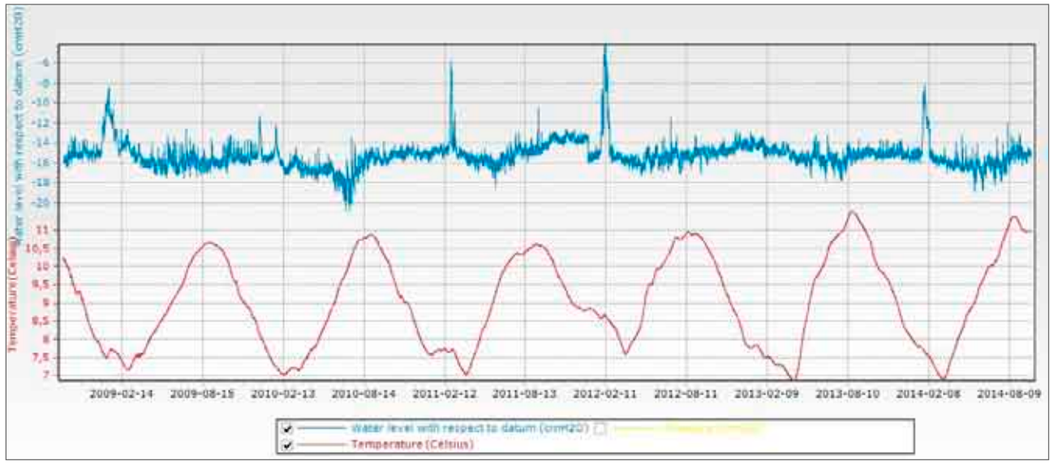


Fig. 4. Changes in level and temperature of ground water in the Ilanka V mire (data from automatic diver located at transect "A").

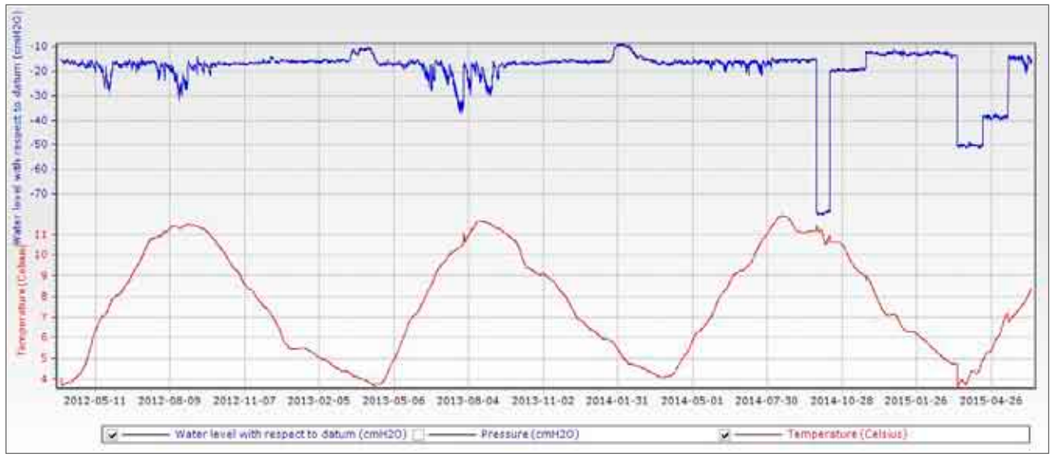


Fig. 5. Groundwater level fluctuations based on the readings of the automatic recorder at the Ilanka VI site, transect "B".

Ilanka I, transect "D"

Throughout the transect, water levels have been high and stable over the last 20 years. Only slight fluctuations in the range of ca. 15 cm were observed. The surface layer of peat is weakly decomposed. The surface of the mire is a floating mat, rising or falling with the fluctuations of the water table. No protective measures were carried out within the transect. During the observation period of 20 years, the vegetation did not undergo any significant changes (Fig. 6), except for partial loss of a small patch of swamp sawgrass in point D6.

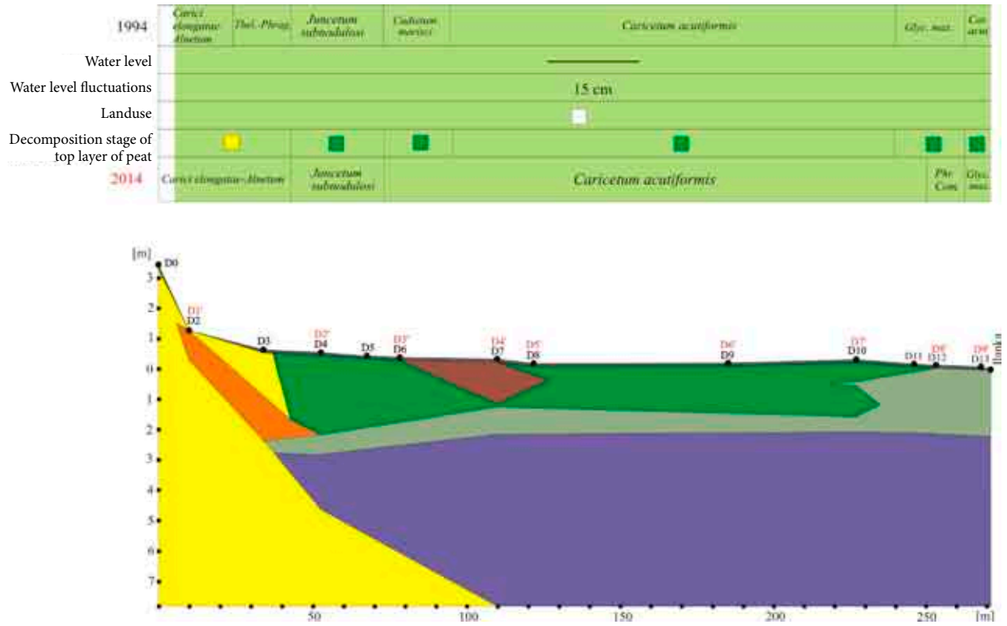


Fig. 6. Distribution of plant communities at the "D" transect (Ilanka I) between 1994 and 2014 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat.

Legend (applies to all the transects)

Water conditions

- Stable water conditions, small amplidute of groundwater levels due to natural causes (precipitation)
- Small rise, systematic rising of groundwater level during the observation period, within the range of 5 - 15 cm
- Strong rise, systematic rising of groundwater level during the observation period, within range of 15 - 25 cm
- Very strong rise, systematic rising of groundwater level during the observation period, above 25 cm
- Alternately strong rise and decrease of groundwater level

Protection measures

- Lack of management and protection measures
- Extensive landuse of sporadic protection measures of no more than 1 – 2 times of mowing and/or 1 – 2 times of tree removal within 10 years period
- More intensive use by more than 2 Times of mowing and/or tree removal within 10 years period

Decomposition grade of Surface peat layer (von Post scale)

- Below 4
- 4-6
- 7-10

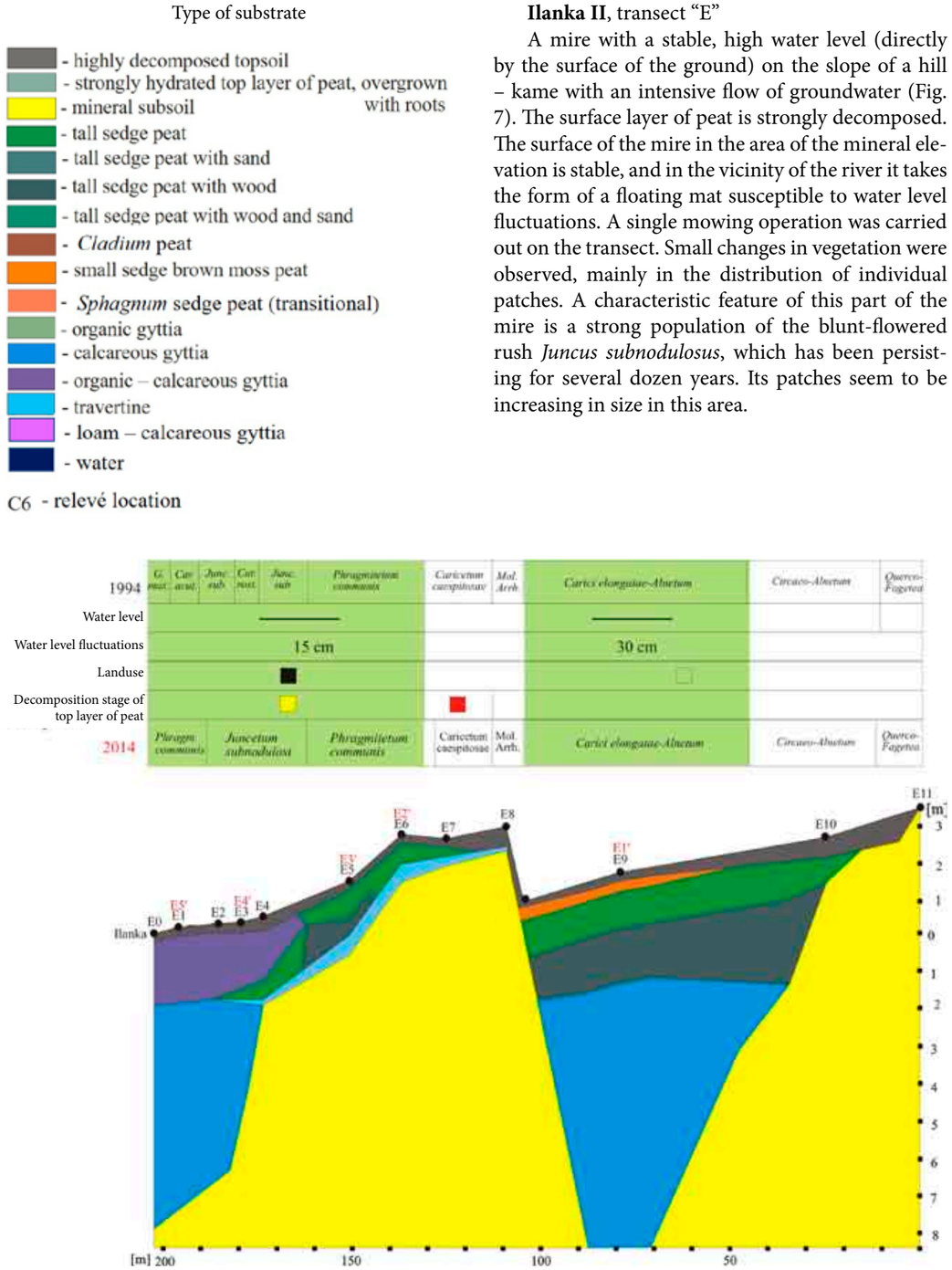


Fig. 7. Distribution of plant communities at the "E" transect (Ilanka II) between 1994 and 2014 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat.

Ilanka II, transect "E"

A mire with a stable, high water level (directly by the surface of the ground) on the slope of a hill – kame with an intensive flow of groundwater (Fig. 7). The surface layer of peat is strongly decomposed. The surface of the mire in the area of the mineral elevation is stable, and in the vicinity of the river it takes the form of a floating mat susceptible to water level fluctuations. A single mowing operation was carried out on the transect. Small changes in vegetation were observed, mainly in the distribution of individual patches. A characteristic feature of this part of the mire is a strong population of the blunt-flowered rush *Juncus subnodulosus*, which has been persisting for several dozen years. Its patches seem to be increasing in size in this area.

Ilanka III, transect "F"

In the observations period, a significant increase of the water level was noted, leading to an almost complete flooding of the mire. The surface layer of peat is decomposed to a medium and strong degree. The surface of the mire is fairly stable with limited capacity of vertical movement along with water level fluctuations. Within the whole mire, protective actions were carried out consisting of two removals of tree wildings and mowing with the removal of biomass. In the period of 20 years, meadow and moss vegetation disappeared completely in favor of reeds (Fig. 8, photo. 12 a,b,c).

In the current situation, restoration of fen vegetation in the next few years probably will not be possible. The site, due to the existing situation, despite the risk of losing a small patches of the sedge – moss vegetation of a relatively average quality, should be left without human intervention, because the registered changes will give the opportunity to assess the natural regenerative capacity of alkaline fens in the situation of pressure from the beavers.

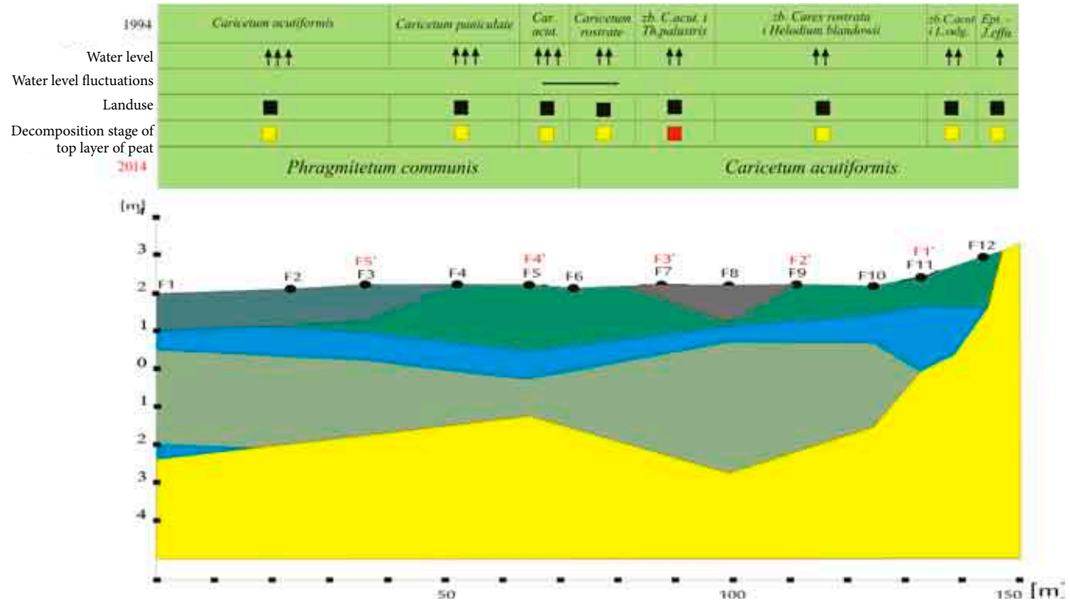


Fig. 8. Distribution of plant communities at the „F" transect (Ilanka III) in the years 1994 and 2014 in relation to water conditions, management measures, intensity of landuse and decomposition grade of peat.

Photo 14 a,b,c: View of transect „F” (Ilanka III) in years 2008-2014 (photo R. Stańko).

Ilanka IV, transect “Y”

Over the last several years, the site was characterized by a stable water level, partially dependent on the water level of the nearby Pnióww Lake, and the gates on the ditch built at the beginning of the 2000s. Reed vegetation dominates the site – mainly lesser pond-sedge (*Caricetum acutiformis*) association, locally with some blunt-flowered rush. Among the species characteristic for alkaline mires, small populations of *Helodium blandowii* were observed on the outskirts of the mire. The site is also an important location for the population of several species of wetland birds breeding in the Dolina Ilanki Reserve. As a part of the project, alder wildings were removed and a single mowing operation was carried out to maintain the open nature of the site. Observations of vegetation indicate its relatively stable character. In the next few years no additional protective measures are foreseen.

Ilanka V, transect “A”

The records of water level fluctuations over the five-year measurement cycle indicate relatively small fluctuations (ca. 15 cm) in the perimeter zone of the mire (point A3). In the part of the transect situated below (points A6 – A14), greater fluctuations and a significant increase (by at least a dozen cm) in the water level were noted as a result of the impact of the beaver dam on the Ilanka River. The surface of the mire remained stable although the surface layer of peat is in a state of medium and strong decomposition. Within the transect, 2 tree wildings removal procedures and 4 mowing operations have been carried out in the last 20 years.

A comparative analysis of the collected phytosociological material indicated a gradual disappearance of meadow vegetation with elements of mosses in favor of reeds, mainly *Phragmitetum australis* (Fig. 9, Photo 13). The site is one of a very few examples of the low effectiveness of the undertaken protection activities. The observations carried out in the Dolina Ilanki area as well as within other sites included in the project indicate the necessity of intensifying the protection activities in order to improve the condition of the plant communities characteristic for the habitat 7230. This task may be difficult to perform in the future due to ownership conditions.

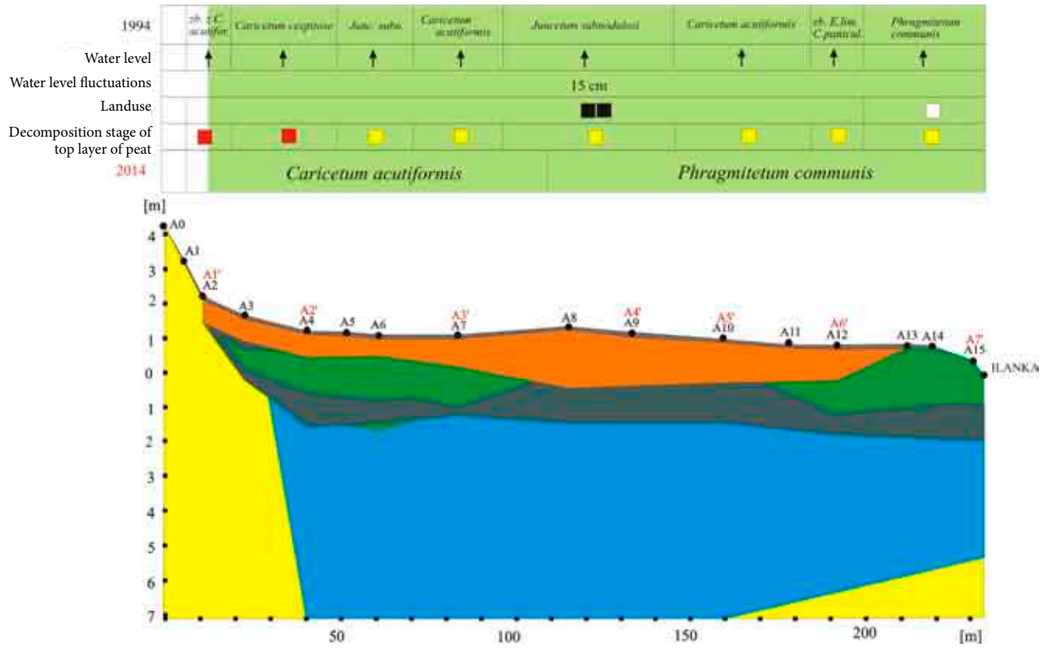


Fig. 9. Distribution of plant communities at the “A” transect (Ilanka V) between 1994 and 2014 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat.

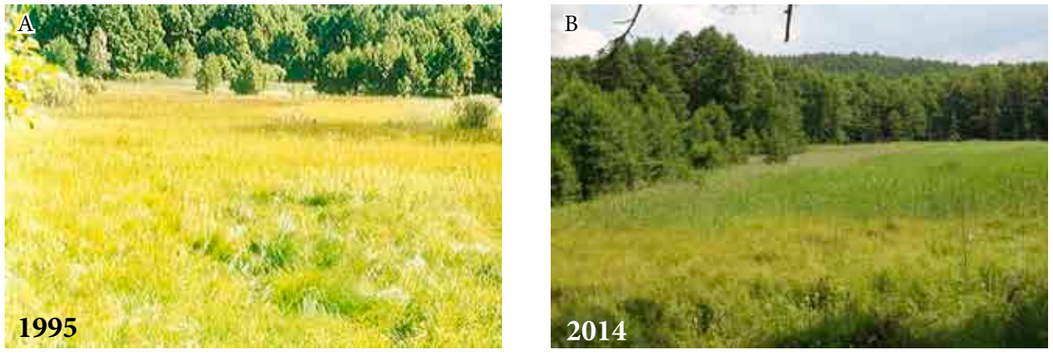


Photo 15 a,b. View of transect „A" in the nature reserve „Dolina Ilanki". At the center of 1995 photo a dark-green patch of *Juncus subnodulosus* is visible (photo R. Stańko).

Ilanka VI

On the basis of a comparison of the map of vegetation prepared for the site in 1995 with the results of the phytosociological analysis carried out within the transect "B", it was concluded that both the qualitative and quantitative state of the individual plant communities did not change significantly. The observed changes within the entire site consisted in an increased share of reed species at the expense of meadow and mire species, and the expansion of forest vegetation. These changes are mainly due to the land use method, i.e., the gradual disappearance of the mowing operations. Limiting the expansion of reed vegetation, e.g., in the area of patches dominated by blunt-flowered rush, was possible thanks to occasional protective activities, while the development of forest plant communities was limited by the removal of trees and tree wildings. The maintenance of vegetation characteristic for habitat 7230 (in this particular site – patches of blunt-flowered rush) will require the continuation of extensive mowing operations in the future. These activities are included in the draft conservation plan for the Dolina Ilanki II Reserve.

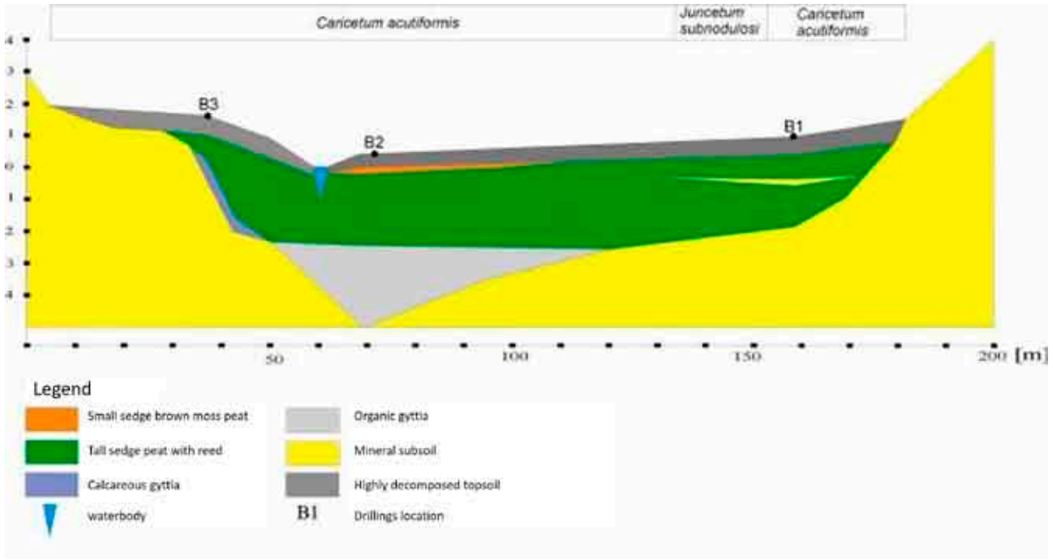


Fig. 10. Stratigraphic cross-section (transect B) through the mire in the Dolina Ilanki II Reserve.

Ilanka VII

In the current situation, restoration of fen vegetation in the next few years probably will not be possible. The site, due to the existing situation, despite the risk of losing a small patches of the sedge – moss vegetation of a relatively average quality, should be left without human intervention, because the registered changes will give the opportunity to assess the natural regenerative capacity of alkaline fens in the situation of pressure from the beavers.

Ilanka VIII

The observations of the vegetation over the last 20 years have not shown any significant changes in vegetation (the site is entirely overgrown with Phragmitetum australis reed) in the situation of maintaining favorable hydrological conditions with simultaneous abandonment of mowing.

Natura 2000 site "Dolina Pliszki" PLH080011

A refuge with the surface area of more than 3,000 ha covering almost the entire valley of the Pliszka River from its springs to its estuary, together with its edges and parts of forest complexes located on the hills and a part of its tributary – Konotop. Like the Ilanka, the river is a tributary of the Oder. The groundwater that feeds it mainly infiltrates areas of sandy sandurs. The surface and underground catchment areas of the river are covered with forests (a forest cover of ca. 85%), mainly pine forests. The natural values of the Pliszka River Valley are described in detail in numerous papers, including popular scientific publications, such as Wołejko and Stańko (1998). Until 1945, the mires in the Pliszka River Valley (except for small, wettest parts) were used as hay meadows after they had been drained. Agricultural use was gradually abandoned in the following years finally to cease completely in the 1990s. Since the abandonment of the argicultural use of the mires, the expansion of scrub and forest vegetation has been observed here.

Fig 11. Historical map (ca. 1930) of the mires in the Kijewo site. The area is entirely used as meadows and strongly intersected by drainage ditches, which indicate the high intensity of agricultural use and strong outflow of groundwater. At present, most ditches have completely disappeared. The process of abandoning the agricultural use applies to all mires in the Pliszka River Valley and the neighbouring Ilanka River Valley.

Despite the above-average natural values described in the documentation and applications for the establishment of a network of reserves to protect the most valuable parts of the valley, it was only in 2016 that two reserves were created at the request of the Naturalists' Club (within the LIFE project): "Mechowisko Kosobudki" (with a surface area of approx. 12.5 ha) and "Jezioro Ratno" (with a surface area of approx. 49 ha).

The mires of the Pliszka River Valley are one of Lubuskie Province's best-preserved moss and spring mires with a through-flow of groundwater. They can be found here in interconnected complexes. The valley has the province's largest populations of species characteristic for habitat 7230, such as *Paludella squarrosa, Helodium blandowii, Tomentypnum nitens.* Among vascular plants, the still numerous populations comprise blunt-flowered rush, fewflower spikerush and marsh helleborine. One of the biggest peculiarities of the valley is the active process of terrestrialization of the Ratno Lake due to the development of a floating mat inhabited by a relatively large population of a fen orchid, estimated at about 60 specimens in 2016.

Within the area, seven sites were identified for the purposes of the project – Konotop, Kosobudki I and II, Kijewo, Pliszka, Wielicko and Ratno mires, which are either parts of larger mire complexes or independently functioning mires.

Active protection measures in the area focused mainly on mowing the mires and removing tree wildings, limiting the negative effects of flooding the mires due to beaver activity and improving hydrological conditions through the construction of earth damlets on former drainage ditches (see chapter 1.5.2). Hydrological monitoring was carried out with-

in selected sites (Kosobudki II, Kijewo) by means of automated measuring devices and phytosociological monitoring was conducted on designated transects, as well. On the basis of the information obtained as part of the project and the research conducted at an earlier time, the effects of the protective measures undertaken and the changes that had occurred in the area over almost the last 20 years have been assessed. The location of individual sites and selected monitoring components (including research transects) is presented in Fig. 12

Fig. 12. Location of individual sites in the Dolina Pliszki area together with the distribution of research transects and hydrological monitoring points.

Konotop

A fen in an ancient terrestrialized lake basin. The most developed patches of vegetation characteristic for habitat 7230 are located in the vicinity of mineral edges constituting the southern and western boundary of the site. There are large patches of blunt-flowered rush and well-preserved patches of a *Menyantho-Sphagnetum teretis*. The area is entirely privately owned. As part of the Life project, natural documentation was prepared for the implementation of the agri-environmental programme and water conditions were optimized by reducing the backwater level caused by the beaver dam. Each year, the area is mowed down to 50% and biomass is removed. Independent monitoring is carried out on the site by the Chief Inspectorate of Environmental Protection.

Photo 16. Konotop – view on the central part of the mire (yellow-brown colour of the vegetation in the central part – patches of blunt-flowered rush) (photo R. Stańko).

Kosobudki I

A fen located in a partially isolated lake basin in the immediate vicinity of the village of Kosobudki. It is mostly covered with alders. Only the southern part of the complex, which has a surface area of approx. 3 ha, has maintained its open character (the area had been used as a meadow until the end of the 1980s). The best-preserved patches of moss vegetation developed in the border zone of the fen with a strong influence of groundwater.

Reserve "Mechowisko Kosobudki" (Kosobudki II)

A compact mire complex of about 14 ha split apart by the Pliszka River. It is overgrown with alders to approx. 60%. The remaining part is covered by soligenous mires with a groundwater through-flow, which change locally into dome-like spring mires (one of the best preserved in the region). Here, the patches of moss vegetation occupy the largest surface area in relation to the whole area of the Pliszka River Valley.

Photo 17. General view of the site vegetation dominated by Phragmitetum australis (photo R. Stańko).

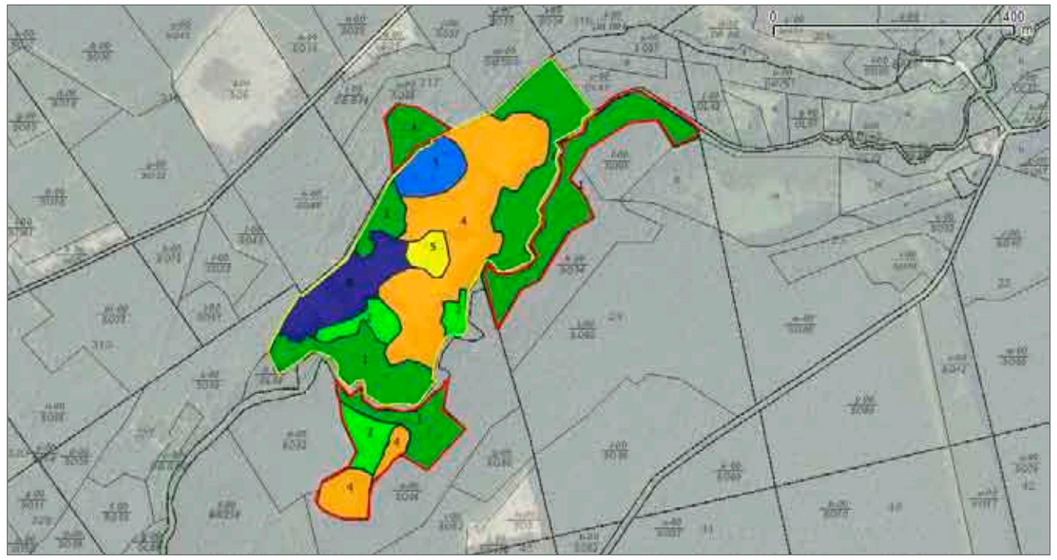


Fig. 13. Simplified map of actual vegetation.

Explanations: 1 – *Fraxino-Alnetum* (directly by the river) and *Cardamino-Alnetum* alder forests entering moss communities, 2 – alder wildings on moss fields, 3 – mosaic of *Caricetum acutiformis, Caricetum appropinquatae and Caricetum diandrae* under the strong influence of the surface waters flowing from the spring dome adjacent to the area, 4 – *Menyantho-Sphagnetum teretis* in various variants, 5 – meadow communities of *Molinio-Arrhenathereta* – raised humid and fresh meadow, 6 – mosaic of *Caricetum acutiformis*, *Scirpetum sylvatici and Angelico-Cirsietum oleracei*, and numerous patches of *Menyantho-Sphagnetum teretis* in the hollows and along the ditches.

Photo 18 a, b. The value of the site is enhanced by other habitats occurring in the alkaline mire complex, i.e. a river covered with *Ranunculion fluitantis,* wet forest of *Alnenion glutinoso-incanae* and dome-shaped spring mires (photo R. Stańko).

Photo 19. A part of the mire bought by the Naturalists' Club as part of the project. There is a meteorological station installed in the far distance (photo R. Stańko).

Photo 20. One of the gates built on a ditch draining the mire as part of the project (photo R. Stańko).

Kijewo

A part of a mire complex with a surface area of several dozen hectares in the former lake basin split apart by the Pliszka River. The site is partially covered by tall sedges vegetation, with domination of lesser pond-sedge association *Caricetum acutiformis*. Only small patches have retained their mossy character.

Photo 21. The best-preserved patches with fewflower spikerush before the removal of alder wildings (photo R. Stańko).

Torfowisko Pliszka (Pliszka Mire)

The largest mire complex in the Pliszka River Valley, split apart by the naturally meandering river. The main vegetation consists of Caricetum mixed with Phragmitetum australis. The best developed patches of vegetation typical for alkaline mires occupy the area of mineral edges of the southern part of the mire complex (where stratigraphy identified sedge and moss peats, as well – see Fig. 14).

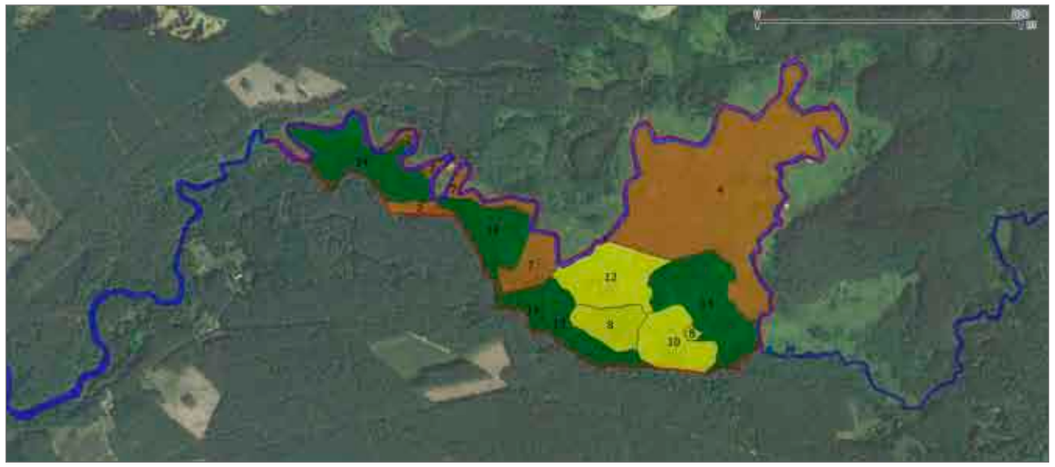


Fig. 14. Simplified map of actual vegetation
4 – mosaic of Caricetum, Caricetum mixed with Phragmitetum, and Typha latifolia, 7 – lesser pond-sedge *Caricetum acutiformis*, 8 – *Menyantho-Sphagnetum teretis* overgrown with alders, 10 – *Menyantho-Sphagnetum teretis* in different variants and a mosaic with *Caricetum appropinquatae,* 12 – *Menyantho-Sphagnetum teretis* – initial form in a mosaic with reeds, 13 – *Fraxino-Alnetum*, 14 – *Cardamino-Alnetum*. The water vegetation in the Pliszka riverbed is marked in blue.

Photo 22. Sedges changing into moss communities with common cottonsedge on the research transect P (photo R. Stańko).

Reserve "Jezioro Ratno"

A natural eutrophic flow - through lake slowly undergoing terrestrialization, under reserve protection since 2017. The values of the site include, among others, a large spring complex located along the southern shore of the lake, one of the few locations of water caltrop *Trapa natans* and a location of fen orchid. However, the most noteworthy is the process of slow terrestrialization of the reservoir and the expansion of the mire vegetation, which is the habitat base of the expanding fen orchid population. Taking into account the surface area of the lake and the potential area for the development of mire habitats, it can be expected that the fen orchid population will develop dynamically in the future. Therefore, ultimately no active protection measures other than the efforts to establish a reserve and draft a protection plan were undertaken within the framework of the project.

Photo 23. The Ratno Lake – a view of a wide strip of reeds from the southern side (photo R. Stańko).

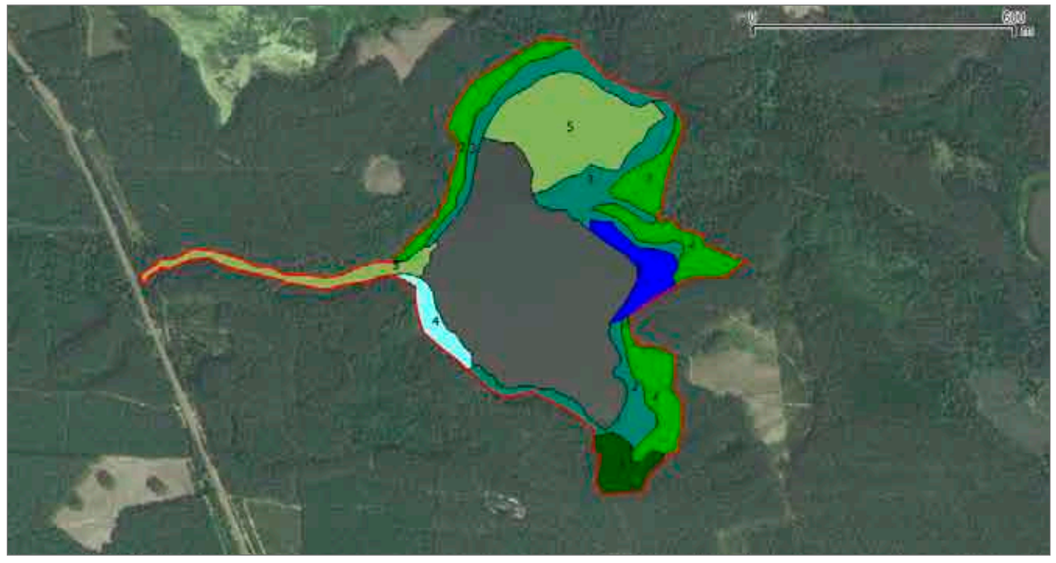


Fig. 15. Simplified map of vegetation. 1 – *Cardamino-Alnetum* forests in a spring complex, 2 – alder forests with *Carici elongatae-Alnetum* alders, 3 – a mosaic of reed and water vegetation with a predominance of *Typhetum latifoliae* and *Thelypteridi-Phragmitetum*, 4 – *Thelypteris palustris* floating mats in a mosaic with reeds, 5 – *Nymphaeo albae-Nupharetum luteae, Lemno-Hydrocharitetum morsus-ranae* water vegetation, 6 – *Trapetum natantis*.

Wielicko

The site is a large complex of terrestrialisation mire above the Wielicko Lake. The parts of open alkaline mires identified in the 1990s contained only residual moss vegetation. The site is not distinguished by significant natural values (only a few species characteristic for alkaline mires, such as marsh helleborine, which occurs here in large numbers, *Tomentypnum nitens*, which is relatively rare here) and quickly overgrows with forest vegetation. Nonetheless it still plays a key role in maintaining the full diversity of vegetation in the Pliszka River Valley and the full gene pool of the plant species characteristic for alkaline mires occurring here. Therefore, within

Photo 24. A part of the Wielicko open alkaline mire before the removal of scrubs and trees (photo R. Stańko).

the framework of the project, actions were taken to stop the expansion of forest and scrub vegetation into the open mires. The removal of trees and the resumption of extensive mowing seem to guarantee the maintenance of habitat 7230 together with its characteristic vegetation in the long term.

Monitoring

For the purposes of this report, the description of the activities and their results for the area has been prepared on the basis of selected transects - namely "B", "C", "J" (Kosobudki II) and "K" (Kijewo). The analysis of the evolution of vegetation within the transects was based on the data collected between 1995 and 2014. Protective measures included: optimization of the water conditions through the construction of dams on drainage ditches (Kosobudki II) and regulation of the water level within the existing

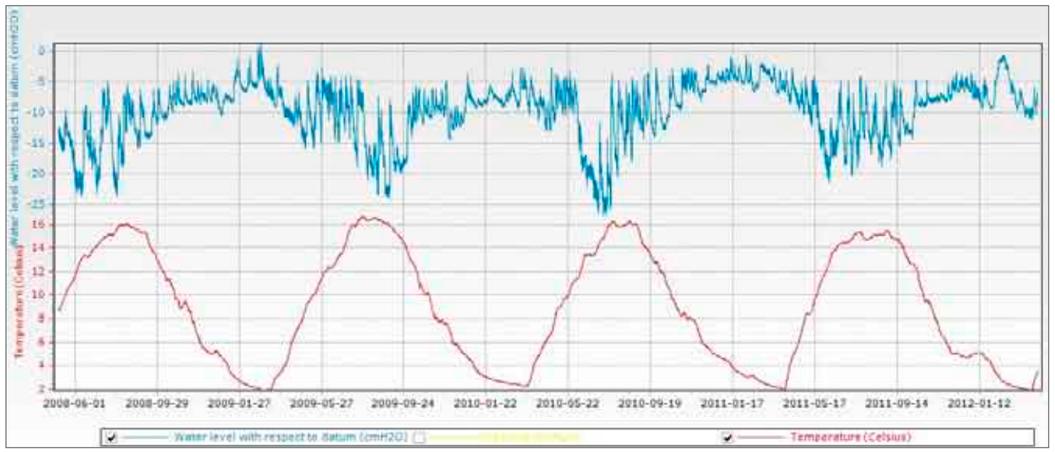


Fig. 16. Changes in the level and temperature of the ground water in the Kosobudki II mire (data from the automatic diver located at transect "B").

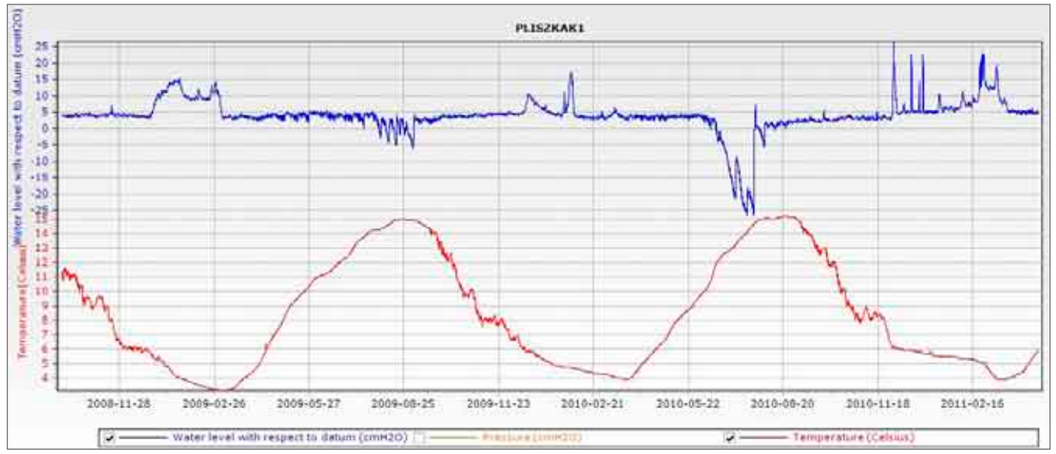


Fig. 17. Changes in the level and temperature of the ground water in the Kijewo mire (data from the automatic diver located at transect "K").

beaver dams, felling of tree wildings and mowing, together with the removal of biomass. The Kijewo and Kosobudki II mires were subjected to hydrological monitoring. Additionally, a meteorological station was installed at the Kosobudki II mire.

The period of vegetation observations is from 1995 to 2014. The protective activities for transects "B" and "K" consisted mainly of the removal of tree wildings. In 2008, extensive use of the transects "C" and "J" was restored, consisting in a single annual mowing of 90% of the area of the mire. From 2013, the mire containing both of these transects is being mown annually on 50% of its surface area.

The increase in water level noted in the transect "B" does not result from the undertaken protective activities, but is an effect of the beaver dam on the Pliszka River. The increase in the water level within the transects "C" and "J" is a result of both beaver activity and the construction of dams on the ditches draining the mire. Within the "K" transect, high and stable groundwater levels have been observed without significant changes during the observation period.

Konotop

No detailed stratigraphy studies of the peat deposit were conducted on the site. A quick reconnaissance confirms the lake origin of the mire and a relatively well preserved surface peat layer showing a strong ability to move vertically along with changes in the water level in the river. The increased degree of mineralization of the deposit was noted in slightly elevated places, in the vicinity of mineral edges.

The observations carried out over the last 10 years (including within the framework of the Chief Inspectorate of Environmental Protection monitoring) indicate that the vegetation of alkaline mires is not undergoing negative changes and, against the background of regional conditions, it is characterized by a relatively good conservation status. That is why the extensive landuse that has been carried out so far will be continued as part of the agri-environmental-climatic schemes.

Kosobudki I

In recent years the part closest to the river has been strongly flooded due to a beaver dam on the Pliszka River, which favors a strong expansion of the Phragmitetum australis reed and the disappearance of vegetation typical for moss - sedge communities. The patches of moss vegetation within the site occupy only about 10% of the surface area. The facility is monitored by the Chief Inspectorate of Environmental Protection. Both the observations carried out for the purposes of the project and within the framework of the monitoring of the Chief Inspectorate of Environmental Protection indicate that the conservation status of habitat 7230 (U2) has been maintained over the last dozen or so years. The presence of communities characteristic for habitat 7230 is ensured by the applied protection activities, including the removal of tree wildings and extensive mowing, that should be continued.

Kosobudki II

The detailed description of the site has been prepared on the basis of data collected within the selected transects presented below. The monitoring of habitat 7230 is carried out within the site as part of the Chief Inspectorate of Environmental Protection monitoring program.

Transect "B" (Fig. 18) Over the last few years of observations there has been a steady, slight increase in groundwater levels. The surface layer of peat in the central part of the transect is very well preserved as opposed to the elevated fragments located near the mineral edges of the valley. The surface of the mire is stable and only slightly susceptible to vertical movement, especially in the central part of the transect. Phytosociological studies show that there are no significant changes in the vegetation character of the entire transect except for the steadily growing surface area covered with alder.

Transect "C" (Fig. 18) During the research period, a significant increase in the water level was observed in the part of the transect closest to the river. In the vicinity of the mineral edges of the valley, the water level reached similar values. The surface layer of peat along almost the entire transect is strongly mineralized. The surface of the mire is stable, with heavily limited vertical movement capacity. In the observation period, the subsidence of reed and meadow communities in favor of forests was observed (transect fragments excluded from mowing use and protection activities). Within the remaining sections, the nature of the vegetation did not change significantly.

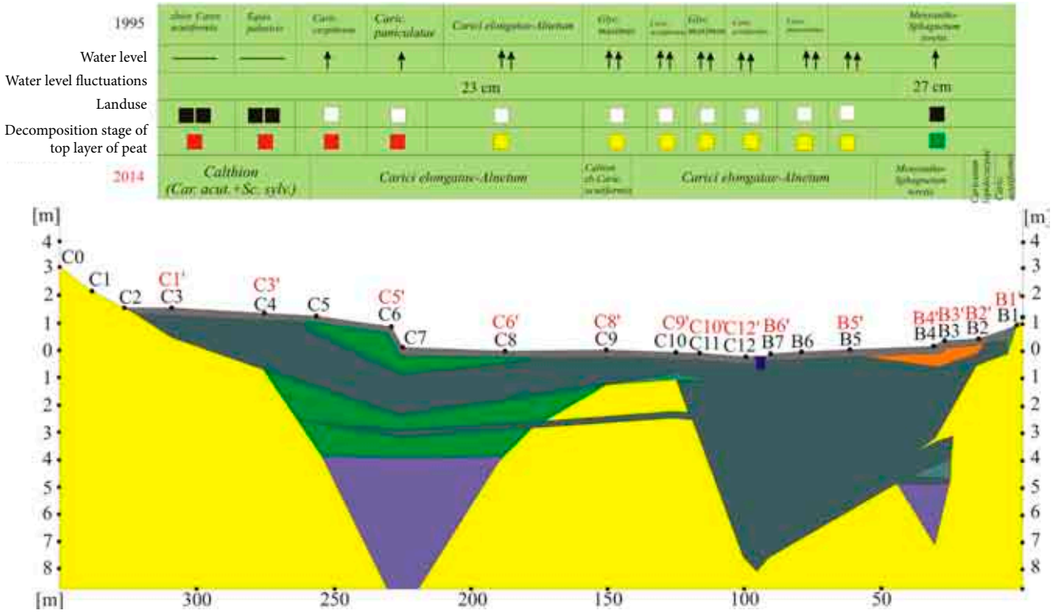


Fig. 18. Distribution of plant communities at the "B" and "C" transects between 1994 and 2014 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat in the proposed Mechowisko Kosobudki Nature Reserve.

Transect "J" (Fig. 19) On most of the transect, during the research period, an increase in the water level was observed, caused by the silting of one of the main drainage ditches, construction of dams on specific ditches and raising of the water level in the Pliszka River (impact of the beaver dams). Locally (within the points marked as J6, J7, J8, J9) flooding with waters from the dome springs of the spring mire is constantly maintained – the point marked as J2 on the transect. A surface layer of peat with a medium degree of decomposition. The surface of the mire is stable, except for the central part which takes the form of a floating mat. The changes observed in relation to the initial period of the study are a significant increase in the share of moss communities (within the scope of the implemented measures and mowing operations) at the expense of meadow and reed vegetation. In the part without protective measures, a slow expansion of alder thickets was noted.

The area for maintaining the desired vegetation requires conservation measures. Currently, it is covered by an agri-environmental scheme.

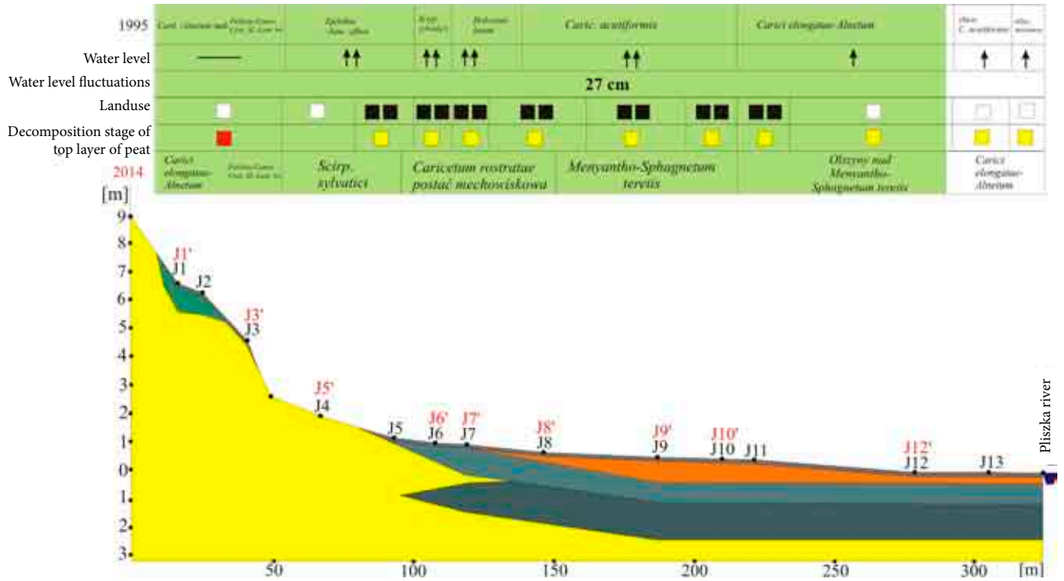


Fig. 19. Distribution of plant communities at the "J" transect between 1994 and 2014 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat in the proposed Mechowisko Kosobudki Nature Reserve.

Kijewo

The current state and changes of the vegetation in the last 20 years are described with the results of the observations carried out in transect "K" (Fig. 17). Within the transect, the groundwater levels have been very stable during the observation period. There is a surface layer of peat in different parts of the transect, with varying degrees of decomposition. The most decomposed peats in the vicinity of the dried sections of the mire are located in the area of mineral edges, and the least decomposed in the lowest parts – in the vicinity of the river. The surface of the mire is stable near the mineral edges and in the central part of the transect. In the vicinity of the river it takes the form of a moving, floating mat. Phytosociological analysis showed that the applied conservation measures contributed to the development of moss communities within the previously registered reeds, but to a limited extent inhibited the expansion of forest communities. Maintaining the present values will in the future require inhibiting the succession of alders or sporadic mowing.

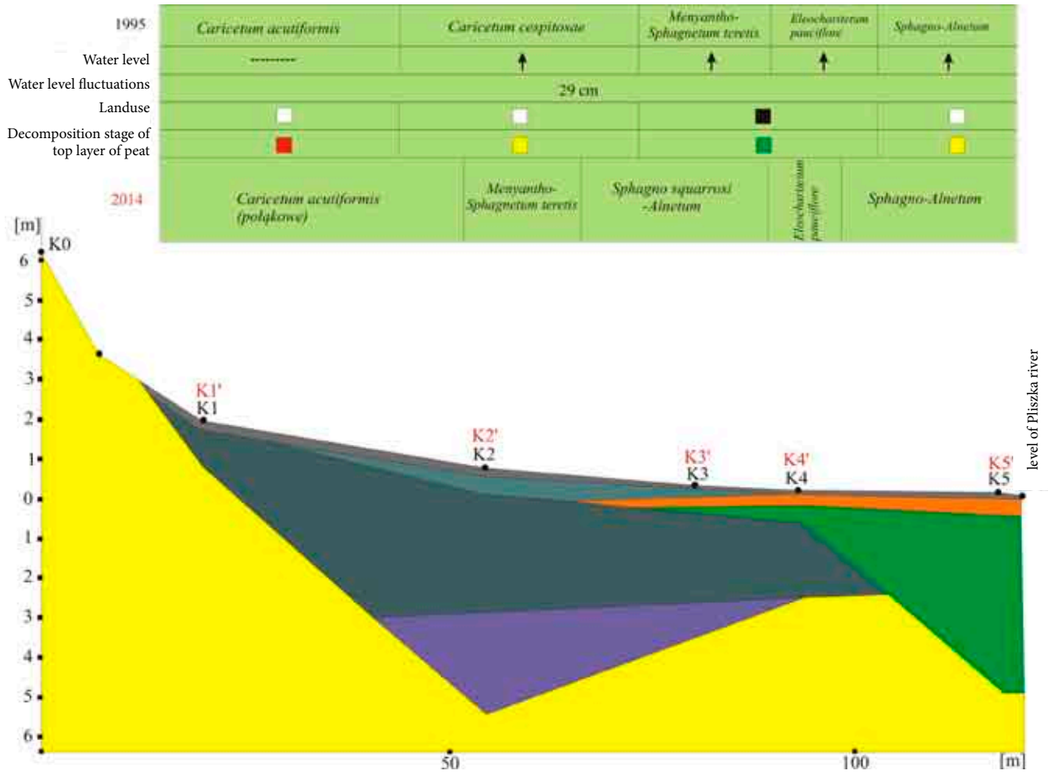


Fig. 20. Distribution of plant communities at the "K" transect between 1994 and 2014 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat in Kijewo site.

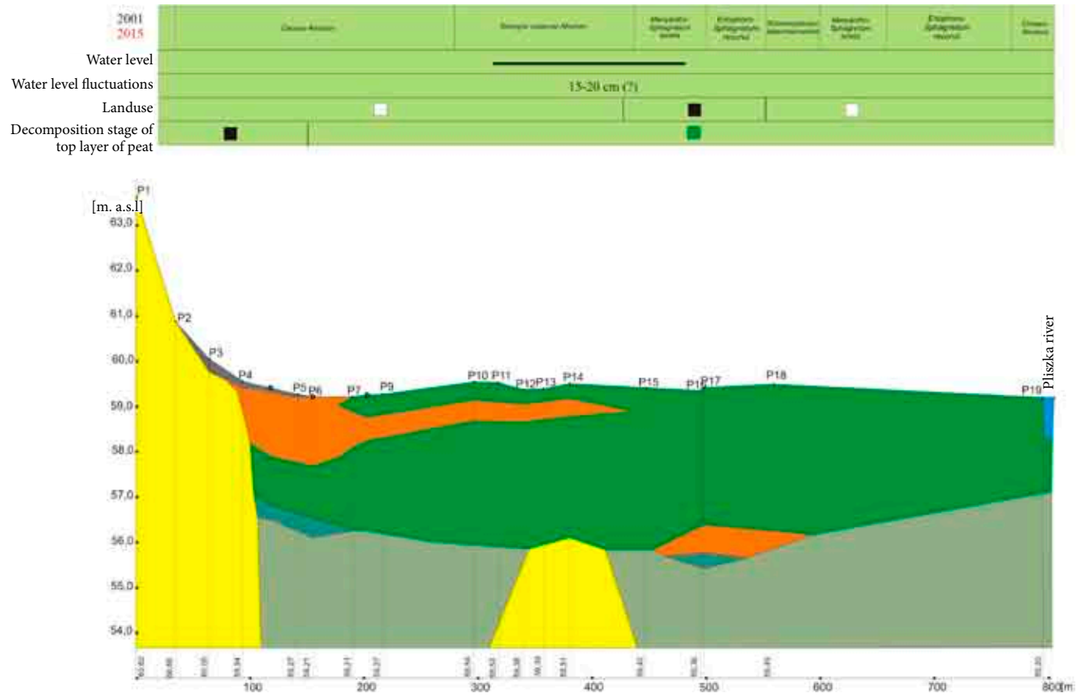


Fig. 21. Distribution of plant communities at the "P" transect between 2001 and 2015 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat in the proposed Torfowisko Pliszka Nature Reserve.

Torfowisko Pliszka (Pliszka Mire)

Fen, with the exception of the zone near the mineral edges, has a well-preserved surface layer of peat, which is very susceptible to fluctuations along with changing water levels.

The observations of vegetation carried out for several years indicate a gradual disappearance of open mires – including moss vegetation – in favor of alder forests. Within the framework of the project, due to favorable and stable water conditions, activities were undertaken aimed primarily at inhibiting the expansion of forest vegetation, i.e., the cutting down of trees and shrubs and extensive mowing. The sites is now subject of extensive mowing.

Photo 25. Proposed nature reserve "Torfowisko Pliszka" (photo R.Stańko).

Ratno

Small patches (with a total area of ca. 3 – 4 ares) of vegetation characteristic for alkaline mires, together with several fen orchids, were identified here only in the mid-1990s. (Wołejko, Stańko 1998). Since then, during occasional visits, a slow process of expansion of the thickets to the mire has been observed, as well as a slow decline in the characteristic moss vegetation, despite the persistently high water level. At the same time, since the beginning of the 21st century, a development of a characteristic floating mat on the surface of the lake has been observed, consisting mainly of the marsh fern *Thelypteris palustris*. In 2015, a new community of the fen orchid of ca. 30 individuals was observed on the hard-to-reach "fern" floating mat. In 2017, this number increased to about 60. The new community is located just a few dozen meters away from the probably no longer existing community from the 1990s. The site is a perfect example of natural succession of mire vegetation in the process of water reservoir terrestrialization as well as development of new habitats and their settlement by other species, including rare and endangered ones.

Photo 26. Fen orchid on the fern mat (photo R. Stańko).

Photo 27. Reserve „Jezioro Ratno" - the floating mat, consisting mainly of the marsh fern, has been increasing its area for several years and is a perfect habitat for the expansion of the fen orchid population (photo R. Stańko).

Reserve "Młodno"

A large (over 200 ha) independently functioning mire complex in the former kettle-like basin. It is located just a few kilometres from the Oder River in the vicinity of the village of Rąpice. The area is located on a higher terrace of the Oder valley adjacent to a sandur plain. The entire surface and underground catchment area is made up of sandy formations**.**

A 1919 historical map (Fig. 23) shows that the area of the reserve was not used entirely for agriculture. Its central part was occupied by a water reservoir. The mires around the lake were used as meadows. At that time, there were few ditches and traces of peat exploitation in the reserve. The agricultural use of the reserve was completely abandoned at the end of the 1970s.

Over 200 plant species, some of which are rare and endangered, have been found in the reserve. The area is of significant regional importance, among others, due to the presence of significant populations of broad-leaved orchid and early marsh orchid. 18 plant communities were described within the reserve. The main vegetation consists of water and reed communities and alder forests, while moss vegetation occupies small areas located mainly in the vicinity of the mineral edges of the mire. Depending on the water conditions, which are changeable here, the reserve is an important refuge for wetland birds (a dozen or so species out of nearly 50 species regularly breeding here), especially crane, snipe, greylag goose and bluethroat *Luscinia svecica* noted in 2014. Among other vertebrates, noteworthy is also European pond turtle.

The survey period covers the years from 2000 to 2015. Within the research transect, a one-time preparatory mowing was carried out involving the cutting of trees and shrubs as well as the clearing and removal of biomass. One of the protective measure was also the construction of dams on the watercourse that drained water from the area in the early 2000s. The construction of a beaver dam on the artificial dam caused heavy flooding of the entire site and in its central part – the re-creation of a water reservoir. After several years of persistent superficial flooding (until 2013), the water level fell sharply (ca. 30 – 40 cm) after the beavers left the site.

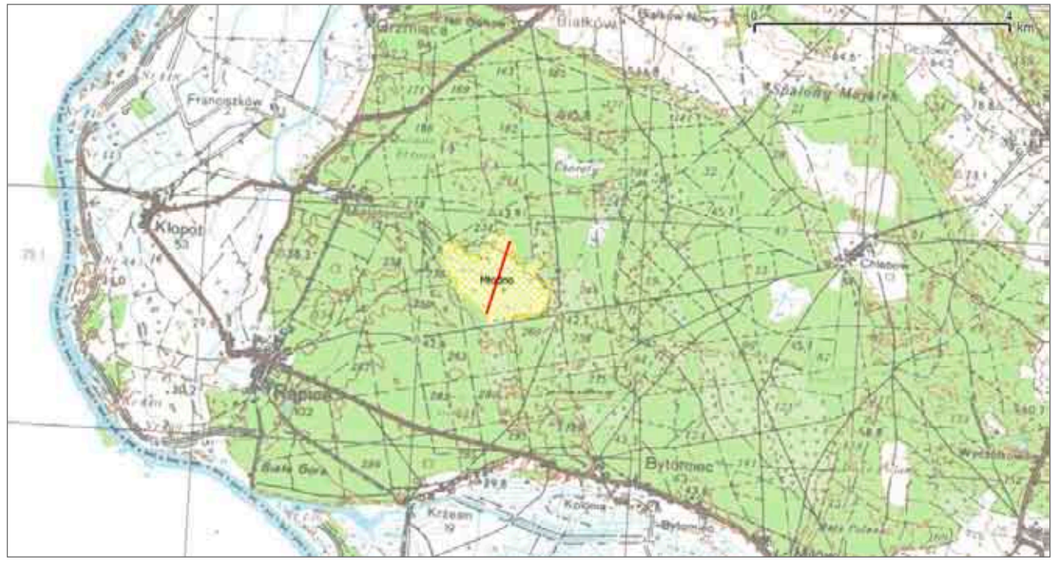


Fig. 22. Location of the area, including the course of the research transect.

Fig. 23. Topographical map of the area around the reserve on the basis of a 1919 map at a scale of 1:100,000.

The site which, during the project implementation period, was characterized by the highest fluctuations in the water level leading, among others, to long-term (lasting for several years) flooding (Fig. 15). A surface layer of peat has a low degree of mineralization. The surface of the mire is quite stable; only in the central part does it take the form of a floating mat. The observations carried out in at the beginning of the survey period showed the rapid development of reed communities due to heavy and persistent flooding. In 2013, the water level decreased, leading to the exposure of the bottom of the former reservoir. In the areas of the deepest flood, small patches of the *Bidentetea* class vegetation are formed in a mosaic with moss -rich forms sedge communities of beaked sedge *Carex rostrata* reed, slender sedge *Carex lasiocarpa*, and fibrous tussock-sedge *Carex appropinquata*, as well as typical *Magnocaricion*. The very high water level – which has been maintained for several years – did not significantly inhibit the expansion of alders.

The protective measures taken should be continued in the future, but limited mainly to sporadic mowing of selected areas in order to inhibit the possible succession of the shrubs.

Photo 28. Sedge and moss communities with a large share of orchids (photo R. Stańko).

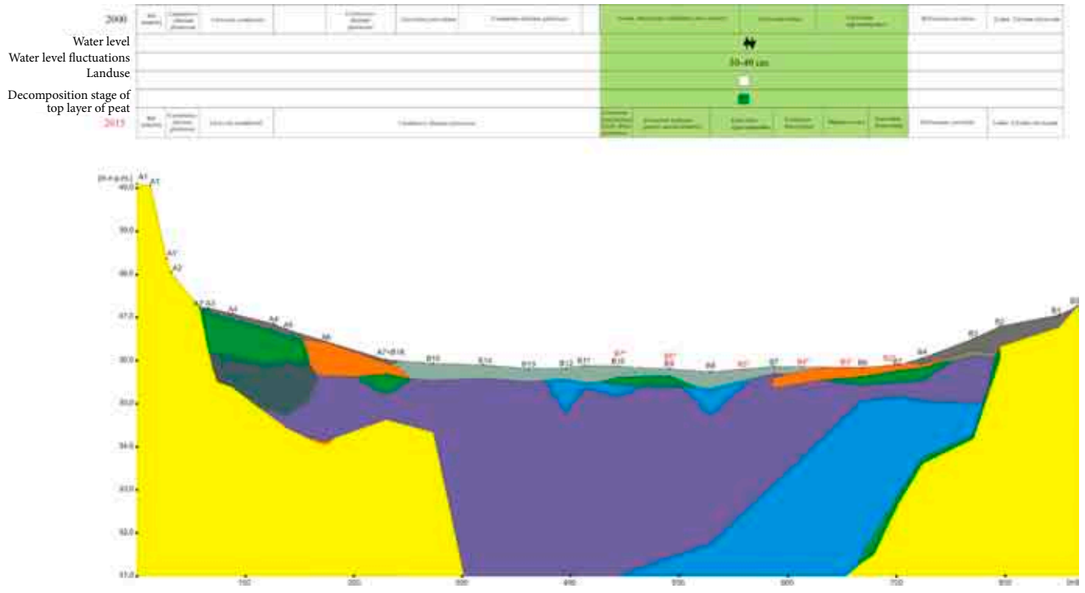


Fig. 24. Distribution of plant communities in transect "B" in individual years of the study against the conducted protective activities (intensity of use) and the degree of surface decomposition of the peat deposit layer on Torfowisko Młodno.

Wierzchołek

Proposed reserve located in the spring section of the Skicka Struga River. The neighbourhood of the planned reserve includes parts of sandur plains and moraines. An analysis of historical maps shows that until 1925, the area of the mire was not used for agricultural purposes and peat was expoited at several locations. The history of agricultural use probably began here after 1945. At the end of the 1980s, the agricultural use at the territory of the mires was abandoned.

130 vascular plant species and 23 species of bryophytes were found within the planned reserve. Among them, the numerous populations of the marsh helleborine, early marsh orchid and bryophytes *Hamatocaulis vernicosus, Tomentypnum nitens* and *Helodium blandowii* are worthy of attention. The vegetation characteristic for habitat 7230 is represented here by two associations, i.e. *Caricetum diandrae* and *Menyantho-Sphagnetum teretis*. Among the many natural peculiarities, Wierzchołek mire is distinguished by the active process of calcareous sinter precipitation, which has been the subject of previous studies (Wołejko et al. 2012).

Fig. 26. Topographic map of the area around the planned reserve from 1925 (AMPZ – Lipka).

Fig. 25. Location of the area, including the course of the research transect.

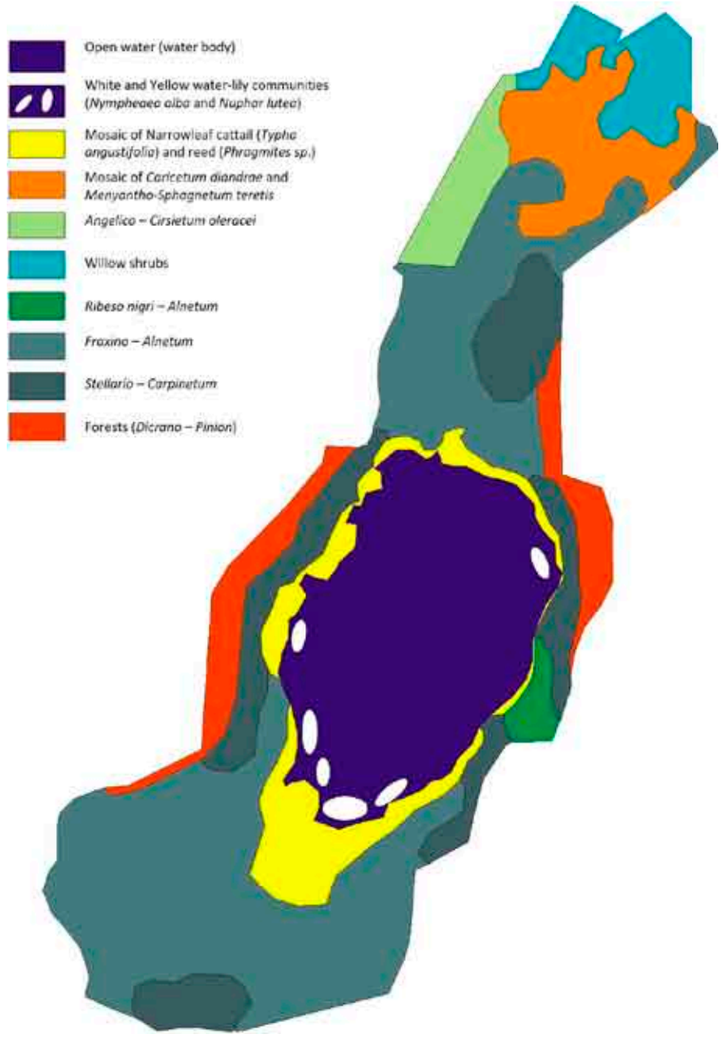


Fig. 27. Map of vegetation of the planned reserve "Jezioro Wierzchołek" (source: Stańko 2005).

In the last 10 years, two treatments of removing shrubs and tree wildings from the surface of the mire have been carried out. In 2015, a device was installed in the beaver dam to reduce the excessive accumulation of water, which threatened flooding of the mire surface. A part of the mires within the planned reserve was bought by the Naturalists' Club within the framework of the project. Despite the submission of relevant documentation, the area – despite its high natural values – has not yet been covered by reserve protection.

A mire with a stable level of groundwater supported by the Wierzchołek Lake. The surface layer of peat is well preserved without any sign of mineralization except for the part of the transect adjacent to the mineral edges (Fig. 29). The surface of the mire in the central part is a floating mat with considerable vertical movement capacity as the water level changes. Within the whole mire, small changes in vegetation were noted. The vegetation originally registered has retained its character (phytocenoses characteristic for alkaline mires). Near the mineral edges of the mire, there was a slight increase in the surface area covered by alder trees.

The preservation of the current character of the mire vegetation in the future will require the continuation of protection activities.

Photo 29. The Wierzchołek Mire after the removal of tree wildings – view of a research transect (photo R. Stańko).

Photo 30. Calcium carbonate deposited on bryophytes growing on the Wierzchołek mire (photo R. Stańko).

Fig. 28. Water level fluctuations recorded in the past in the area of the Wierzchołek mire.

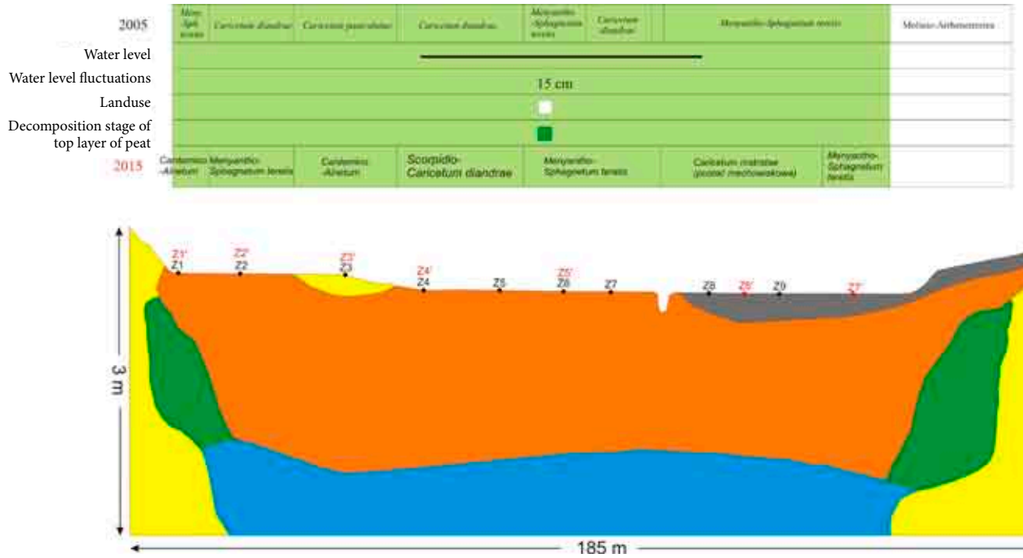


Fig. 29. Distribution of plant communities at the "Z" transect in the years 2005 – 2015 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat in the planned Jezioro Wierzchołek Nature Reserve.

Natura 2000 site "Sandr Brdy" PLH220001

Reserve "Dolina Kulawy",
Jezioro Głuche Małe 1, 2, 3 and Zapceń 1, 2

A nature reserve covering the upper and middle course of the Kulawa River together with lakes and alkaline mires in their vicinity (a naturally eroded river valley as a result of a natural geological catastrophe partially exposing the bottom of water reservoirs and springs). The reserve is located within the boundaries of Natura 2000 area "Sandr Brdy". The site is home to a great variety of orchid species, including *Cypripedium calceolus, Liparis Loeseli, Dactylorhiza majalis, D. incarnata, D. fuchsi, D. maculata, Listera ovata, Epipactis, palustris, Epipactis helleborine, Epipactis atrorubens and Coralorhiza trifida.* Information on the natural values of the valley's wetlands can be found in the studies by Boiński (1988), Prajs and

Photo 31. A mire on transect A (photo R. Stańko).

Antkowiak (2010), Utracka et al. (2007), Wołejko et al. (2012) while detailed natural data were used to prepare documentation and protection plans covering the area of the research by Wołejko et al. (2007) and Stańko et al. (2011). The catchment area consists mainly of sandur sands. The Kulawa River channel has an interesting geological structure, partly due to the interruption of the natural barrier maintaining the water level in the glacial reservoirs. As a result of erosion, in a part of the area of the Kulawa River

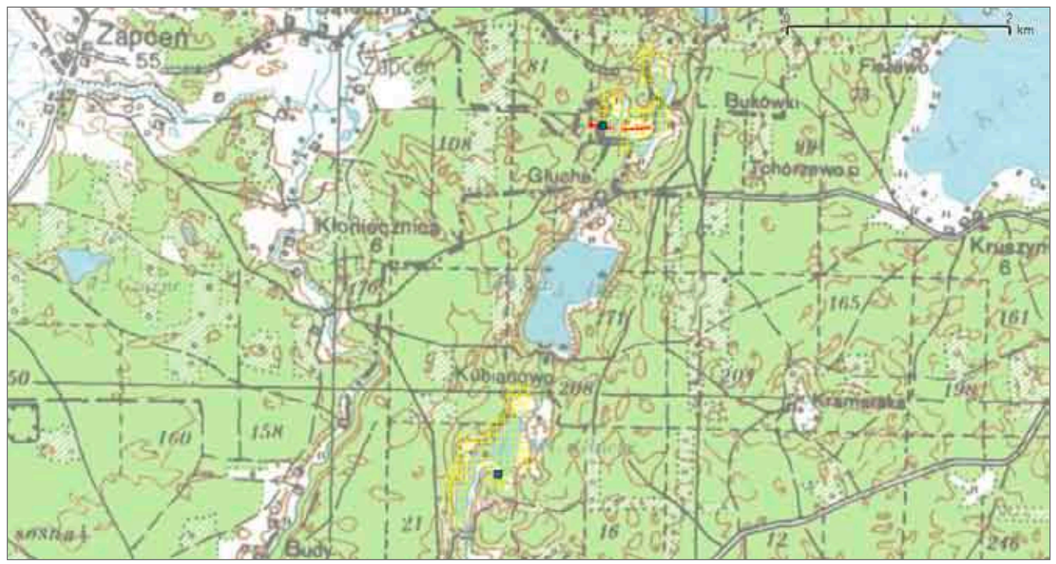


Fig. 30. Location of investigated transects (red lines) and water-level measuring devices (blue points) in the nature reserve "Dolina Kulawy".

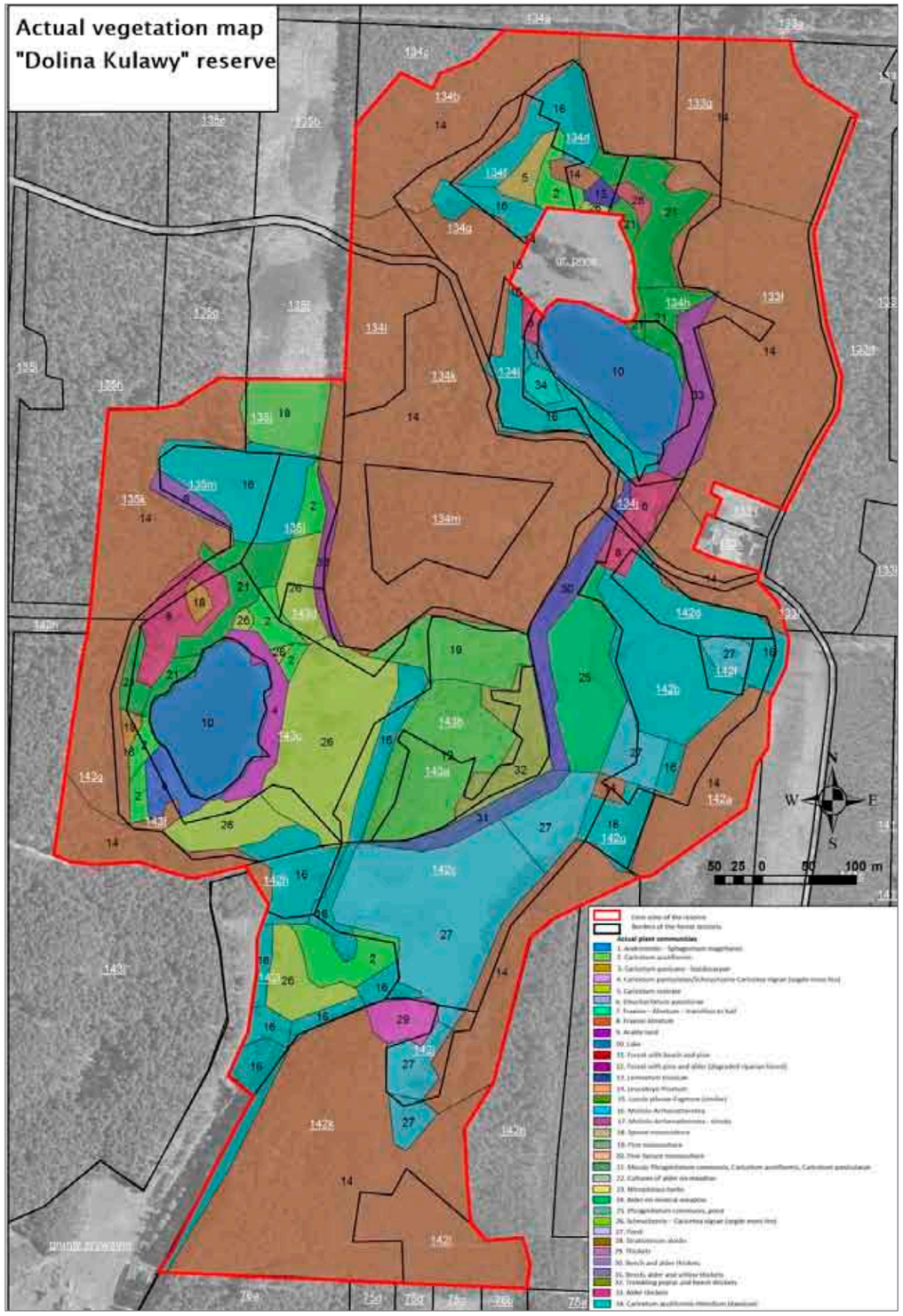


Fig. 31. Map of actual vegetation of the Dolina Kulawy Reserve – northern part including research transects.

Valley, layers of calcareous gyttja and travertine (of spring origin) lining the bottoms of former water reservoirs and the seeping valley edges were exposed (Prusinkiewicz and Noryśkiewicz 1975).

The area of the investigated mires was extensively used probably until the end of the 1980s and occasionally mown at a later stage. The research was conducted between 2003 and 2015. Within research transect "O", the protective measures included regular (annual) mowing of the vegetation along with the removal of biomass and the maintenance of a permanently high and stable lake water level by means of outflow culvert-gates. The plan for the protection of the reserve, prepared in 2011, was approved in 2017.

Hydrological and phytosociological monitoring was carried out within the research transects ("A" and "O") located in the spring section of the Kulawa River valley, by a small, nameless lake near the Bukówki forest administration house. For both transects located on opposite sides of the small lake (Fig. 31), a stable level of groundwater was recorded, depending on the constant damming at the outflow from the reservoir. In 2015, after the renovation of the existing culvert, the water level increased slightly. The degree of mineralization of the surface layer of peat varies. Very poorly distributed peats occur in the lowest parts of the mire, in the vicinity of the water reservoir. As the ground surface rises towards the mineral edges, the degree of decomposition increases. The surface of the mire in the vicinity of the reservoir is a floating mat, and it is stable in the vicinity of its mineral edges. The site underwent very intensive conservation activities consisting in near-annual mowing and removal of biomass from the entire surface area of the studied transects. The observed changes in mire vegetation indicate a slight increase in the share of moss plant communities at the expense of reeds. In the immediate vicinity of the water table, the increase in the share of phytocenoses and species associated with the moss communities results from natural succession, while in the central part of the mire it may also be associated with the protective activities limiting the share of herbaceous species (especially high sedges) in favor of brown mosses.

Fens, located especially in the vicinity of mineral edges, should be sporadically mowed in the future.

Fig. 32. Changes in level and temperature of ground water in the Dolina Kulawy mire (data from the automatic diver located at transect "A").

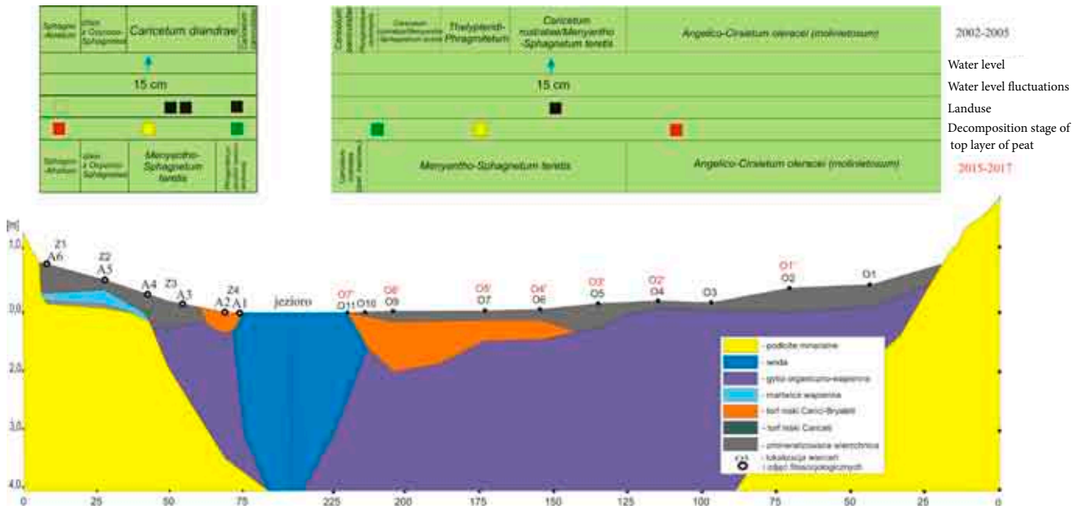


Fig. 33. Distribution of plant communities at the "A" and "O" transects in the years 2002 – 2005 and 2015 in relation to water conditions, management measures, intensity of land use and decomposition grade of peat in the Dolina Kulawy Nature Reserve.

Reserve "Bagno Stawek"

A nature reserve with a surface area of approx. 40 ha that includes a part of open alkaline mires displaced in the natural succession process by minerotrophic moss fens, a lake (the remains of a former large reservoir filling the lake basin) and alder forests in the vicinity of mineral edges. A site of outstanding natural value (locations of occurrence of several dozen rare and endangered plant species associated with alkaline mires, the occurrence of several plant complexes extremely endangered and associated with this type of mire) known for several decades from various scientific reports. It is one of the most valuable sites of this type in the country. The reserve is located in a sandur area and surrounded by a very large forest complex (Tuchola Forest) dominated by poor pine forests. In the vicinity, there are numerous water reservoirs, including a large part of hard-water lakes dominated by charales and lakes dominated by water lobelia.

Fig. 34. Location of investigated transect (red line) and water-level measuring device (blue points) in the Bagno Stawek nature reserve.

Photo 32. The Bagno Stawek Reserve – a part of a mire complex located in the vicinity of the lake after the removal of tree wildings (photo R. Stańko).

Within the limits of the reserve, over 150 species of vascular plants and 63 species of bryophytes were found. Among vascular plants, several dozen are protected, rare or endangered species. Among them, the biggest peculiarities are marsh saxifrage, fen orchid, string sedge and dioecious sedge. Among bryophytes, the reserve is distinguished by the presence of significant populations of species such as *Cinclidium stygium, Hamatocaulis vernicosus, Helodium blandowii, Meesia triquetra, Paludella squarrosa, Pseudocalliergon trifarium, Scorpidium scorpioides, Sphagnum warnstorfii and Tomentypnum nitens.*

In the area, there are numerous, well-formed phytocenoses characteristic for alkaline mires.

In the reserve, monitoring is conducted by the Chief Inspectorate of Environmental Protection for habitats 7140 and 7230 and for marsh saxifrage.

The conducted observations indicate stable and favorable hydrological conditions of the whole mire complex and its relatively high "resistance" to forest vegetation overgrowth. The favorable hydrological conditions are probably one of the most important causes for the inhibition of tree regrowth after the implementation of protective activities.

The stratigraphic study of the reserve has confirmed the excellent preservation of organic sediments, including moss and moss-sedge peats. The surface of the mire is susceptible to changes in groundwater levels.

During the project implementation period, no significant changes in the vegetation cover were noted within the delineated research transects.

Probably in the next dozen or so years, the mire will not require protective measures except sporadically removing individual tree suckers

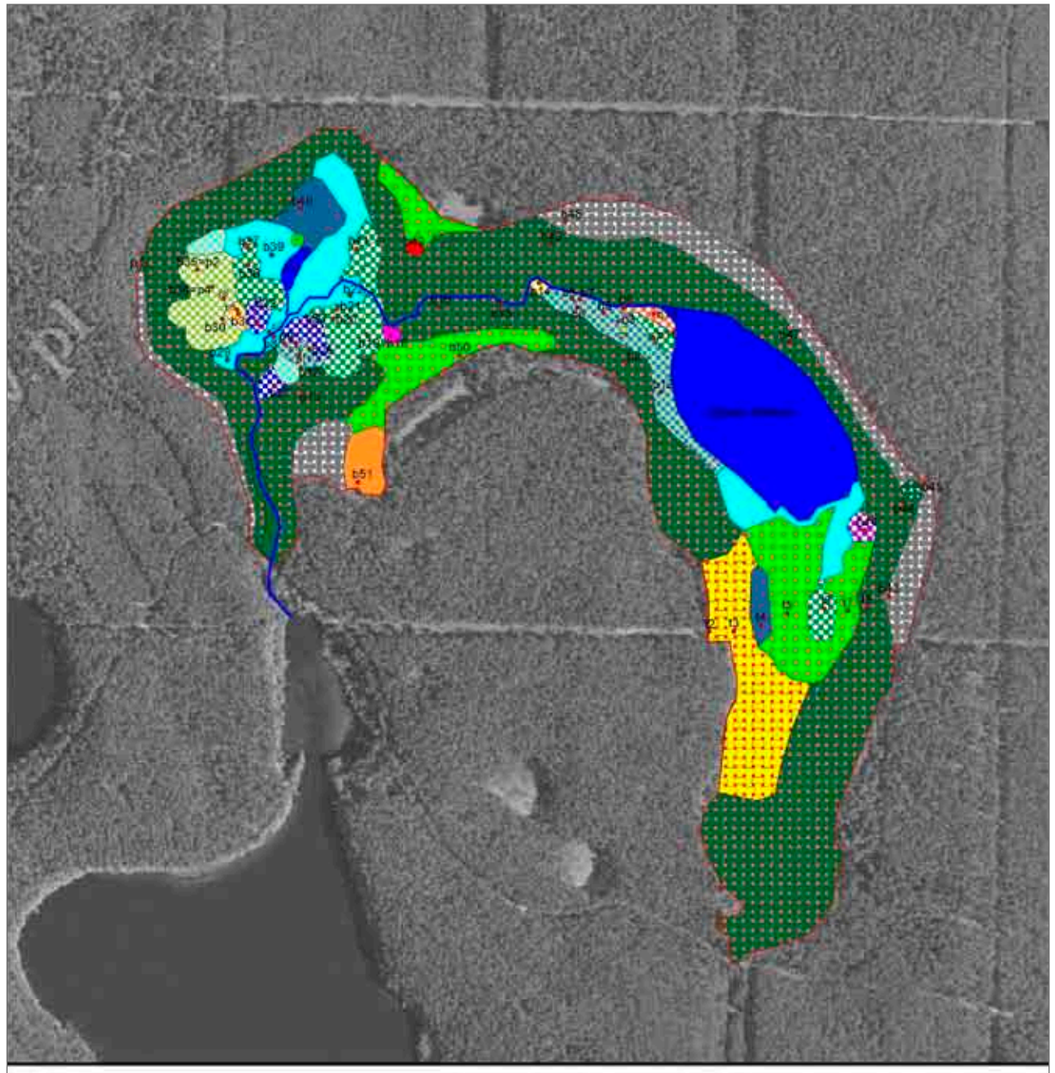


Fig. 35. Map of actual vegetation as an example of vegetation diversity in one of Poland's best-preserved mire complexes including moss fields (Stańko et al. 2009).

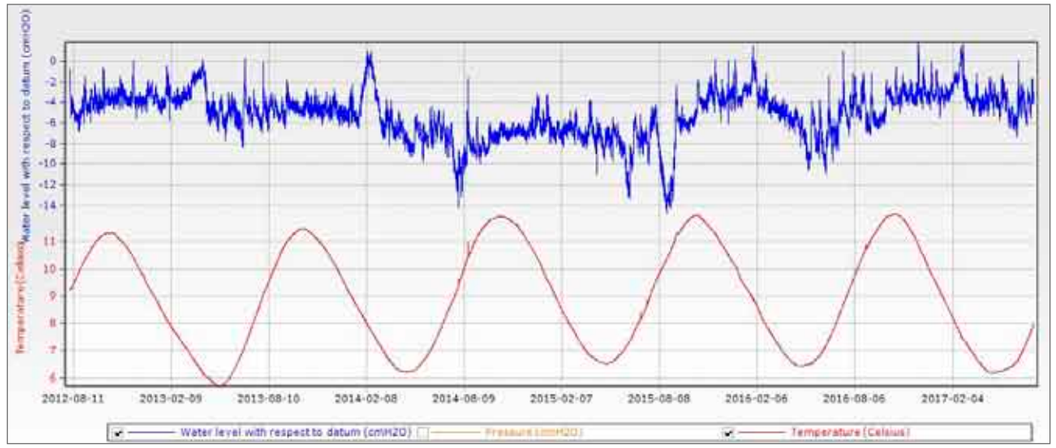


Fig. 36. Changes in level and temperature of ground water in the Bagno Stawek mire (data from the automatic diver located at transect "P").

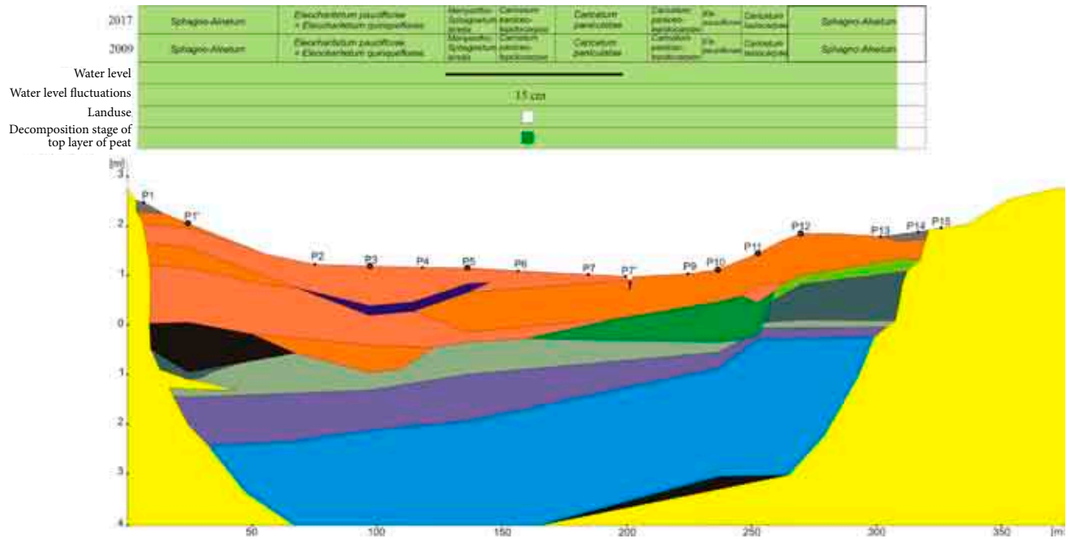


Fig. 37. Distribution of plant communities at the "P" transect between 2009 – 2017 in relation to water conditions, management measures, intensity of land use, and decomposition grade of peat in the Bagno Stawek Nature Reserve.

Natura 2000 site "Ostoja Zapceńska" PLH220057

Reserve "Mechowisko Radość"

A nature reserve with a surface area of approx. 9.6 ha. established within the framework of the project for the protection of alkaline mires. The reserve is located within the boundaries of the sandur Charzykowska Plain, which is overgrown with poor pine forests. The reserve covers the best-preserved part of the complex of open mires located in the terrestrialized bay of the Kielskie Lake in the immediate vicinity of the town of Luboń. North-western part of the mires was used for grazing until recently (year 2014). Numerous locations of occurrence of various species, such as *Saxifraga hirculus, Liparis loeselii, Cinclidium stygium* and *Pseudocalliergon trifarium*, make this site one of the most valuable in the country from the viewpoint of the protection of alkaline

Fig. 38. Location of water-level measuring device (blue points) in the Mechowisko Radość nature reserve.

mires. Numerous well-preserved phytocenoses characteristic of alkaline mires can be found here (see Fig. 38). The site is covered by Chief Inspectorate of Environmental Protection monitoring for alkaline mires and marsh saxifrage populations. Despite its considerable size and value, the site was noticed only in 2007 and described in 2009 (Kujawa-Pawlaczyk et al., 2009). The observations carried out during the implementation of the project confirmed the extremely stable character of its plant communities characteristic for alkaline mires, which do not require intensive active protection measures, such as inhibiting the expansion of trees. The project focused on measures aimed at its legal protection and preparation of a protection plan.

Photo 33. Nature reserve "Mechowisko Radość" (photo R. Stańko).

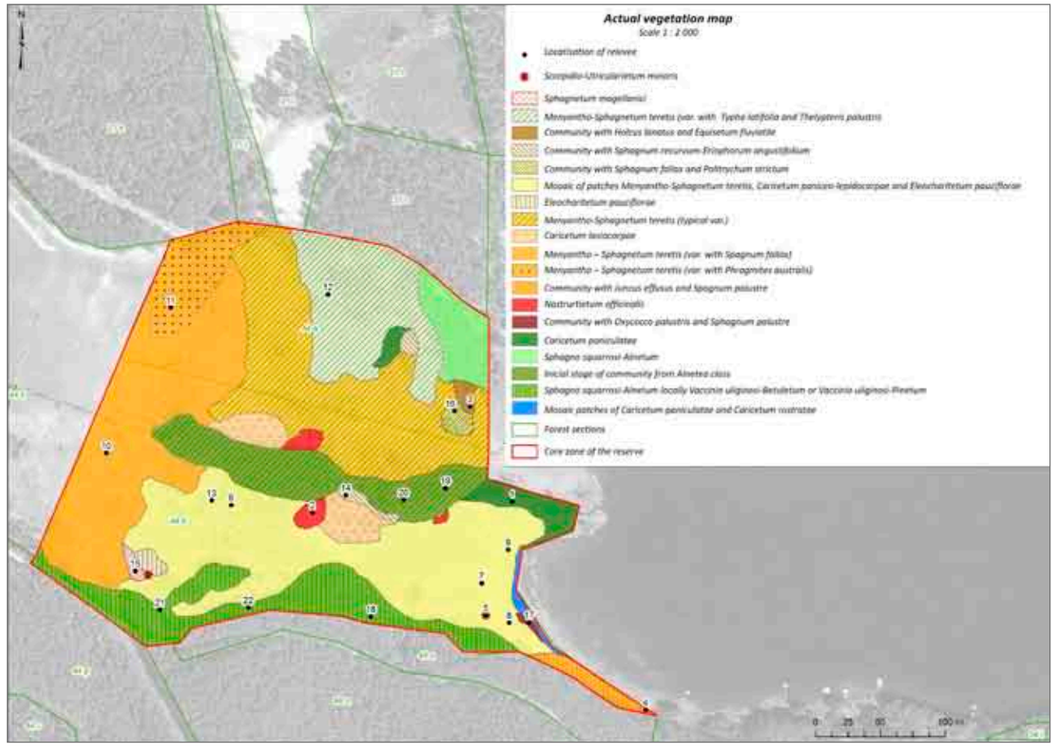


Fig. 39. Map of actual vegetation of the Mechowisko Radość Reserve (source: Rekowska et al. 2014).

As part of the work on the protection plan, 192 vascular plant species and 36 species of bryophytes were found to occur here. The existence of 18 plant communities, including 12 at the level of an association (Rekowska et al. 2014), was confirmed in the reserve.

The surface of the mire remained perfectly hydrated during the period of several years of observation.

During the observations carried out from June to September for the purpose of drawing up the protection plan (Rekowska et al. 2014), a gradual decrease of the water level in the lake and the groundwater level within the mire were observed. In the summer of 2014, despite lower than average rainfall, no deterioration of peat water content in the area of the reserve was observed. In the eastern part, situated close to the lake, and in the central and south-western parts, the level of groundwater was just near the surface. Closer to the western, northern and southern edges of the mire, the water level in the peat decreased to a depth of 90 – 120 cm. The central part of the mire, especially near the ditch, as well as its south-western part, which is a very productive spring, should be considered as being the best hydrated.

Photo 34. Remains of water reservoirs as a perfect habitat for calciphilic species of bryophytes such as: *Scorpidium scorpioides* and *Pseudocalliergon trifarium* (one of the rarest species of bryophytes associated with alkaline mires in Poland) (photo R. Stańko).

Photo 35. The reserve "Mechowisko Radość" is one of the most important sanctuaries of marsh saxifrage in western Poland. The monitoring carried out for the species indicates an excellent conservation status of the population and the habitat which, except for occasional felling of tree wildings, does not require any protective measures (photo R. Stańko).

Reserve "Kruszynek"

A mire with an area of nearly 10 ha. developing in the narrow bay of the Kruszyńskie Lake located in the sandur landscape of the Charzykowska Plain, overgrown mainly with poor pine forests. In 2014, on the basis of the natural documentation prepared as part of the project, a nature reserve was created for the area of 8.42 ha. A draft protection plan was also drawn up in the same year.

The site represents a typical terrestrialisation mire developing in the process of terrestrialization of a hard-water water reservoir dominated by charales.

The stratigraphic studies confirmed the existence of a well-preserved peat deposit built by various types of moss, sedge-moss and sedge peats underlined with organic-calcareous and calcareous gyttja.

The observations carried out within the framework of the project indicate that the condition of model-grade plant communities characteristic for alkaline mires within the entire site does not change. Their arrangement is shown in Fig. 39.

This process was initiated by the filling of the lake basin with sediments – mainly organic and organic-calcareous gyttja. At a later stage, the bay was colonized by bog and mire vegetation, whose visible traces in the stratigraphy are moss and sedge-moss peats. Their thickness in the vicinity of the water surface is ca. 35 cm and increases towards the north-west (the end section of the bay) reaching a maximum of ca. 85 cm. The layer of peats within the whole mire has an underlying layer of organic and organic-calcareous gyttja. Due to direct hydrological connections with the lake, the mire is characterized by favorable water conditions.

Fig. 40. Location of the reserve "Kruszynek".

During the field works for the requirements of the protection plan, 142 vascular plant species were found in the reserve area (including 6 species of pteridophytes, 3 species of gymnosperms, and 133 species of spermatophytes), 37 species of bryophytes (two marchantiophytes, 8 species of sphagnales, and 27 species of brown mosses) and 1 species of charales. An important value of the reserve flora is the presence of a group of species associated with fens habitats rich in calcium compounds. These include the following: yellow sedge *Carex flava*, long-stalked yellow sedge *C. lepidocarpa*, dioecious sedge *C. dioica*, marsh helleborine *Epipactis palustris*, fen orchid *Liparis loeselii*, fewflower spikerush *Eleocharis quinquaeflora*, and species of orchids in the marsh orchid genus *Dactylorhiza* (*Dactylorhiza majalis*, *D. maculate*, and *D. incarnata*). The mire also contains calcicole bryophytes – considered to be glacial relics: tufted fen-moss *Paludella squarrosa*, woolly feather-moss *Tomentypnum nitens*, and Blandow's helodium moss *Helodium blandowii* as well as yellow starry feather-moss *Campylium stellatum*, varnished hook-moss *Hamatocaulis vernicosus*, Cosson's limprichtia moss *Limprichtia cossonii*, and Warnstorf's bog-moss *Sphagnum warnstorfii* (Bociąg et al. 2014).

Eighteen plant communities were identified in the reserve, including 14 of them at the level of an association. They form a complex of moss and reed communities surrounded by forests on organic soils and coniferous forests on mineral soils. The moss vegetation of the reserve is diverse and characteristic for alkaline soligenous mires. It is characterized by a high degree of naturalness and good conservation status. The reeds and submerged vegetation are typically formed and have a natural character. The forests are mostly natural or moderately distorted. Only at the southern and northern borders of the reserve are patches strongly transformed by man. The value of the vegetation was assessed as outstanding for the moss communities (Bociąg et al. 2014). The most valuable communities in the reserve are phytocenoses of the association of *Caricetum paniceo-lepidocarpae*, *Eleocharitetum pauciflorae*, and *Menyantho-Sphagnetum teretis*.

Within the project, in addition to preparing natural documentation for the purpose of creating the reserve and then drawing up the protection plan, the focus was on active conservation activities, i.e., removing tree wildings from the area partially overgrown by alder wildings. These measures allowed

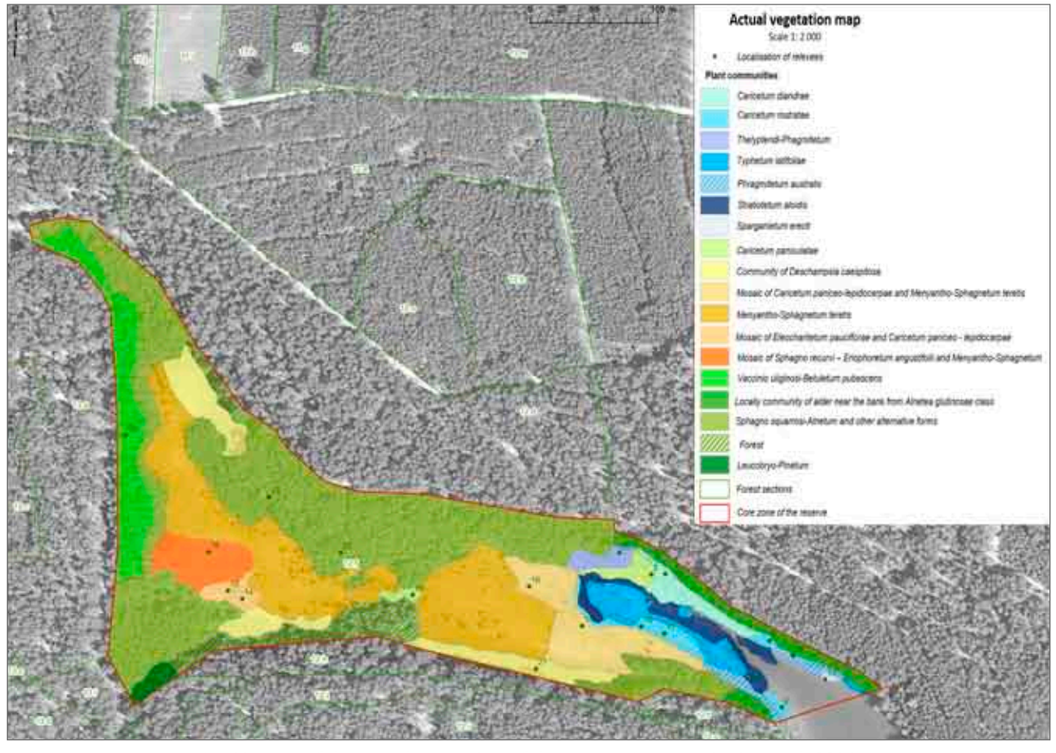


Fig. 41. Map of the actual vegetation of the reserve (source: Bociąg et al. 2014).

Photo 36. The southern part of the reserve includes a moss field and a fragment of the shallow bay of Kruszyńskie Lake (photo R. Stańko).

the current conservation status of the habitat to be maintained during the project period, but should be continued after its completion.

The water level in the mire and the outflow of water from the area depend on the changes in the water level in the lake, which constitutes the drainage level. When the water level in the lake rises as a result of the direct influence on the groundwater level, it may be an additional source of mire water recharge. This is confirmed by measurements of the water level in the lake and the piezometers where, during the measurements, fluctuations were observed at a similar level (Bociąg et al. 2014).

During the observations carried out from June to September for the purpose of drawing up the protection plan, a gradual decrease of the water level in the lake and the groundwater level within the mire was observed. In the summer of 2014, despite lower than average rainfall, no deterioration of peat water content in the area of the reserve was observed. In the eastern part, located close to the lake, the groundwater level was right next to the surface, while in the central part it did not fall below 10 cm from the surface. At the northern and southern edges of the mire, the water level in the peat was at the depth of about 20 – 30 cm. In the north-western section, it ranged from 30 – 60 cm below the surface.

Stratigraphic studies confirmed a very well-preserved surface layer of peats, which together with vegetation has the ability of vertical movement with changing water levels.

Photo 37. Numerous alder wildings, which initiated the succession of forest vegetation on the open alkaline mire (photo R. Stańko).

During the implementation of the project, it was observed that despite the permanently maintained favorable hydrological conditions within almost the whole mire, the process of forest vegetation succession is taking place. If it is not possible to identify the direct causes of these adverse events; it appears that the only way to maintain the current status of habitat 7230 would be to continue the removal of tree regrowth.

Natura 2000 site "Mechowiska Sulęczyńskie" PLH220017

Reserve "Mechowiska Sulęczyńskie", Sulęczyno

A mire complex with an area of about 50 ha. in a glacial channel situated in the sandur landscape. In the years 1994 – 95 documentation was drafted in connection with an attempt to create a reserve which would cover almost the whole mire complex (Herbich, Herbichowa, Siemion 1994 – 95, Herbichowa and Herbich 1998). The stratigraphic structure of the mire clearly confirms the ancient lake character of the site. The thickness of the moss and sedge-moss peats ranges from 0.5 to 5.0 m. The peats are underlined with limnic sediments, i.e., mainly calcareous gyttja with a maximum thickness of slightly more than 7 m.

In 2014, the part of the complex managed by the State Treasury and owned by the Naturalists' Club (areas purchased from private owners as part of the project) was transformed into a nature reserve of over 22 ha. In 2015, a draft plan for the protection of the reserve was also drawn up as part of the LIFE project.

The mire complex, within which the reserve is located, is diversified. The southern part includes dystrophic water reservoirs around which a well-preserved, transitional mire has developed. The central part consists of numerous peat-cuts, fragments of brown moss fens, moss and sedge phytocenoses, as well as initial forms of bog forests. The northern part of the complex, located in the immediate vicinity of the settlement, is dominated by moss and sedge phytocenoses with numerous reed species such as reed, broadleaf cattail, and lesser pond-sedge.

The vascular plant flora recorded so far on the area of the entire complex amounts to 173 species. Among the lower *Cryptogamae* (bryophytes and algae) 68 taxa were found. Among them, the bryoflora is well identified (53 species of moss, including 23 taxa of the genus *Sphagnum*). In addition, 13 species of marchantiophytes and 2 species of algae were recorded (Herbichowa and Herbich 2015).

In terms of ecological and sociological structure, the vascular plants flora and the bryoflora are distinguished by an outstanding share of species characteristic for moss and sedge communities, generally in-

Fig. 42. Location of Mechowiska Sulęczyńskie.

cluded in the *Scheuchzerio-Caricetea nigrae* class and some of its lower syntaxa. A total of 40 of them were found, including 14 species with a narrow ecological amplitude, typical for moss phytocenoses on alkaline mires, which deserve special attention. These are species characteristic for communities of the order *Caricetalia davallianae* and the *Caricion davallianae* alliance.

Some of them have only single few locations in Poland, e.g., *Hammarbya paludosa,* or are rare due to loss of habitats (*Stellaria crassifolia, Liparis loeselii*). The site is also distinguished by a group of species considered to be glacial relics, e.g., *Stellaria crassifolia* and the mosses *Cinclidium stygium, Paludella squarrosa, Tomentypnum nitens, Helodium blandowii*, *Hamatocaulis vernicosus*, *Scorpidium scorpioides,* and *Sphagnum warnstorfii* (Herbichowa and Herbich 2015).

According to the vegetation description contained in the characteristics of the reserve (Herbichowa and Herbich 2015): "*the vegetation of the whole mire complex consists of 21 associations and communities. The largest spatial role is played by Menyantho-Sphagnetum, which occupies the entire northern part of the mire, previously periodically mown but not exploited. A very important role in the structure of phytocenoses is played by bryophytes, including the abundant Paludella squarrosa, Tomentypnum nitens, Helodium blandowii, and Sphagnum teres. Other interesting species include the abundant growth of Epipactis palustris and the single instances of Liparis loeselii. Much smaller areas in this part of the mire are occupied by Caricetum diandrae, Caricetum appropinquatae, and Calamagrostietum strictae. The central part of the mire is much more varied. In the past, peat was exploited on almost all of its surface, the remainder of which are numerous excavations, now in various stages of overgrowth by vegetation. A very interesting mosaic of valuable communities has been created in the area of influence of water seepage from the mineral slopes of the basin and the edge of the moss fields of the northern part. In the youngest exploited peat-cuts with open water surface, these include Scorpidio-Utricularietum and Nymphaetum candidae, in slightly older, already terrestrialized – Eleocharitetum quinqueflorae, which in the course of succession is replaced by Caricetum diandrae, Caricetum lasiocarpae, and Caricetum paniceo-lepidocarpae. Menyantho-Sphagnetum is found between the exploited peatlands. In recent years, Cladium mariscus has appeared in two exploited peatlands, surrounded by typical moss vegetation, forming a very small patch of the Cladietum marisci association. The plant communities in the southern part of the complex are representative of acidic and barren mire habitats, predominantly disturbed by peat extraction. Spatially, the area is dominated by secondary phytocenoses of different ages formed in the exploited peatlands. A mosaic of phytocenoses of Sphagno-Caricetum rostratae and Sphagnetum magellanici has developed in the area of older excavations (classified here as habitats 7140 Transitional peatlands and quagmires (mostly with vegetation of Scheuchzerio-Caricetea) and Vaccinio-uliginosi-Pinetum bog forest, identifying the habitat *91D0 Bog woodland). The part of the area where exploitation ended much later is characterized by the presence of numerous peat-cuts with open water surface with Nymphaeetum candidae and large areas of mats of Sphagno tenelli-Rhynchosporetum albae, Caricetum limosae, Eriophoro-Sphagnetum, Caricetum lasiocarpae, and Sphagno-Caricetum rostratae (habitat 7140). The diversity of this part is complemented by two well-preserved dystrophic lakes – habitat 3160 Natural, dystrophic water reservoirs. The only phytocenosis of Glycerietum nemoralis-plicatae has been locally present for many years on the seepage on the mineral boundary, just outside the mire deposit boundary.*"

In relation to plant communities, the mire is distinguished by the occurrence of an *Eleocharitetum quinqueflorae* association, rare on the entire country scale (Herbichowa and Herbich 2015).

Mechowiska Sulęczynskie belongs to the group of the best preserved areas in Poland, where the 7230 habitat is still found. The identified risks include the expansion of phragmites, broadleaf cattail, lesser pond-sedge and grey willow. Regular reed cutting operations have been carried out here on an area of ca. 1 ha. since 2003. As part of the Life project, cutting of the cattail began in 2014. In the years 2015 – 2017, treatments were carried out consisting in cutting phragmites, cattail, as well as the willow thickets and tree wildings. As part of the protection plan, the excessive outflow of water from the mire is also planned to be inhibited by the construction of dams on the ditch draining the mire. The protection plan also provides for the installation of equipment to continuously record water level fluctuations in the mire. These tasks will be carried out after the end of the project.

The highest water level occurred in March, and at that time it was within the range of 0 – 17 cm below ground level. The greatest decrease of the water level in the mire was observed in the summer, but despite the occurrence of hydrological drought, no significant deterioration of water content in the peat sediments was found in the area of the reserve. In the north-eastern part, throughout the entire research period, the groundwater level was just next to the surface, while in the central part it did not fall more

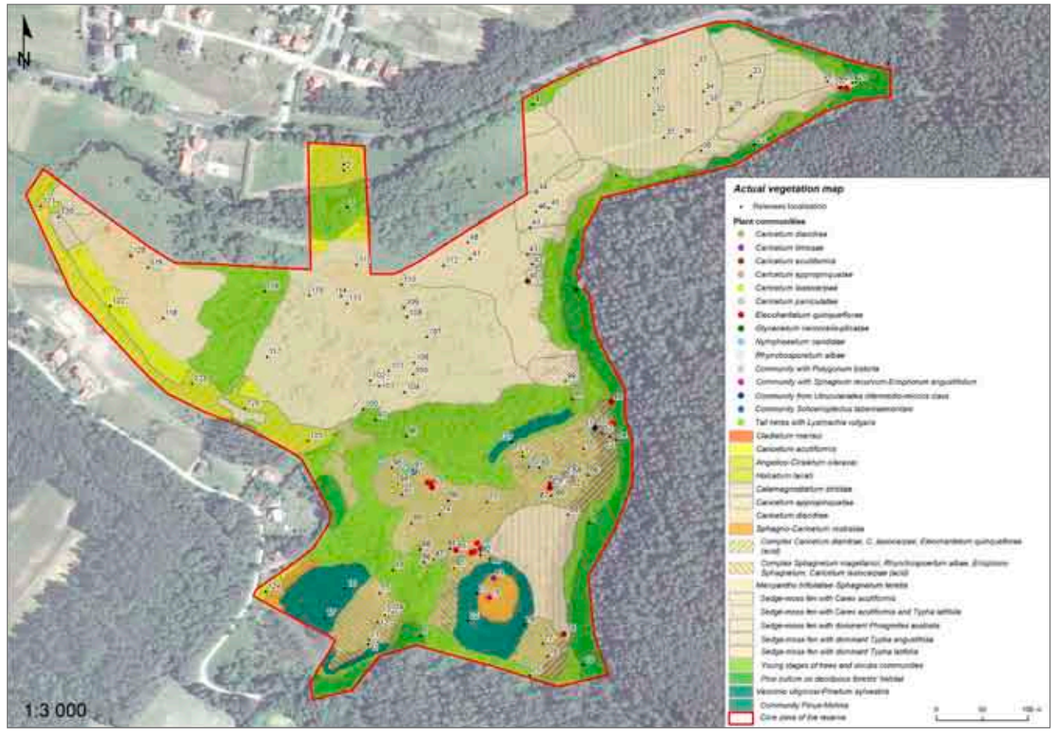


Fig. 43. Actual vegetation of the Mechowiska Sulęczyńskie (source: Bociąg et al. 2015).

than 20 cm below ground level. In piezometers at the edges of the mire, the level dropped in summer from a maximum of 23 cm (piezometers no. 486 – northern edge and 482 – eastern edge) to 26 cm below ground level (piezometer no. 481 – western edge). In September, as a result of reduced evaporation and rainfall, the water resources of the mire were gradually replenished.

The average depth of groundwater retention in the peat was within the range of 0 in the north-eastern part of the mire, to 21 cm below ground level near the western and northern edges of the mire. In the centre of the area, the water level was on average between 7 (piezometer no. 478) and 12 cm below ground level (piezometer no. 479; Fig. 43).

The highest amplitude of water level fluctuations (14 cm) occurred in the piezometer no. 479, located in the central part of the mire. In March, the water level was found to be 5 cm below ground level and decreased to 19 cm below ground level by July. More amplitudes greater than and equal to 10 cm were recorded only in the piezometers located on the outskirts of the mire (piezometers no. 481, 482, and 406). At the other observation stations, the amplitudes of water levels did not exceed 8 cm. The line of the smallest amplitudes of groundwater level fluctuations and, at the same time, the line of high groundwater position in the mire area is determined by the course of the main drainage ditch constituting the basis for water drainage from this area (Fig. 43).

This indicates the important role the drainage ditch fulfills in the drainage of the area. The ditch contributes to an excessive drainage of water during wet periods, when it could be retained within the moss field. In addition, in dry periods it further depletes the water resources of the area. This poses a potential risk of water shortages in the area of the moss field and, consequently, of drying out of the deposit (Bociąg et al. 2015).

As part of the work on drafting the protection plan, the authors (Bociąg et al. 2015) described the dynamic trends in the plant communities of the reserve on the basis of about 30 years of observations. It was found that:

"*The changes in the vegetation of the reserve are caused by two factors – natural and anthropogenic. Anthropogenic factors include previous land use, varying in form and intensity, and then its abandonment. In many cases, especially in the case of peat, this was the most important factor in triggering or initiating succession. These were as follows:*

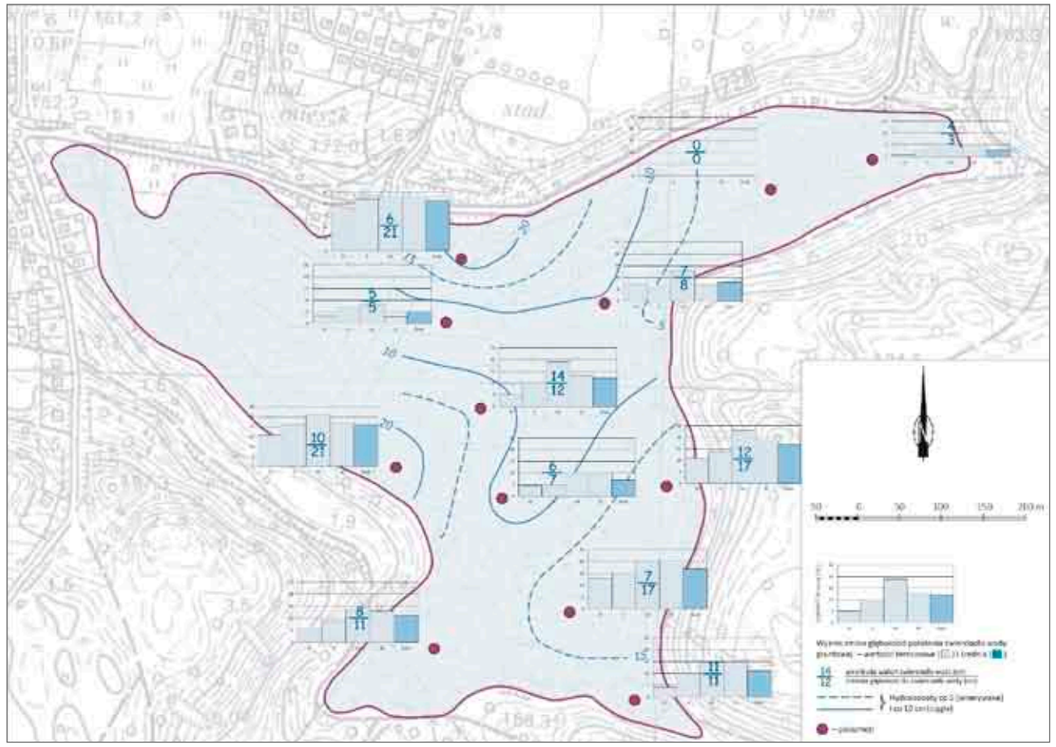


Fig. 44. Spatial distribution of average depth of the location and fluctuations of ground water table in the Mechowiska Sulęczyńskie Reserve (Bociąg et al. 2015).

- *changing water conditions by digging drainage ditches for the mire,*
- *peat and chalk exploitation,*
- *changing the composition of tree stands due to the planting of pine trees.*

Our own research conducted in the reserve for 30 years, supported by literature data, allows to identify the following changes in vegetation as the most important to date.

The most important natural factor is ecological succession. As a result, in the exploited peatlands:

- *as the water surface becomes overgrown with vegetation, the initial stages of succession disappear – patches of Nymphetum candidae and Scorpidio-Utricularietum associations,*
- *the initial community of Eleocharitetum quinueflorae disappears,*
- *the local area of the community with long-stalked yellow sedge Carex lepidocarpa increases in surface, which in turn gives way to Caricetum diandrae and Caricetum lasiocarpae,*
- *the surface area of Sphagnetum magellanici increases,*
- *on old exploited peatlands and dykes between the excavations, a development ("maturation") of bog forest is visible,*
- *expansion of the trees starts,*
- *a Cladietum marisci association, which is new for the reserve, appeared.*

On areas that have been mown in the past:

- *the expansion of tall perennials, reeds, broadleaf and narrowloeaf cattail, lesser pond-sedge and grey willow takes place. It is worth mentioning that in the photograph of the northern part of the mire, published in the Succow and Jeschke monograph (1986), in the areas currently controlled by the lesser pond-sedge Carex acutiformis, broadleaf cattail Typha latifolia, and willows, none of these invasive species were visible, and only the vegetation with the appearance of the low sedge communities was to be found),*
- *more than a dozen years ago, the only patch of the Campylio-Caricetum dioicae association disappeared, replaced by Carex acutiformis.*

In all cases, in the last 30 years the internal diversity of several of the most important communities in the reserve has decreased, including Menyantho-Sphagnetum (represented in 1994 by 3 subassociations and 2 variants), the slender sedge Caricetum lasiocarpae association (in 1994, there were 3 subassociations), C. diandrae (in 1984, 4 subassociations), Eleocharitetum quinqueflorae (2 subassociations). The loss of some of these syntaxa is due to the disappearance of their distinctive species, such as Campylium stellatum in Caricetum lasiocarpae campylietosum stellati, among other factors. The local range of some valuable communities has decreased, particularly that of Caricetum appropinquatae.

Forecasts of change – thanks to the knowledge of trends from the last decades – are largely reliable. They are:

- *progressive succession in exploited peatlands leading to the disappearance of the stages of development of initial and young vegetation,*
- *overtaking of the formerly mown areas by high perennials and shrubby willows,*
- *further simplification of the internal diversity of some of the most valuable communities,*
- *the disappearance of communities built, inter alia, by heliophilous bryophytes and low vascular plants, displaced by higher plants which thus provide shade and cover of abundantly deposited necromass (particularly Campylio stellati-Caricetum dioicae).”*

Due to the short period of time that has passed since the protective measures were carried out as part of the project, it is difficult to objectively assess their effectiveness. The validity of the actions taken so far and the necessity to continue them were indicated in the reserve protection plan prepared as part of the project (Bociąg et al. 2015).

These activities are currently carried out under the statutory activities of the Naturalists' Club and RDEP in Gdańsk.

Photo 38. Section of the mire in the photo from 2010 (photo R. Stańko).

Photo 39. Section of the reserve after the tree wildings removal and mowing procedure at the turn of 2014/2015 (photo R. Stańko).

Reserve "Mechowisko Krąg"

The site includes a small (about 17 ha.) soligenous mire located in the terrestrialized bay of the Krąg Lake. The Krąg Lake was formed in a melt basin located at the back of the belt of the marginal moraine, which determines the range of the Pomeranian section of the Vistula lobe. In the Holocene, the basin of the reservoir was filled with sediments, creating a plain of biogenic accumulation, within which there are fragmented fragments of sandur surfaces, elevated several meters above the level of the Krąg Lake and adjacent mires. A small fragment of the mires (due to the complex ownership structure, the area of the reserve is only 3.81 ha.), adjacent to the lake from the eastern side, was placed under reserve protection in 2016, based on the natural documentation prepared as part of the project (Wołejko et al. 2015). In the same year, a draft conservation plan was drawn up.

The thickness of peat on ancient lake deposits (mainly organic-calcareous gyttja) is small and ranges from 0.25 to ca. 1 m. The deposit consists mainly of moss and moss-sedge peats. The peats are distributed slightly thicker in the peripheral parts of the mire, adjacent to mineral soils. These slightly raised sections have the features of initial spring mires. Moss-sedge peats play a greater role in their composition.

In 2015, 89 taxa of vascular plants and 20 taxa of bryophytes were found in the area of the reserve. The most valuable flora of the reserve include such species as: *Liparis loeselii, Hamatocaulis vernicosus, Paludella squarrosa, Helodium blandowii*, and *Tomentypnum nitens*. Within the same mire, however outside the reserve area, there is a strong population of Saxifraga hirculus.

The vegetation of the reserve according to the prepared protection plan (Gawroński et al. 2016) covers a total of 12 types of communities. 7 communities threatened with extinction were distinguished within the reserve. Of these, 5 are identified as rare. The occurrence of 2 natural habitats that are subject to protection were also shown; they take up almost the entire area of the reserve. In terms of syngenesis, all the communities in the reserve are natural. The range and distribution of the individual phytocenoses is presented in Fig. 45.

The peat deposit within the entire bay is characterized by a low degree of decomposition (2 – 4 on the von Post scale).

The current water conditions should be considered as favorable, except for the highest parts of the mire, and maintaining a sufficiently high and stable lake water level is a prerequisite for the proper functioning of the hydrological system of the reserve.

Fig. 45. Location of the Krąg Lake and reserve "Mechowisko Krąg".

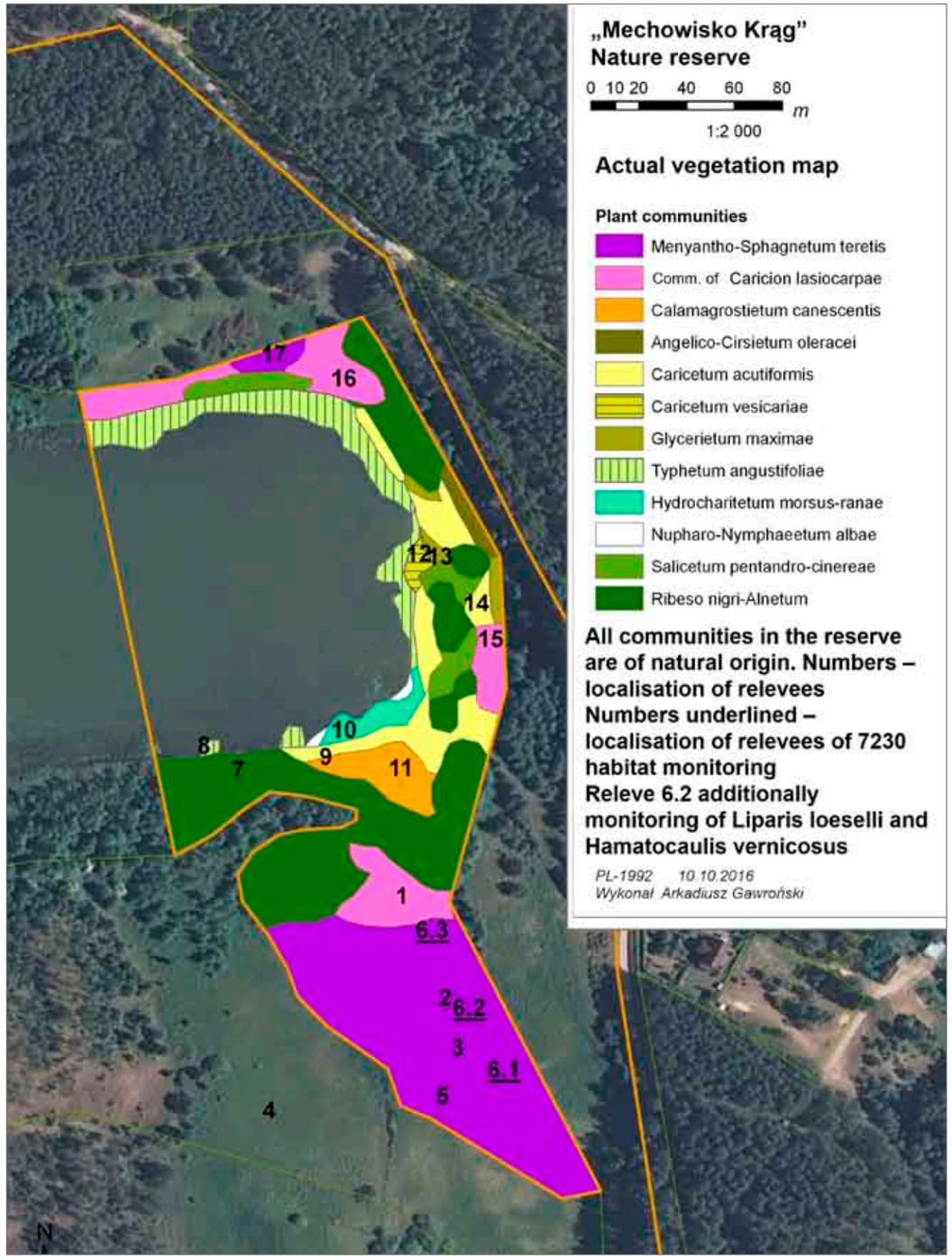


Fig. 46. Map of the actual vegetation of the Mechowisko Krąg Reserve (source: Gawroński et al. 2016).

Photo 40. Central section of the site – *Saxifraga hirculus* location (photo D. Horabik).

The observations of the vegetation carried out during the project period did not show any significant changes in the nature of the plant communities – which should probably be associated with the favorable hydrological conditions, stabilised by the water level in the Krąg Lake and a well-preserved surface layer of peat capable of vertical movement with changing groundwater levels. The slow expansion of trees should be sufficiently limited by planned and implemented occasional felling of trees and shrubs, as well as by occasional mowing, planned as necessary after the completion of the project.

Photo 41. Poorly distributed moss peats deposited on organic-calcareous gyttja. Krąg Lake, borehole K4 (source: Wołejko et al. 2015) (photo D. Horabik).

Orle

An area covering a complex of several hundred hectares of low mires filling the Łeba-Reda ice marginal valley together with the remains of a former large reservoir – Orle Lake. The mineral elevations surrounding the mires are poor sandy habitats of pine forests. Stratigraphic studies in the location showed the occurrence of a layer of fen peat, reaching the thickness of up to 1.5 m, underlined with a layer of calcareous gyttja with a thickness of nearly 7 m. Most of the surface area is heavily drained. The most interesting fragments of alkaline fens have been preserved within the mineral islands in central part of the proposed reserve (the area is supposed to be covered by a reserve protection).

The mires within the boundaries of the Natura 2000 area Orle are mainly supplied by groundwater flowing from the northern and north-eastern edges of the upland, and moving through the mires towards the south, i.e., to the main receiving body (Orle Lake), which is at the same time the erosion base. In the past these waters were included in a fairly well-developed network of surface ditches and channels discharging the incoming groundwater to the Orle Lake or the Reda Canal. Currently, the network of ditches and canals (a total of several km of ditches) remains largely overgrown, but most of them still serve as drainage.

Alkaline mires in the Natura 2000 area Orle cover an area of about 30 ha. and are characterized by the occurrence of an almost complete set of species characteristic for the habitat in the conditions of the lowland part of Poland, especially in the Pomerania area. Within individual phytocoenoses, they are characterized by a high proportion and degree of overlap. Among the many characteristic species, there are numerous rare, threatened and legally protected taxa. These include: *Liparis loeselii, Dactylorhiza fuchsii, D. incarnata, D. maculata, D. majalis, D. russowii, Drosera rotundifolia, Dryopteris cristata, Epipactis palustris, Juncus subnodulosus, Listera ovata, Polemonium coeruleum, Paludella squarrosa, Helodium blandowii, Tomentypnum nitens*, and *Hamatocaulis vernicosus*. Some of them are abundant and their populations constitute an important part of the national resources of the species, e.g., *Liparis loeselii, Epipactis palustris*, and *Juncus subnodulosus* (Stańko R. 2011).

Already in 2011, a Plan of Conservation Measures was prepared and approved for the area, including measures to eliminate the identified threats. These activities included the improvement of water conditions through the construction of so-called gates on drainage ditches, removal of trees and their wildlings, and restoring extensive mowing operations. The tasks formulated were then planned to be implemented as part of this project. Due to private

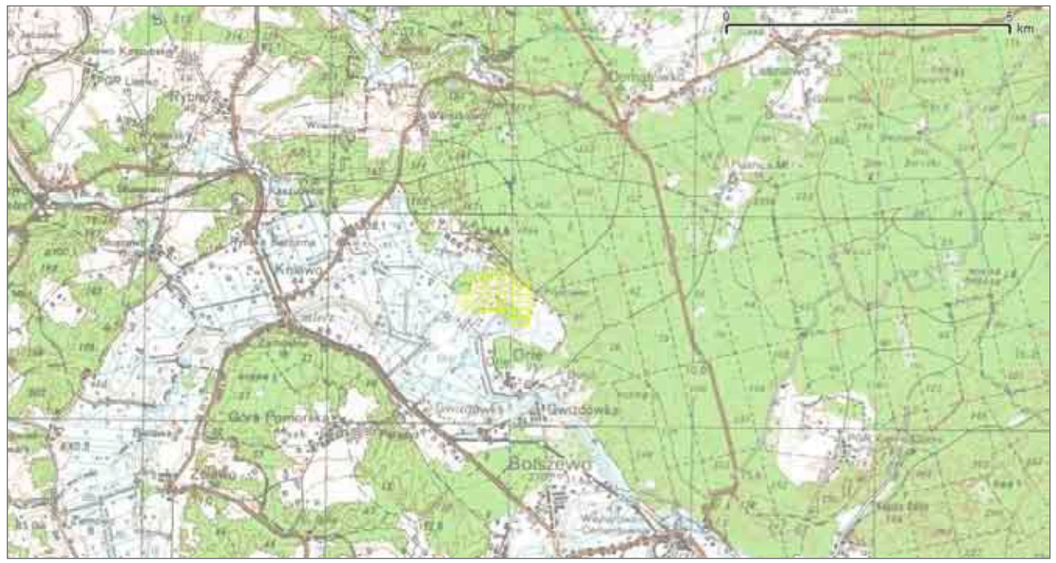


Fig. 47. Location of the complex of alkaline fens in the Natura 2000 site "Orle".

Photo 42. Orle is one of the best preserved patches of habitat 7230 in the initial phase of forest vegetation expansion (photo R. Stańko).

ownership restrictions, efforts were made to purchase the most valuable patches of the alkaline mire. Unfortunately, these efforts failed. The lack of consent of the owners to carry out conservation activities may contribute in the next 20 – 30 years to the complete disappearance of vegetation characteristic for the 7230 habitat.

Nature 2000 area Rynna Dłużnicy – PLH220081

Małe Długie Lake

A small (about 6 ha.) mire in a narrow and deep ancient lake channel – the former bay of the Małe Długie Lake in the vicinity of the Gostomie settlement within the limits of the Tuchola Forest mesoregion. Like most of the sites covered by the project, the area is geomorphologically composed of sandur formations, and the surface and underground catchment areas are dominated by pine forests. However, the waters infiltrating the mire catchment area and the adjacent lakes have a high concentration of calcium and magnesium salts, which has a key impact on the development of alkaline mires within the mesotrophic hard water lakes accumulating limnic sediments in the form of calcareous gyttja. The upper strata of the peat contains mainly poorly distributed sedimentary sedge-moss peats deposited to the depth of ca. 0.5 m, underlined with a thin layer of reed peat deposited directly on a layer of several meters of organic-calcareous and calcareous gyttja. In the past, the majority of the mire was used as a meadow. This use was restored on some of the mires in 2013 as part of an agri-environmental program carried out by one of several landowners. A shallow layer of peat was exploited on a small area (several acres) several decades ago. Currently, interesting moss vegetation is developing in the area with a large population of marsh helleborine.

The current vegetation of the mire is mainly composed of reed phytocenoses (*Phragmitetum* and sedges). The southern part of the complex is overgrown with alder trees, while the moss vegetation is found in the outskirts and the sections closest to the lake. Some of the former moss mires located closest to the mineral banks are covered by floristically rich and naturally valuable meadow phytocenoses of the *Calthion* alliance.

Fig. 48. Location of the Małe Długie Lake mire.

Despite its small size, the mire is of exceptional value in the entire country scale – mainly due to the presence of the population of *Saxifraga hirculus* found here in 2009 (Gdaniec 2010). In 2011, an unknown locality of the fen orchid (Stańko R., Kia-szewicz K. – oral inf.) was found in the mire. In addition, marsh helleborine is abundant locally.

During the project implementation, the conservation measures were focused on the elimination of threats related to flooding of the mires by beavers (installation of devices limiting the level of damming in 4 dams), and limiting the expansion of reeds and forest vegetation (mowing) to open mires not yet included in the agri-environmental program. These activities have preserved the status quo, but will nevertheless need to be continued after the project is finished.

Photo 43. Location of the area in the deep glacial channel (photo R. Stańko).

Photo 44. The best preserved moss -sedge vegetation in the central part of the site with a small population of the fen orchid Liparis loeselii (photo R. Stańko).

No detailed and regular hydrological or phytosociological monitoring was carried out within the site. The obtained materials that enable the formulation of conclusions regarding the achieved environmental effects were based on several site visits and information concerning the vegetation recorded during these visits (phytosociological relevees taken at selected locations). During the site visits, the water conditions of the mire were also recorded due to the study of local activity of beavers (devices installed in beaver dams). The materials collected during the project implementation period are sufficient to state that due to the permanently maintained favorable level of surface and ground waters (devices installed in beaver dams), and the protective measures carried out as part of the project and implemented by the owners of agri-environmental packages (mowing), the vegetation of the mire did not change unfavorably. The observations of the vegetation dynamics indicate that the activities initiated to preserve the current condition should be continued in the future.

Photo 45. Within the boundaries of the site, despite its small area, the largest number of devices were installed in the beaver dams, ensuring optimal hydrological conditions for further development of vegetation characteristic for alkaline mires (photo R. Stańko).

Reserve "Mechowiska Czaple"

Site (ca. 9 ha.) located in a side valley is an erosion channel cutting off the marginal zone of the sandur plain descending towards the Słupia valley. Along the bottom of the valley, of ca. 500 m in length and shallow in depth, flows a stream which is a left-bank tributary of the Słupia River. The initial section of the valley is made up of two broad, merging shallow basins filled with organic sediments. In its middle part, the valley narrows considerably (several meters) and the stream cuts deep into the bottom of the valley. In the final section, the valley expands and connects with the Słupia valley. The area of the reserve is characterized by relatively small elevation differences of the area which, in part, results from filling the bottom of the valley with organic matter. The reserve, despite the fact that the vegetation characteristic for alkaline mires occupies a small area, and it is not distinguished by the presence of a large number of indicator species of flora, has many other features that distinguish it from other protected areas. An undoubtedly positive element distinguishing the reserve is the presence of diverse soligenous flow-through and spring mires. The stratigraphic structure of the mires found in the reserve is also interesting, especially the presence of the so-called calcareous sinter, which sometimes reaches considerable thickness (see Fig. 50). Among the indigenous flora, there are relatively large populations of broad-leaved orchids and the so-called relic species of mosses: *Helodium blandowii* and *Tomentypnum nitens*. The vegetation of the reserve is dominated by meadow phytocenoses and specific reeds developing on the heavily hydrated domes of hanging spring mires. The reserve, despite the fact that the moss vegetation occupies a relatively small area (several ares), is locally an important element in the network of areas important for the protection of the habitat 7230. At present, the site seems to be properly protected by extensive use and maintenance of long-standing dams on drainage ditches preventing excessive drainage of the mires. However, the area of mowing operations should be slightly extended (only manual cutting) in order to cover also the most valuable fragments of soligenous wetlands. The proposal for additional conservation measures is set out in the protection plan drawn up as part of the project implementation.

The small post-glacial channel along a nameless stream is characterized by a wide variety of hydrological conditions, manifested by the presence of hanging spring mires and soligenous flow-through mires. Their stratigraphy is presented in the Figures below. In the context of stratigraphic structure, the site (central part) is distinguished by the presence of a significant thickness of calcareous sinter deposits lined with moss peats and covered with reed peats, which may be associated with naturally occurring changes in the hydrological conditions. The anthropogenic

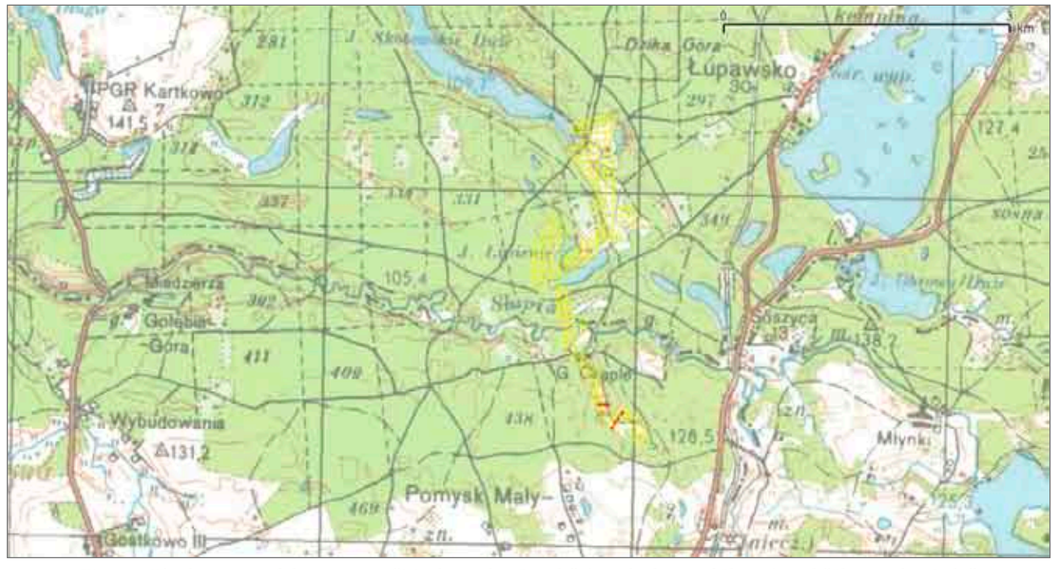


Fig. 49. The location of the reserves "Mechowiska Czaple" (south shore of Słupia) and "Skotawskie Łąki" (northern shore of Słupia) together with the course of transects.

Photo 46. A fragment of a spring bog with an abundance of the broad-leaved orchid (photo R. Stańko).

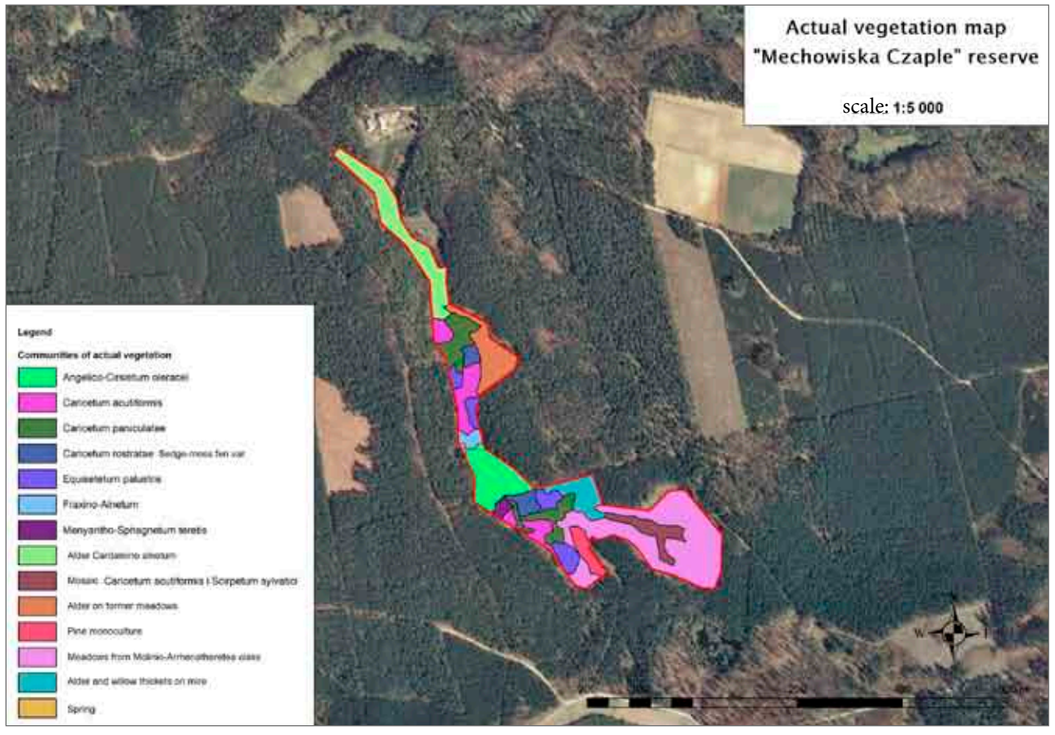


Fig. 50. Actual vegetation map in „Mechowiska Czaple" reserve (source: Stańko et al. 2018).

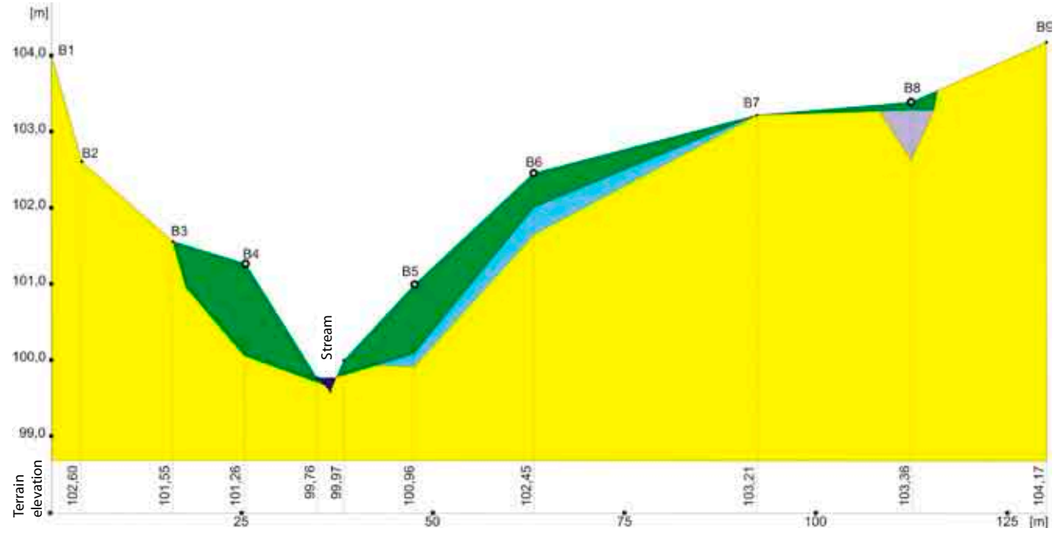


Fig. 51. Geodetic and geological cross-section through spring mires in the "Mechowiska Czaple" nature reserve.

changes in water conditions over the last 100 – 150 years have also had a significant impact on the development and present state of these peat deposits. This included on the one hand drainage works, and on the other hand the construction of a damming barrier in the valley just outside the northern border of the reserve. Despite the drastically changing conditions in the reserve, small patches of vegetation typical for the habitat of alkaline mires have been preserved. Their current and future presence depends to a large

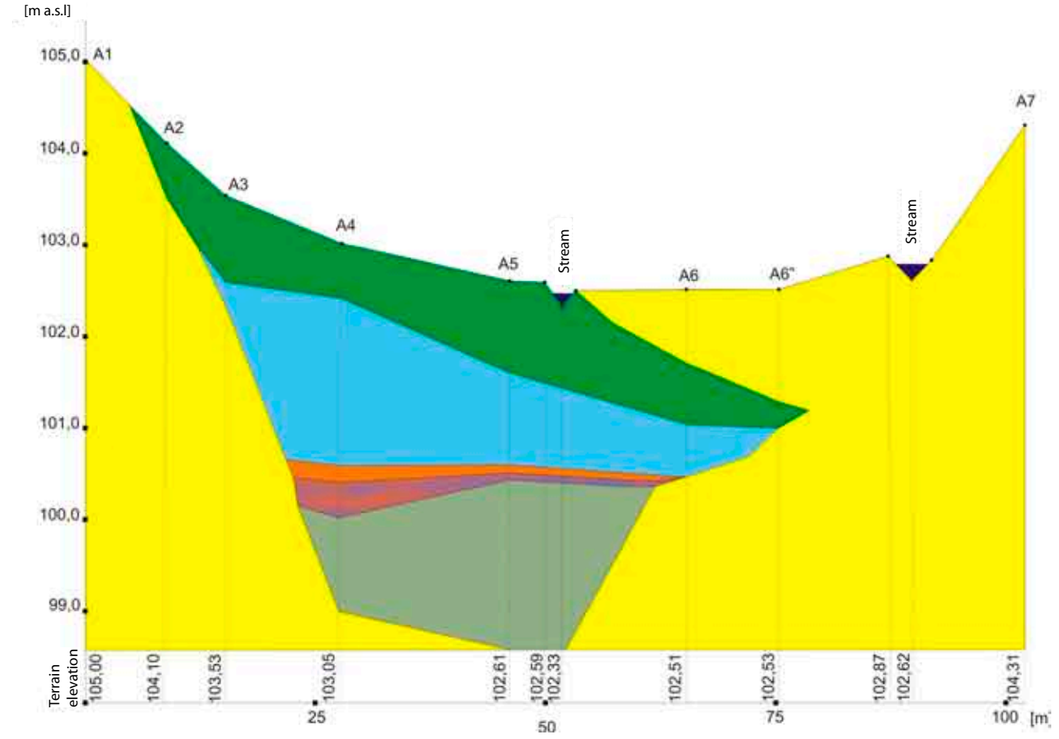


Fig. 52. The Mechowiska Czaple Reserve is distinguished by its interesting geological structure, in particular by the presence of calcareous sinter deposits.

Photo 47. One of over a dozen gates on drainage ditches built several years ago that contributed to almost complete overgrowth of the ditch draining the hanging spring mire (photo R. Stańko).

extent on the implemented conservation measures. The maintenance of the moss dominated vegetation has been supported by the Pomeranian Landscape Park Complex for several years and continued by the Bytów Forest Inspectorate. These activities focused on the improvement of water conditions (the construction of gates on drainage ditches) and extensive mowing. The phytosociological research carried out as part of the project in 2016 indicates that the vegetation of the reserve has not changed significantly over the last 15 years, which confirms the effectiveness of the existing protection operations. The protection plan prepared as part of the project specifies the scope of activities for the next 20 years.

"Skotawskie Łąki" Reserve

A complex of fens and small lakes in the spring section of the Skotawa River under reserve protection – nearly 55 ha. The Skotawiskie Łąki Reserve and the Mechowiska Czaple Reserve are divided from each other by the Słupia River. The reserve is located at the edge of the Polanów Upland mesoregion, in a glacial channel surrounded by sandur formations. The majority of the catchment area is covered by pine forests. The reserve was established in 2008 on the basis of nature inventory documentation prepared in 2001 (Stańko et al. 2001). In 2017, a protection plan was drawn up for it.

The mires that develop here, for the most part, occupy the place of former water reservoirs. The upper part of stratigraphic profile (Stańko et al. 2001) is dominated by reed peats, locally covered with brown- and sphagnum moss peats of varying degrees of decomposition. The bottom strataare formed by several meters of organic and organic-calcareous gyttja. During the works carried out in 2001, a layer of peat was identified under the gyttja, which confirmed at least partially the melting character of the reservoirs.

The reserve is characterized by a quite broad variety of habitats (from water through bog and mire to meadows and forests), which results in its diversity of vegetation. From the point of view of nature protection, the most valuable phytocenoses are moss vegetation communities (although they occupy a relatively small area) with elements of initial forms of poor fens and semi-natural meadow communities developing on dried alkaline fens. The most valuable and connected with the 7230 habitat are: the lesser tussock-sedge and beaked sedge associations with the participation of numerous species of bryophytes characteristic for alkaline mires and the *Menyantho-Sphagnetum teretis* association.

Of the plant species found to be associated with habitat 7230, bryophytes seem to be the most valuable group, especially due to the presence of species such as *Cinclidium stygium*, *Hamatocaulis vernicosus*, and *Helodium blandowii* (Lewczuk et al. 2017). Among the threats identified in the reserve, the most important one is the expansion of reeds, especially Phragmitetum australis. This process is significantly inhibited by the local forest inspectorate's reinstatement of mowing operations a few years ago.

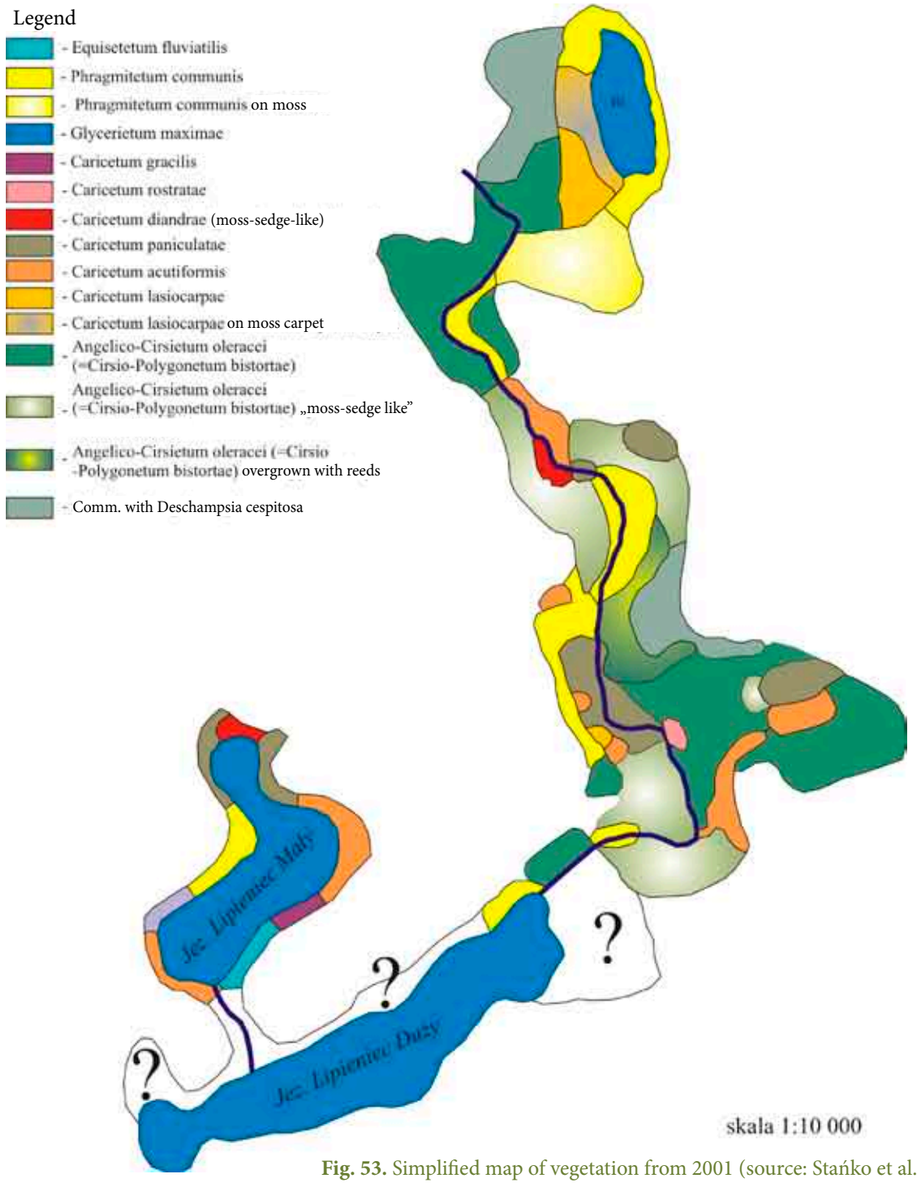


Fig. 53. Simplified map of vegetation from 2001 (source: Stańko et al. 2001).

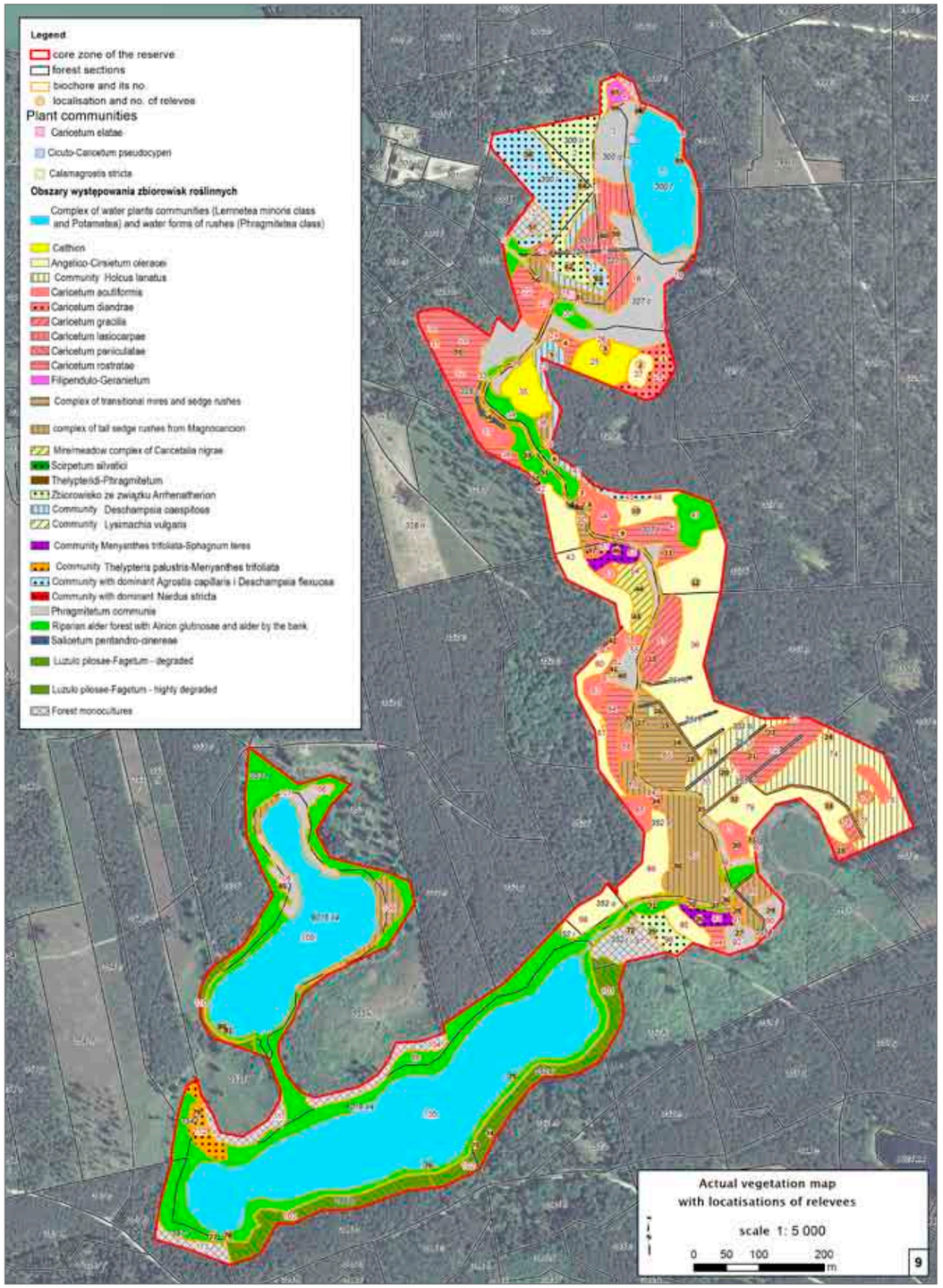


Fig. 54. Map of the actual vegetation of the reserve from 2017 (source: Lewczuk et al. 2017).

Photo 48. The reserve is dominated by fens developing in the basins of old water reservoirs, drained by the Skotawa River (photo R. Stańko).

As part of the project, the gates on the drainage ditches in the reserve were repaired and a protection plan was drawn up.

In the period of more than fifteen years of observations carried out in the reserve, despite the lack of regular hydrological measurements, we can see a gradual improvement in water conditions. This process is partly related to the spontaneous overgrowth of unmaintained drainage ditches, as well as to the implemented conservation measures. At the beginning of the 2000s, the Dolina Słupi Landscape Park built several gates on drainage ditches and started mowing the mires within the reserve. These activities are continued until today by the Bytów Forest Inspectorate. The research carried out within the project for the purpose of drawing up the protection plan enables a positive assessment of the effectiveness of the undertaken protection measures. A comparison of the actual vegetation of the reserve over the last 15 years shows that there are no significant negative changes, especially in the vegetation associated with habitat 7230. The observed process of Phragmitetum australis reed expansion seems to be quite effectively inhibited due to extensive use. The conservation of the alkaline mires will be supported by the gates on drainage ditches, repaired as part of the project, and a protection plan prepared that will provide for the extension of the areas indicated for mowing..

Photo 49. Phytocenoses dominated by lesser tussock-sedge, bogbean, and *Hamatocaulis vernicosus* are among the most valuable elements of the reserve's vegetation The comunnities developed on strongly hydrated sedge-moss peat with varying degrees of decomposition and thickness of about 80 cm, on the top of organic-calcareous gyttia (photo R. Stańko).

Photo 50. Wet meadows and mires mown by the Bytów Forest Inspectorate in the reserve „Skotawskie Łąki" (photo R. Stańko).

Photo 51. One of the dozen or so gates that have been repaired as part of the project - here before the renovation (photo R. Stańko).

Reserve "Gogolewko"

With an area of ca. 37.5 ha. it includes a fragment of a large complex of mires adjacent to the Gogolewko settlement from the south and west. The reserve was established in March 2018 as part of the project implementation.

The area of the reserve is situated in the moraine hills zone consisting mainly of loamy sands and various-grained sands. The vicinity of the reserve is dominated by leached brown soils. From the west, the reserve is adjacent to the valley of the Skotawa River flowing through a subglacial channel filled with organic sediments. There are two islands in the reserve, elevated slightly above the level of the surrounding area, where intensive groundwater seepage is observed.

Studies of the structure of the deposit of organic sediments in the reserve clearly confirms its ancient lake character. Under the 1.5 m (on average) layer of peat, there are layers of organic and organic-calcareous gyttja with considerable thickness. In the central part of the deposit, above the gyttja, there is a layer of low sedge peats, which means that the communities responsible for the final stage of the process of the restoration were reeds vegetation. The situation is slightly different in the area of the mineral edges of the former reservoir, in the area of strong influence of groundwater.Here, the gyttja layers, mineral substrate or shallow layer of sedge peats are covered with peat-forming moss-sedge and moss communities. This part of the complex is occupied by the so-called soligenous mires. The stratigraphic profile shows a significant disturbance in the vertical arrangement of the individual sediment layers. This phenomenon is probably a consequence of the partial drying of the mire, and deformation of the deposit as a result of its subsidence as well as local shallow peat exploitation.

As maps from the beginning of the 20th century show, the area was used for agricultural purposes as hay meadows or pastures. The mire was surrounded by small settlements, the locations of which are also indicated on maps from the 19th century. It was, therefore, an area on which the human economy had a visible impact. The location of the drainage ditches indicates that basically the entire area of the mire was developed. Due to the wet nature of the terrain, the watercourse flowing through the central part of the area was turned into a drainage ditch in order to increase the outflow of water and turn the area into a meadow.

The analysis of geological cross-sections shows the occurrence of four types of ecological mires in the reserve (Succow 1988). These are fluviogenic, soligenous, spring, and terrestrialisation mires. Mires of different types are connected into spatial complexes and can be transformed from one to another as a result of succession, often induced by hydrological changes on a landscape scale.

The largest area here is represented by fens that fill the ancient lake basin. The peat deposits, with a thickness of ca. 1 – 2 m, cover the deposits of limnic sediments – organic and organic-calcareous gyttja with a slightly higher thickness.

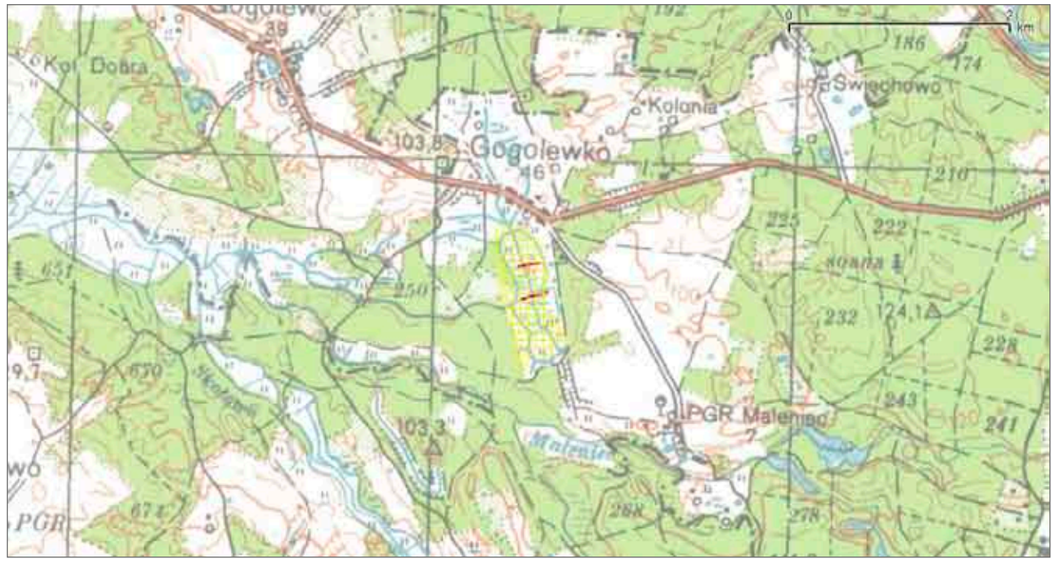


Fig. 55. Localisation of reserve „Gogolewko".

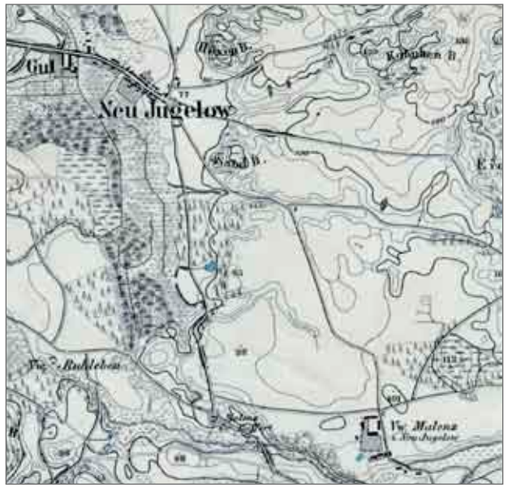


Fig. 56. The area of the reserve on an archival map from 1921 (source: http://www.mapywig.org/m/WIG_maps/series/100K/68_Lupowo_IWG_1921.jpg).

The best-preserved soligenous mires are located around the mineral hills stretching from south to north in the central part of the former lake basin. This is due to land drainage carried out in the past, which partially cut off the inflow of groundwater from the uplands. Nearly the entire mire is surrounded by ditches that intercept the groundwater. The lack of surrounding ditches around the mineral islands was a prerequisite for the survival of alkaline mires with characteristic vegetation in their vicinity. Within the mires in the reserve, a rare, spontaneous regeneration of moss vegetation was observed in the area of small exploited peat-cuts.

Within the area of the reserve, rarely observed spontaneous regeneration of the segde - moss vegetation was detected within small peat-cuts.

The dominant type of vegetation of the whole mire complex is a mosaic of meadow communities belonging to the class *Molinio-Arrhenatheretea*, and the so-called moss communities belonging to the class *Scheuchzerio-Caricetea nigrae*, which results from the long-term agricultural use of the entire site. The *Scheuchzerio-Caricetea nigrae* class is represented by *Caricetum nigrae* and *Menyantho-Sphagnetum teretis* associations. The best-formed patches of these communities have been preserved in the area of the mineral island located in the northern part of the reserve. This is the result of the still active influence of groundwater in the area, through the so-called "hydrological window", which is the mentioned mineral island. The most valuable and exceptionally well-formed moss communities have been preserved in the central part, in places after the former exploitation of peat. It is notable that the most valuable moss -sedge vegetation, with numerous rare and endangered species, are related to the sites of shallow peat exploitation carried out in the past.

It is worth mentioning that these patches are located far from the mineral edges, almost in the immediate vicinity of the main watercourse. This fact unequivocally confirms the extremely significant and still existing potential regeneration capacity of the entire mire complex. The moss phytocoenoses growing in the exploited peatlands are characterized by numerous occurrence of high mire species from the class *Oxycocco-Sphagnetea*. From the point of view of nature protection, the "moss fields" area is one of the most valuable parts of the reserve due to, among other things, the most numerous occurrence of orchids within the boundaries of the site. The high natural values of these communities are also evidenced by the high concentration of rare and endangered species of bryophytes, including the so-called glacial relics.

Photo 52. The area was granted informal protection several years before the Pomeranian Landscape Park Complex in Słupsk officially established the reserve (photo R. Stańko).

Photo 53. A view of the best-preserved fen patches in the vincinity of the mineral islands (photo R. Stańko).

As part of the project, the existing gates on drainage ditches were renovated and tree and bush wildings were removed from the major, overgrown area of the reserve.

The hydrological studies officially (Stańko et al. 2002), inspired by the particular distribution of specific plant communities around the mineral islands in the middle of the mire, explain the relationship between the development of soligenous mires and the specific type of groundwater supply. At the same time, these studies (supported by the identification of the stratigraphy of the deposit) reveal the negative consequences of the disturbances in the water conditions caused by drainage works. The ana-lysis

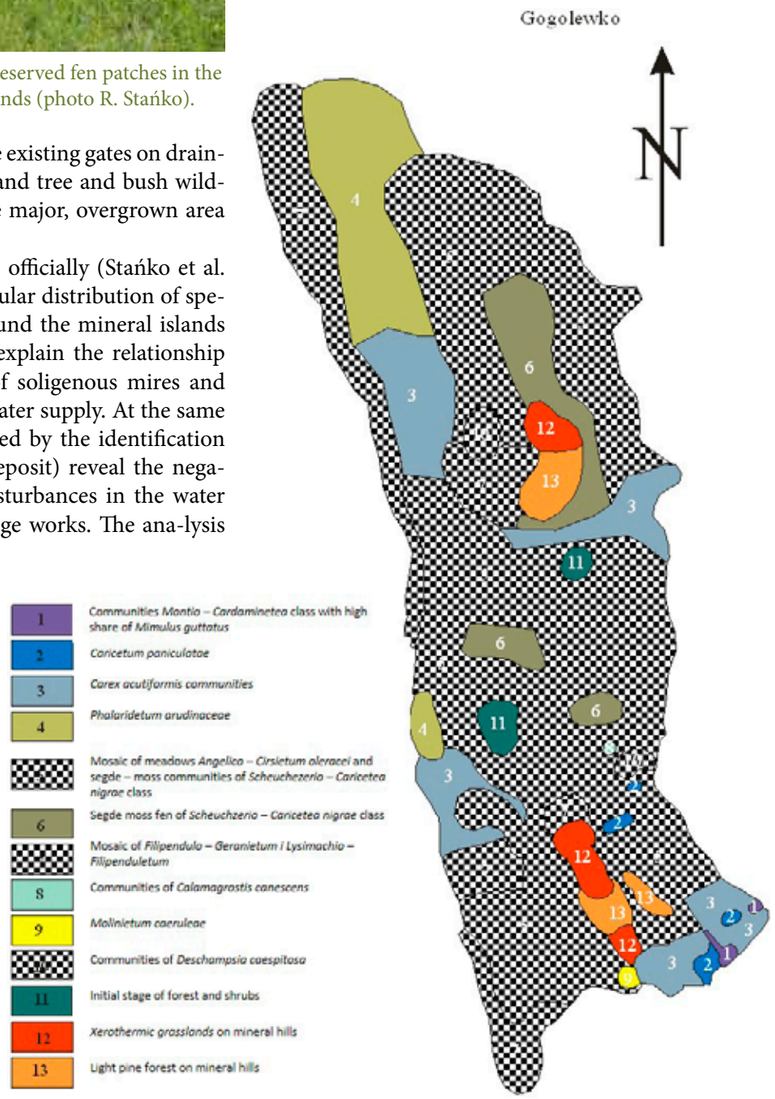


Fig. 57. Simplified map of vegetation based on 2002 studies (source: Stańko et al. 2002).

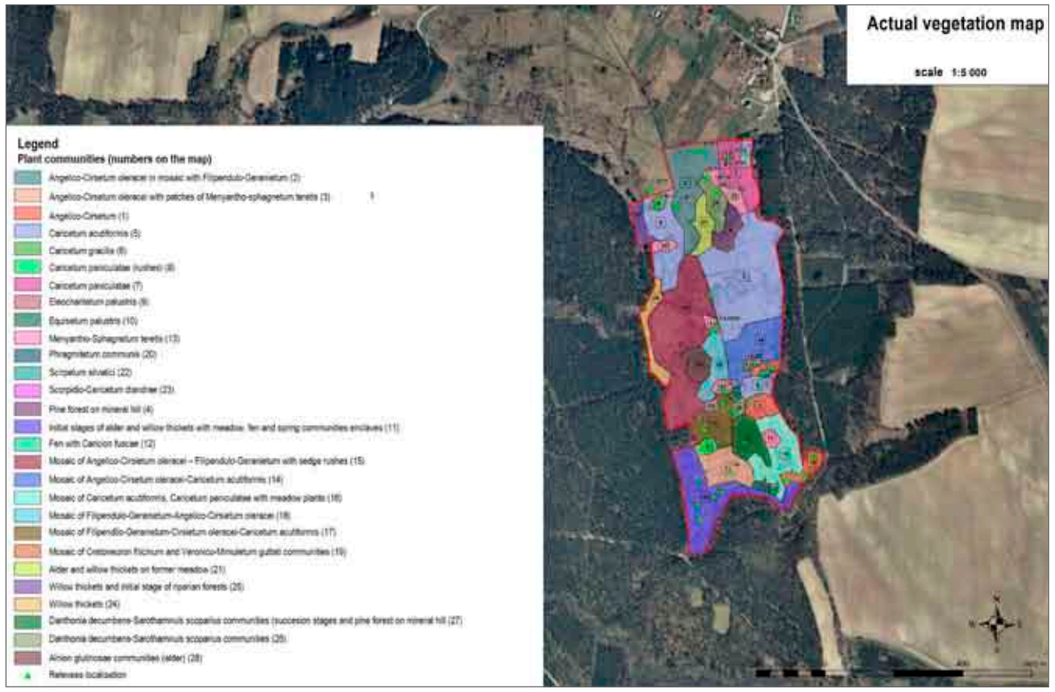


Fig. 58. Actual vegetation map in 2016 on a basis of the Conservation Plan (Stańko et al. 2018).

of the structure of peat deposits and lake sediments in the cross-section of the entire mire and the mineral island located in its central part, as well as the measurements of selected physical and chemical groundwater parameters (see Fig. 58 transect "GO") allow for determining the direction of their flow from mineral formations through the peat deposits to the network of natural and artificial surface watercourses. At the same time, it indicates the role of the impermeable lake sediments (calcareous gyttja) in shaping the water flow in the area. The occurrence of moss field vegetation patches (see GO2 – GO4) is closely related to the undisturbed flow of groundwater (no surrounding ditches between the mineral edge and the mire) from the island, which acts as a so-called "hydrological window". The water feeding

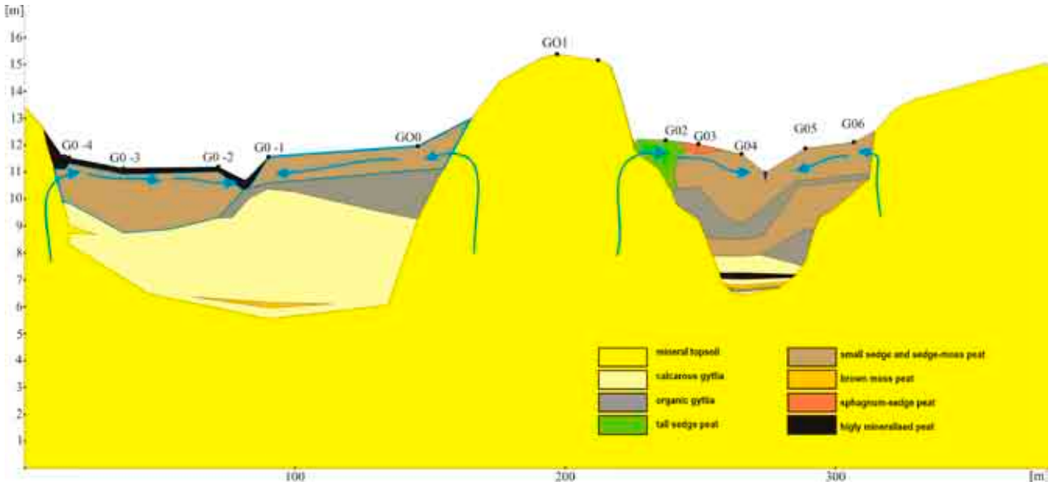


Fig. 59. Geodesic and geological cross-section through the Gogolewko mire complex in the vicinity of the mineral island in the northern part of the reserve.

the mire from the slopes of the upland reaches the deposit to a limited extent due to deep surrounding ditches, which manifests itself in the degradation of surface layers of peat and the complete disappearance of moss field vegetation.

For several years, the "Gogolewko" Reserve has been managed and covered with protective activities by the Dolina Słupi Landscape Park. As part of the conservation measures, gates were built on drainage ditches to prevent excessive drainage of the mire and mowing operations were carried out to prevent the expansion of trees to the most valuable fen patches. The studies carried out within the project confirmed their high effectiveness (see comparison of vegetation on individual transects below). As part of the project, the ditch gates were repaired and the trees and shrubs on areas not yet under active protection were removed.

Photo 54. View of a section of the mires in the spring of 2018 after the removal of thickets used later for blocking drainage ditches and mowing, as well as the reconstruction of dams to improve water conditions in the mire (photo R. Stańko).

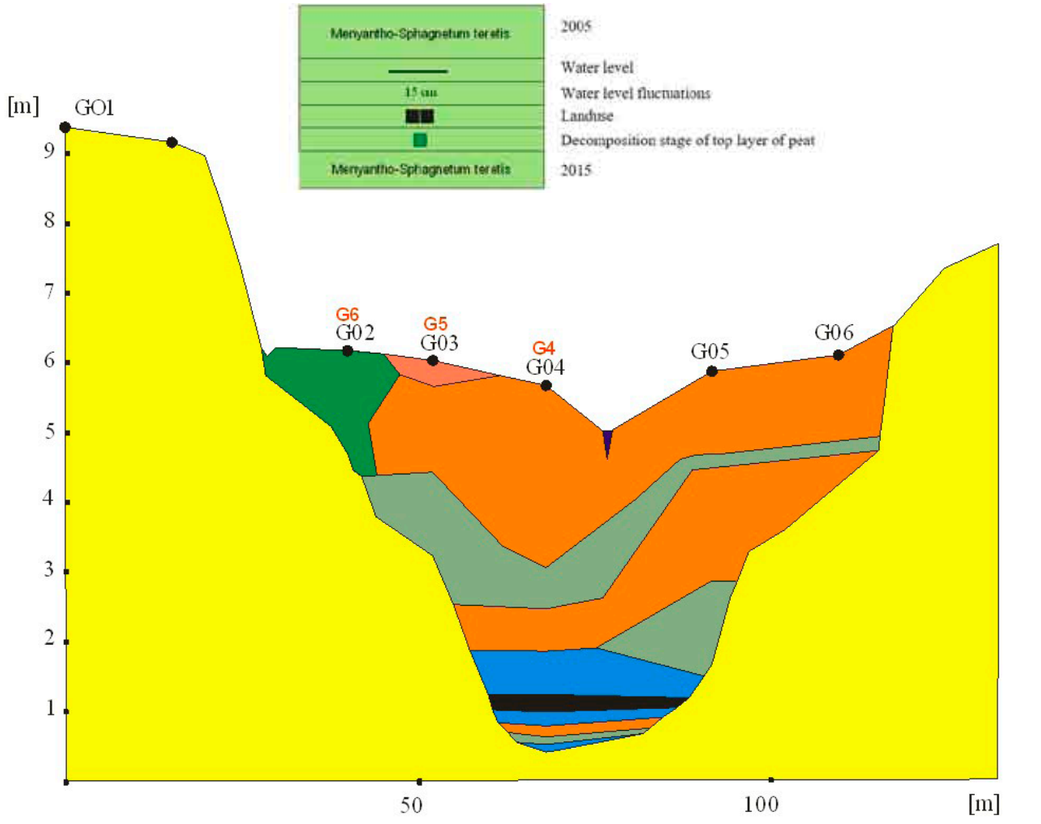


Fig. 60. Distribution of moss fen plant communities in a selected part of the "GO" transect in 2005 and 2015 against the background of water conditions, implemented protection activities, intensity of use, and the degree of surface decomposition of the peat deposit layer in the "Gogolewko" Reserve.

Alkaline fens (with a total area of ca. 50 ha) which are the subject of activities under the project are located within a vast forest complex of the Drawsko Woods. It covers the area of the post-glacial Drawsko Plain, which is a wide strip of sandur fluvioglacial sands. The terrain is characterized by a complex system of glacial tunnel valleys and former outflow routes of melting glacier waters (mainly in the directions: N – S, NE – SW, NW – SE). These valleys are currently used by the Drawa River and its tributaries: the Korytnica and Płociczna with the Cieszynka. The terrain also features tunnel valleys of the marginal zone with a course similar to the parallel, numerous kame formations and kettle depressions.

In addition to the Natura 2000 habitat site **PLH320046 Uroczyska Puszczy Drawskiej** and bird site **PLB 320016 Lasy Puszczy nad Drawą**, a part of the area is located within the buffer zone of the Drawa National Park. The surface of the area is dominated by forests, but the main natural values are related to wetland ecosystems: rivers, lakes and mires. For several decades, agricultural activity has been declining in the Drawsko Woods and the forest area has expanded. The alkaline fens of the area are owned by the State Treasury and managed by the following forest inspectorates: Drawno, Głusko, Człopa, Tuczno, and Kalisz Pomorski. In the past, they were used as extensive meadows and are now largely excluded from regular use, with the exception of small fragments used by hunters.

It is an area with one of the highest concentrations of alkaline fens in the West Pomeranian Voivodeship of regional importance. It is also a place of quite numerous occurrence of species typical for habitat 7230, i.e.: *Paludella squarrosa, Hamatocaulis vernicosus, Cinclidium stygium, Scorpidium scorpioides, Helodium blandowii, Tomentypnum nitens, Limprichtia cossoni, Sphagnum teres, Liparis loeselii, Epipactis palustris, Parnassia palustris, Carex diandra,* and *Carex flava.* Some sites of high natural value still deserve reserve-type protection. However, the implementation of this form of conservation encounters resistance from the tourism industry.

The subject of conservation activities under this project are five alkaline fens (sites) in the area:

I – Jezioro Bukowo (reserve "Bukowskie Bagno"),

II – Mielęcin-Bukowo,

III – V Complex of fens in the valley of the Korytnica River (Stara Korytnica, Nowa Studnica, Nowa Korytnica). Their location can be seen in Fig. 61 and 62.

The fens of the Drawsko Forest region have been the subject of many publications and studies of various status, including a number of design documentation and protection plans. The proposal to extend natural reserve conservation to several fens, the main objective of the project, is presented in detail in the studies by: Jermaczek et al. 2006, Kujawa-Pawlaczyk et al. 2009, and Wołejko et al. 2014. A historical review of the most important studies of the fen of the Drawsko Forest region is included in the publications of Kujawa-Pawlaczyk (2014) and Pawlaczyk (2015). Other data pertaining to alkaline fens included in the scope of the project are provided by the following publications and documentations: Loeb et al. 2015, Owsianny and Gąbka 2007, Pałczyński 2007, Pokryszko et al. 2016, and Wołejko et al. 2012; 2014/2015.

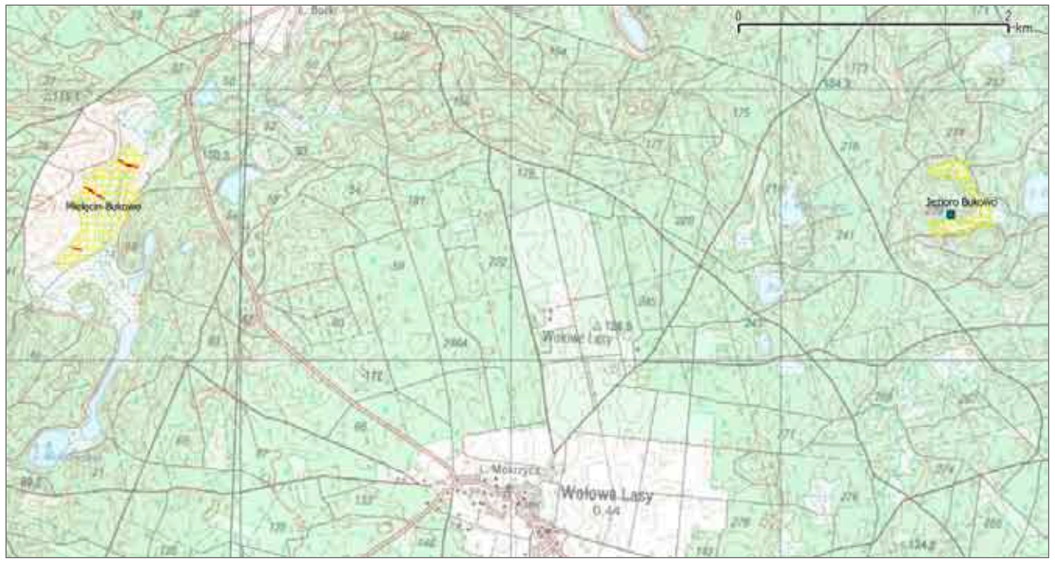


Fig. 61. Location of sites Mielęcin Bukowo and Jezioro Bukowo in the area Uroczyska Puszczy Drawskiej, together with location of research transects and hydrological monitoring points.

Fig. 62. Location of sites in the Korytnica river valley: Stara Korytnica, Nowa Studnica and Nowa Korytnica in the area Uroczyska Puszczy Drawskiej.

The identified threats to the existence of some alkaline fens in the area are the drying caused by reduced groundwater levels due to an efficient drainage system and the simultaneous disappearance of traditional agricultural use.

Reserve „Bukowskie Bagno"
(= Bukowo Długie and Małe Lake)

Based on the documentation prepared by the Naturalists' Club (Jermaczek et al. 2006), the Bukowskie Bagno Nature Reserve, with the area of 21.99 ha, was established in 2009. It includes an alkaline and transitional fen, bog forests, reeds, and a relict lake, as well as valley slopes covered mainly by deciduous forests. As part of this project, a protection plan was prepared for the reserve (Wołejko et al. 2014/2015) and the water conditions of the entire fen and lake complex were stabilized

The fen – of ancient lake origin – occupies two glacial tunnel valleys that connect at a right angle. The remains of the original water reservoir is the Bukowo Lake. The lake, which was previously considered a hard-water habitat, is considered by some authors to be an alloiotrophic lake. These are reservoirs with a reaction close to neutral, which are usually subject to the balanced effects of distrophication and eutrophication processes (Owsianny & Gąbka 2007). The waters flowing out of the lake constitute a spring area for the Bukówka stream, a small tributary of the Noteć.

The segde - moss communities found in the alkaline fen complex classified as *Scorpidio-Caricetum paludelletosum* form a spatial mosaic with a quagmire community of large clusters of sedge *Carex paniculata* with significant presence of *Sphagnum fallax* and *Thelypteris palustris.* Water stands in places between the tussocks. An important part is played by bryophytes: *Marchantia polymorpha*, *Paludella squarrosa, Helodium blandowii,* and *Tomentypnum nitens.* We can also find the fen orchid *Liparis loeselii* (the largest population in the Drawsko Forest) and marsh helleborine *Epipactis palustris* as well as the softstem bulrush *Schoenoplectus tabernaemontani.* Similar communities – also with the occurrence of the fen orchid and marsh grass of Parnassus *Parnassia palustris* as well as the eyebright *Euphrasia sp.* – can be found on the moss -sedge communities near

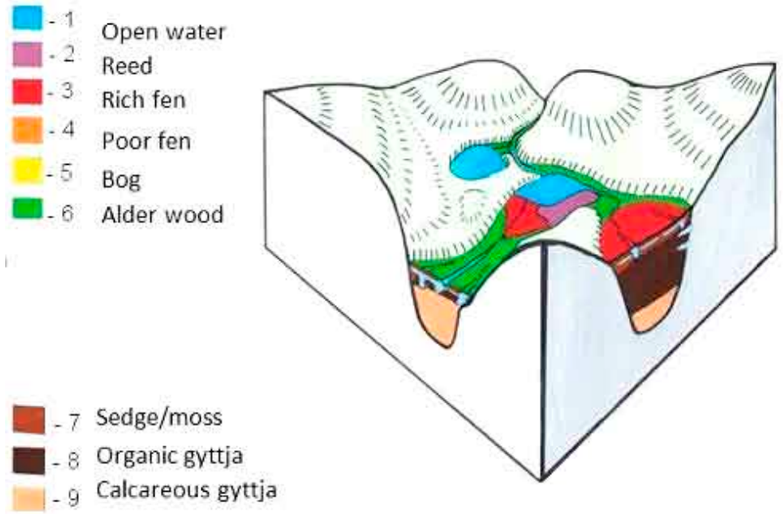


Fig. 63. Position of the Bukowskie Bagno wetland complex in the landscape; model developed on the basis of ecohydrological, geobotanical, and stratigraphic studies conducted in 2014 (according to Loeb et al. 2015).

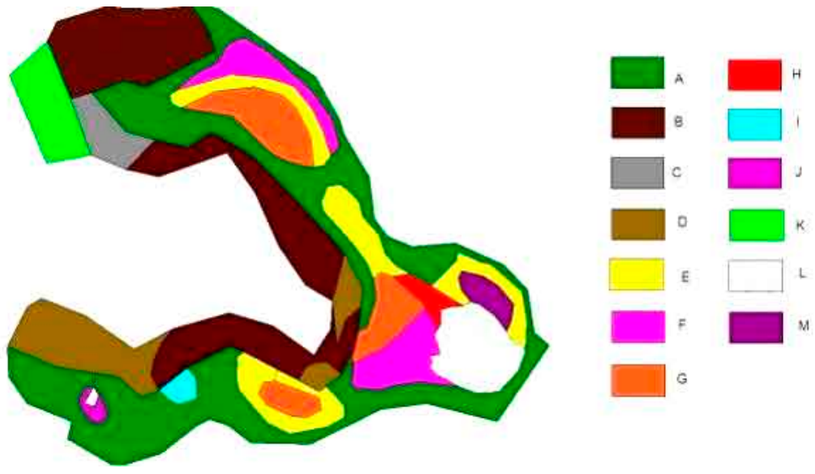


Fig. 64. Actual vegetation of the Bukowskie Bagno reserve (as of 2006). A – *Sphagno-Alnetum*, B – *Deschampsio flexuosae-Fagetum*, C – *Galio-Carpinetum*, D – *Calamagrostio arundinaceae-Quercetum petraeae,* E – *Caricetum paniculatae,* F – *Thelypterido-Phragmitetum,* G – *Scorpidio-Caricetum diandrae,* H – *Thelypterido-Typhetum,* I – *Molinia coerulea* comm., J – *Vaccinio uliginosi-Pinetum,* K– cultivated forestation, L – aquatic plants, M – *Sphagno-Caricetum rostratae* (acc. to Jermaczek et al., 2006, modified).

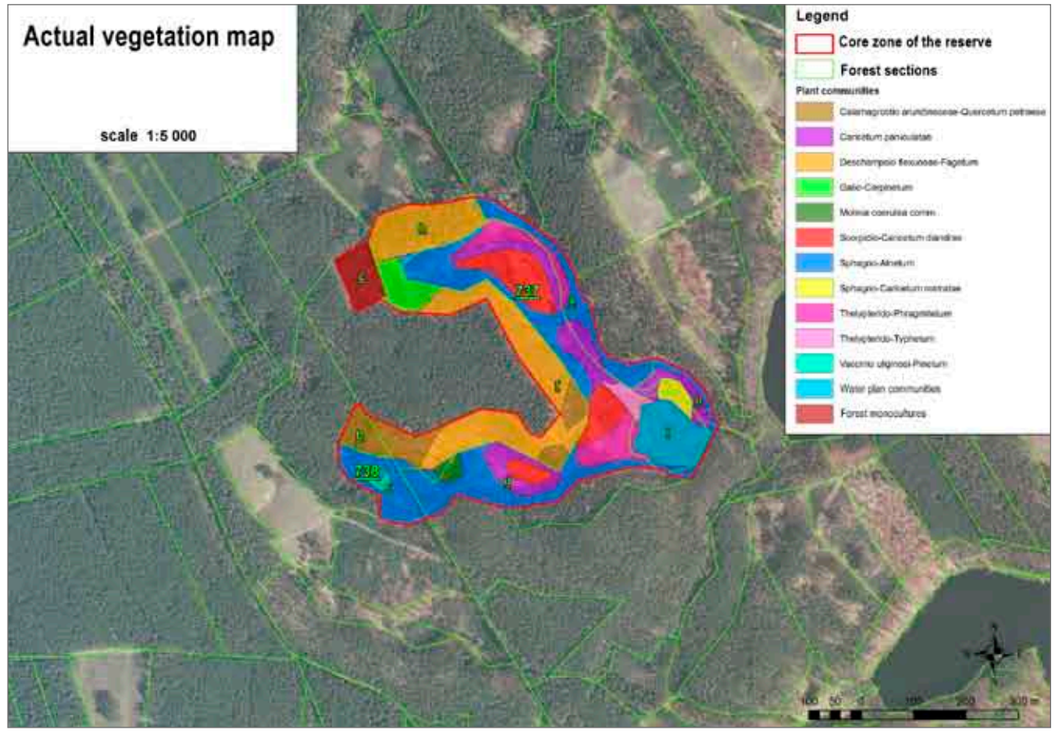


Fig. 65. Actual vegetation of the Bukowskie Bagno reserve – as of 2015 (source: Wołejko at al. 2014/2015).

Photo 55. Mosaic segde-moss i minerotrofic fens (photo R. Stańko).

the lake, west of the water table. At the borders of the fen, in the area of groundwater seepage at the foot of the valley slopes, there are interesting patches of a community with the fewflower spikerush *Eleocharis quinquaeflora*.

A large part of the fen near the lake is covered with *Thelypteridi-Phragmitetum* fern reeds. Between the clusters, there is a community of the lesser bladderwort *Scorpidio-Utricularietum minoris* in the water-filled depressions. In less drained areas, a transition moss mire with the common cottongrass *Sphagno recurvi-Eriophoretum angustifolii* is formed. The northern part is dominated by well-preserved communities of mosses and sedges of ancient lake origin with greater tussock-sedge *Carex paniculata* of quagmire nature floating over a several-meter thick bed of organic gyttja, as well as quagmire *Thelypteridi-Phragmitetum* fern reeds.

"Bukowskie Bagno" is one of the few fens in the Drawsko Forest where the beetle fauna was examined. Noteworthy was the occurrence of a number of rare species typically found in transitional fens: *Oodes helopioides, Microsporus acaroides*, *Euconnus rutilipennis, Eusphalerum minutum*, *Stenus boops*, *Stenus crassus*, *Tetartopeus sphagnetorum*, *Erichsonius cinerascens, Acylophorus glaberrimus,* and *Atanygnathus terminalis*. Two phytophage species should be named – *Longitarsus nigerrimus* and *Tryogenes scirrhosus*. The first of them feeds on bladderworts and is extremely rare in Poland. In northern Poland, it was only found in the Mazurian Lake District. *Tryogenes scirrhosus* feeds on bur-reeds and bulrushes and is only occasionally found in the country. Protected species were also found here: the yellow-spotted whiteface *Leucorrhinia pectoralis* (protected in the Natura 2000 areas) and the medicinal leech *Hirudo medicinalis* sources of data cited in (Wołejko et al. 2014/2015).

On the basis of simplified stratigraphic drilling, the structure of the deposit of biogenic formations, which constitute the basis for the development of wetland vegetation in the reserve, was determined. Nearly all stratigraphic profiles represent the type of construction of a terrestrialisation mire at an early stage of development. The phase of the open water reservoir is documented by the thick deposits of organic and organic-calcareous gyttja. Deposits of poorly decomposed sedge, moss, and transition mire sphagnum peats have been deposited on the surface of lacustrine formations. Their location in the reserve corresponds well with the location of current peat-forming communities.

All the peat profiles are now well hydrated and their upper part is emersive and floating, which is facilitated by the water lens found in all profiles at a depth of several dozen centimeters below ground level.

Wetland ecosystems of the Bukowskie Bagno fen are supplied with groundwater and rainwater. This is confirmed by temperature cross-sections and results of physicochemical analyses of water (Table 4).

Table 4. Physical and chemical parameters of surface waters on alkaline fen in the Bukowskie Bagno reserve (data: Loeb et al. 2015).

Sample no.	pH	alk meq	EGV µS/cm
W3	7,01	6,1	320
W4	7,16	5,51	404
W5	7,33	6,17	236
W6	7,93	5,5	273
W7	7,46	5,57	270
W8	8	5,38	275
W9	7,44	6,03	289
W10	7,3	5,5	302
W11	7,37	4,83	242
W13	7,42	5,62	247
W14	7,3	6,5	291
W18	7,39	6,39	291
W19	7,35	5,93	264

At present, the supply conditions seem stable and the state of moisture in the biotopes is mainly determined by the water outflow conditions. The only surface outflow is a trench connecting Lake Bukowo Małe with the Bukówka River. Flows in this watercourse were modified by beaver activity. At present, the water level has been stabilized by installing appropriate devices in the existing beaver dam.

The water conditions are also affected by the old drainage systems. Their locations are visible on archival maps and still distinguishable in the field, despite significant naturalization. The specific hydrological conditions of terrestrialisation mire ecosystems allow for the floating of the mire surface and adaptation to minor changes in water conditions. This is due, among other things, to the presence of a water lens in the peat profiles. Relatively stable (with a tendency to increase the level) water conditions in the moss part of the reserve were recorded by automatic water level logger (fig. 66).

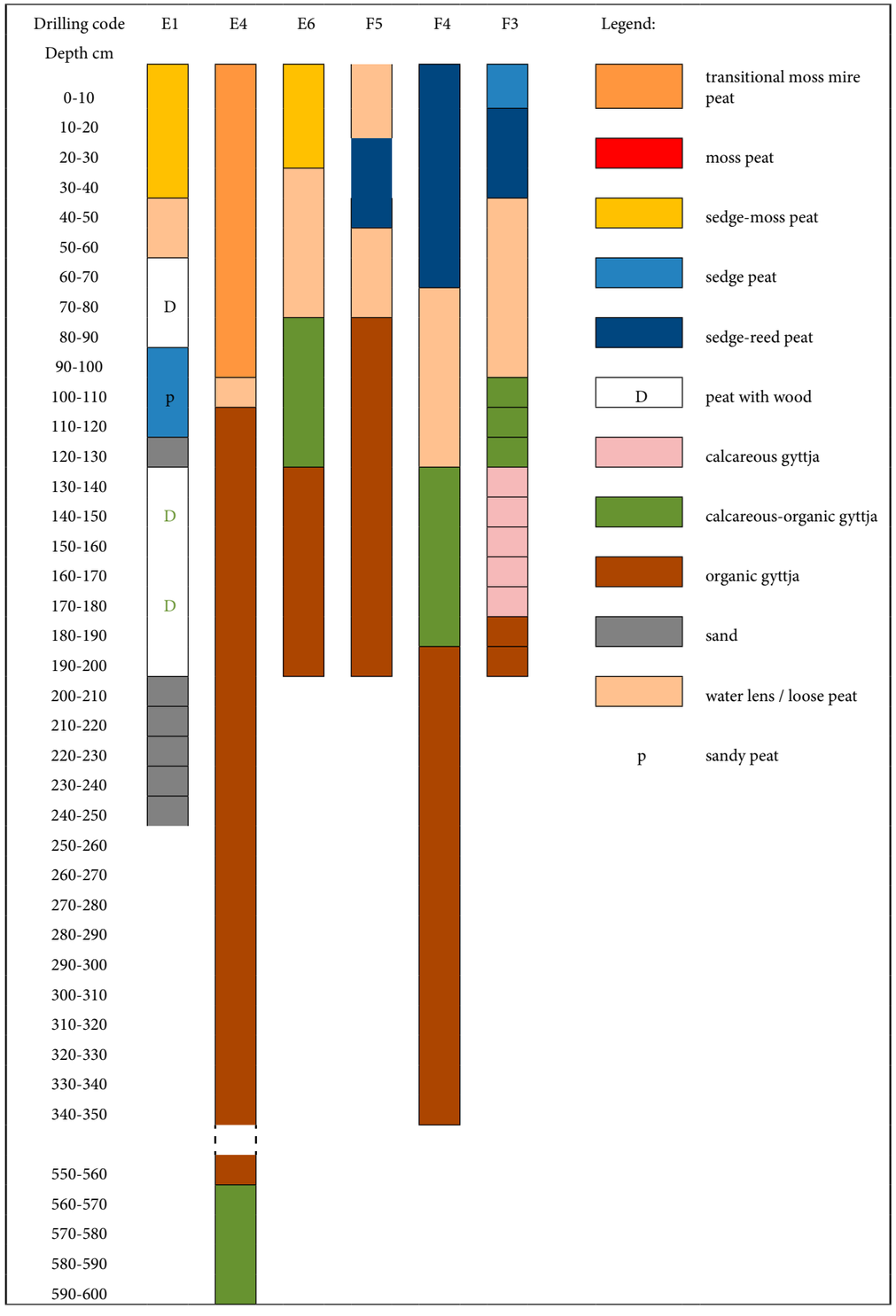


Fig. 66. Simplified stratigraphic profiles of the Bukowskie Bagno fen.

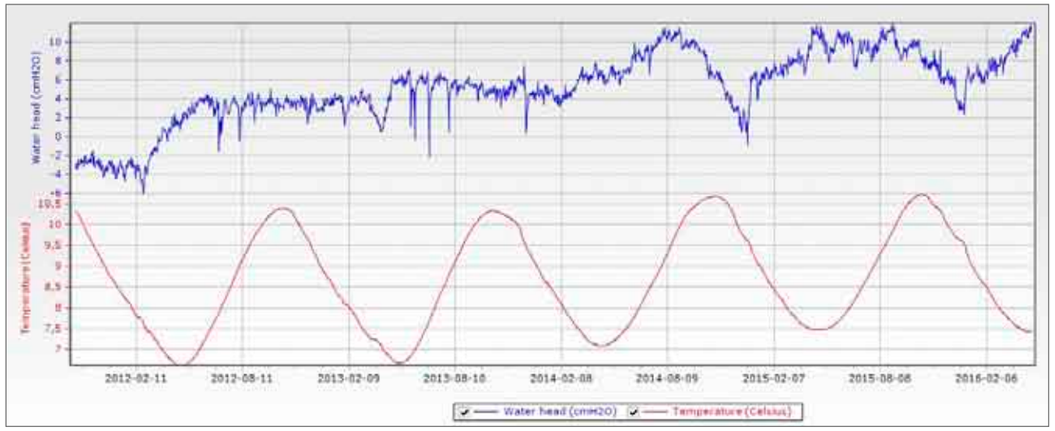


Fig. 67. The dynamics of groundwater levels in the area of the moss fen in the western part of the Bukowskie Bagno fen. Automatic water level recorder logs from the period November 2011 – February 2016.

On the basis of the analysis of the vegetation cover of the reserve based on the maps of actual vegetation from 2006 and 2016 no significant changes in the composition or distribution of individual plant communities were noted. The conservation status of the fen should be considered satisfactory, and the area does not require any protective measures in the near future, except for the monitoring of vegetation and water conditions.

Photo 56. PVC pipe stabilising the water level in the lake raised excessively by beavers (photo L. Kułak).

Mielęcin-Bukowo

(= fens near the Cieszynka river between Mielęcin and Bukowo, Kujawa-Pawlaczyk & Pawlaczyk 2014)

The spring part of the Cieszynka river valley is filled with an ancient lake and soligenous fens, richly supplied with groundwater. Despite land drainage and the still functioning, active ditches, rather steep cupolas of the spring fen were maintained from the northern side.

The site is covered by a mosaic of moss and sedge communities. Groundwater seepages are found near the border of the valley. The dominant community characteristic of alkaline fens is *Menyantho-Sphagnetum teretis*. It occurs in the form of small patches on the slopes of the soligenous fens. A rare moss special typical of moss fen vegetation has been found (*Helodium blandowii*). Most of the area in the valley is covered by tall sedge communities, among which a significant share are of *Carex appropinquata*.

A zoological peculiarity of the fen is the occurrence of whorl snails – the narrow-mouthed whorl snail *Vertigo angustior* and Desmoulin's whorl snail *V. moulinsiana*.

Project activities included inhibiting the succession of forest and thicket vegetation and improving water conditions.

The research into the stratigraphic structure of the deposit in its central part conducted as part of the project has shown that the majority of the fen is covered by sedge-moss and sedge peats with a variable thickness of up to ca. 100 cm and varying degrees of decomposition. They can be found on gyttja deposits up to 2 m thick. In some places, the gyttja is exposed to the surface (see drillings B2 and B4, Fig. 67).

Photo 57. Sedge patches in the central part of the Mielęcin-Bukowo fen (photo D. Horabik).

The protective measures carried out, consisting in the removal of tree wildings and mowing, significantly inhibited the succession of forest and shrub vegetation. There were no significant changes in the vegetation within the areas subjected to protective treatment, except for the trees and shrubs that were cut down. Raising the groundwater level through the built gates and light removal of bushes and trees

Photo 58. Relics of meadow communities on the spring slopes of the cupola of the Mielęcin-Bukowo fen (photo D. Horabik).

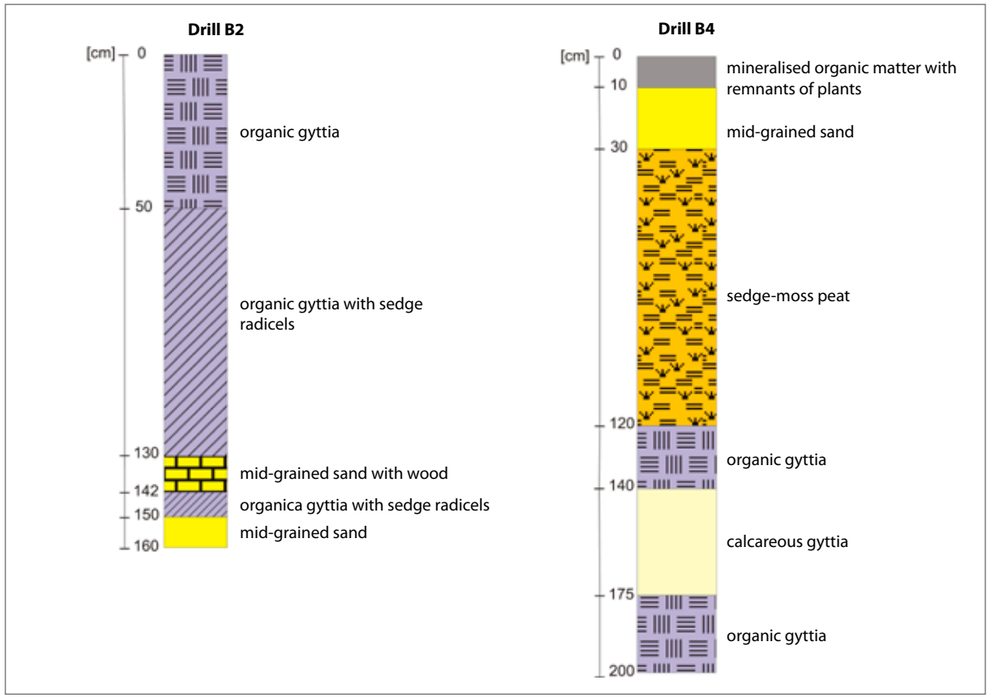


Fig. 68. Simplified stratigraphic profiles at points B2 and B4.

clearly contributed to the improvement of the condition of the occurring species characteristic for alkaline fens. The activities consisting in extensive mowing are continued by the Człopa Forest Inspectorate on the basis of, among others, natural documentation prepared within the project.

Photo 59. One of several gates built as part of the project in „Mielęcin-Bukowo" site (photo R. Stańko).

Photo 60. Few willow basal shoots one year after the removal of trees and shrubs from the surface of the fen „Mielęcin-Bukowo" (photo R. Stańko).

Stara Korytnica
(= Dolina Zgnilca, Kujawa-Pawlaczyk & Pawlaczyk, 2014)

A complex of flow-through and spring fens of various conservation status, in the valley of the Zgnilec stream – a tributary of the Korytnica River, about 1.5 km from Stara Korytnica. In the past, the stream was regulated and dredged, and the fens in the valley were cut by ditches.

The fens cover the bottom and slopes of the channel valley, which is mostly filled with limnic sediments. In many places, the bottom of the ditches is crossed by efficient aquifers. There are numerous point springs and flushes. The intensity of groundwater supply is indirectly indicated by the dense network of drainage ditches dug up before 1939 (Fig. 68).

A fragment of an alkaline fen has been preserved in the western part of the complex, in an offshoot of the valley, with vegetation composed of bogbean *Menyantho-Sphagnetum teretis* and moss - sedge communities with lesser tussock-sedge *Scorpidio-Caricetum diandrae.*

The best preserved fragments of the alkaline moss fen in the complex with spring fen cupolas are located in the eastern part of the mire, in an offshoot of the valley, surrounded by the hills from which the groundwater flows. Fully saturated with water, the moss fen patches probably also developed here in small, fully regenerated peat-cuts after peat exploitation. The monitoring transect of habitat 7230 is located here (Kujawa-Pawlaczyk, 2009). Patches of typical moss vegetation related to *Menyantho-Sphagnetum teretis* are located in the part of the former bay near its slope. Here, there are found the concentrations of botanical and phytosociological rarities with vegetetation composed of moss - sedge communities with bogbean *Menyantho-Sphagnetum teretis* and lesser tussock-sedge *Scorpidio-Caricetum diandrae.* Also found are numerous populations of marsh helleborine *Epipactis palustris* and very numerous communities of orchids: early marsh-orchid *Dactylorhiza incarnata* and western marsh orchid *D. majalis,* rare mosses: *Paludella squarrosa*, varnished hook-moss *Hamatocaulis vernicosus*, *Helodium blandowii, Tomentypnum nitens, Cinclidium stygium,* and *Scorpidium scorpioides*. Partially drained spring cupolas are covered with reeds and sedges with a developmental tendency to form forest communities.

At the transition to mineral soils, there are plant communities of mesophilic meadows and herbs indicating periodic mowing, currently probably related to hunting management. In these areas, succes-

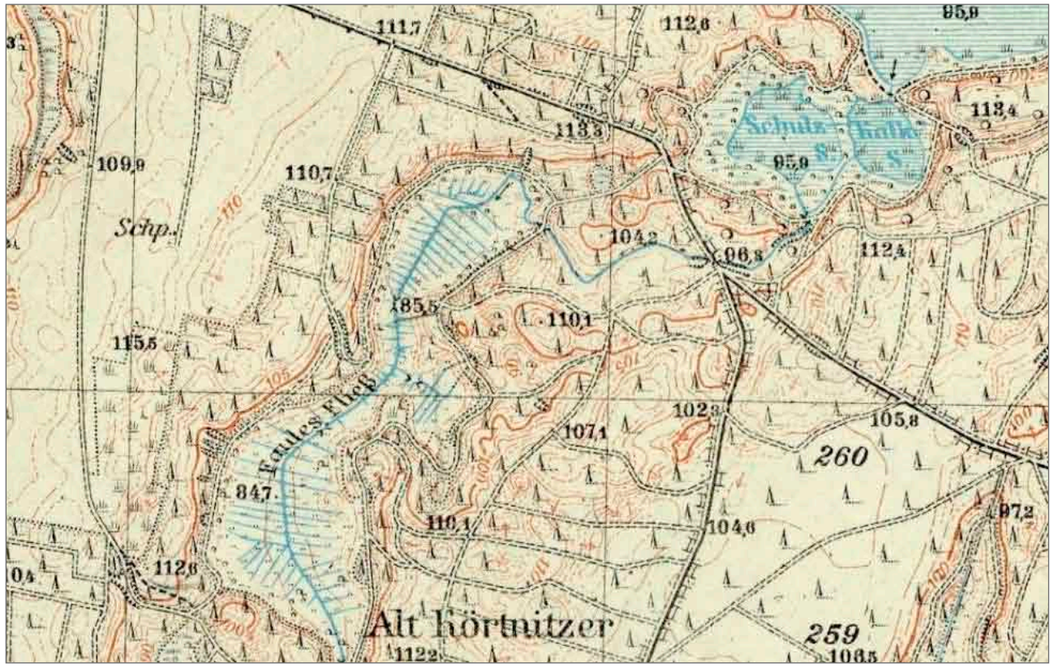


Fig. 69. A dense network of drainage ditches on an archival map.

Photo 61. The best-preserved, fen section of the Stara Korytnica fen (photo A. Szafnagel-Wołejko).

Photo 62. Tussocks of *Carex paniculata* in the heavily drained part of the Stara Korytnica fen (photo D. Horabik).

sion to herbaceous and willow thickets is generally observed.

The vegetation of the rest of the valley consists mainly of tussock and prostrate sedges with dominant *Carex paniculata* and *C. acutiformis*. The floristic composition and physiognomy of these communities indicate their post-meadow nature and significant degradation due to the dryness of the peat substrate and the release of biogenes. There is currently no agricultural use of these areas. They form a mosaic with small surface enclaves of spring alder forests and fragments of open, eroding springs with elements of typical vegetation from the class *Montio-Cardaminetea*.

A zoological peculiarity of the fen is the occurrence of whorl snails – the narrow-mouthed whorl snail *Vertigo angustior* and Desmoulin's whorl snail *Vertigo moulinsiana*.

In order to preserve the site values, in 2006 the Naturalists' Club, in cooperation with the Forest Inspectorate of Kalisz Pomorski, built wooden and stone gates on the ditch into which the stream of Zgnilec was transformed.

The stratigraphic studies conducted as part of the project documented the occurrence of relatively well-preserved sedge-moss and moss peats characteristic for alkaline fens within the vegetation patches.

In order to maintain the characteristic vegetation and the peat deposits in good condition, actions were

Photo 63. Well-preserved moss and moss-sedge peats from the Stara Korytnica fen (photo D. Horabik).

taken to improve water conditions, i.e., to build several gates on drainage ditches. Periodic hydrological observations confirmed the effectiveness of the protective measures applied. A significant improvement in the water content of the surface layer of the fen was observed. Due to the short period of observation after mowing, it is not possible to determine the extent of its impact on vegetation. A reliable assessment of the protective measures taken will be possible after a period of at least 3 – 5 years.

Photo 64. One of the biggest gates enhancing the water conditions on most of the area of mire complex (photo R. Stańko).

Nowa Studnica
(= Sedge moss mires in the middle Korytnica Valley, Kujawa-Pawlaczyk & Pawlaczyk, 2014)

The site is located within a vast valley of the Korytnica River (tributary of the Drawa River), near the village of Nowa Studnica. The diversity of the natural and landscape values (Pałczyński 2007, Kujawa-Pawlaczyk & Pawlaczyk 2014) justifies the proposal to establish a nature reserve, which has been repeated several times (Kujawa-Pawlaczyk et al. 2009, Wołejko et al. 2014).

The snowmelt valley of Korytnica cuts the sandur surface, composed of the sands of the fluvioglacial origin. Its edges are cut by shallow erosion ravines. The valley is to a large extent filled with sediments of terrestrialized lakes. In its central part the Korytnica River flows, the current riverbed of which is partly a relic of a former flow-through lake. In the northern part a larger water reservoir – the Studnickie Lake – has been preserved. The river flowing into it creates a unique delta. The water level in the lake was artificially lowered before World War II and the exposed bottom sediments are now occupied by reed communities. On the surface of these sediments, low peats of various thickness have been deposited.

The northern part of the planned reserve is dominated by spring fens. They assume the form of large cupolas "suspended" on the western slopes of the valley. At present, the spring fens are subject to severe erosion, which has been caused by intensive drainage works in the past. The seeping water flows down the valley through deep ditches and eroded ravines. Only small patches of vegetation related to the plant communities of alkaline fens are preserved here. However, they are still home to valuable species of flora, including the *Paludella squarrosa* moss and orchids.

In the southern basin, south of the railway bridge, well-hydrated and relatively extensive fragments of low terrestrialisation fen of an emmersive character are located adjacent to the river. Significant here are large, multi-hectare surfaces of floating sedge-fern communities with *Thelypteris palustris.* A belt of soligenous flow-through fen, supplied by groundwater flowing out from the slopes of the sandur upland, has developed farther away. The mineral island in the valley, overgrown with pines, performs a special role in the supply of these fens. They act as a "hydrological window" through which groundwater discharges, supplying the best-preserved fragments of fen vegetation.

The valley of the Korytnica River is to a large extent supplied with groundwater, flowing perpendicularly to the valley axis, which resulted in the formation of a striped layout of fen ecosystems of varied origins, and now also of varying degrees of anthropogenic transformation. Well hydrated and relatively extensive, completely natural fragments of emmersive fen of a lake-origin are adjacent to the river, i.e., they react actively – floating during changes in the water level in the river. A belt of flow-through soligenous fens supplied by groundwater flowing out of the slopes of the sandur upland surrounding the valley. It is now on a stage of naturalisation after being used as a meadow. Mineral islands located in the central part of the valley play a key role , supplying with discharging groundwater the best preserved fragments of fen vegetation. They act as hydrological windows through which groundwater escapes, supplying the best preserved fragments of fen vegetation. Table 5 below presents selected physicochemical characteristics of these waters, measured in the peat forming layer in the vicinity of stratigraphic drillings.

Table 5. Reaction and electrical conductivity of the water supplying the Nowa Studnica fen; measured on 30 June, 2014.

Drilling code	W1	W2	W3	W4
pH	7,43	7,13	6,98	7,55
Electrical conductivity [µS/cm]	257	304	428	308

Within the limits of the planned reserve, fen and other wetland plant communities dominate. In places with lower groundwater levels, communities of wet meadows of the *Calthion* alliance have developed. The forest and thicket vegetation is mainly composed of different types of bog alders. A small fragment – on a mineral hill within the boggy valley – is overgrown by a pine forest. The map of actual vegetation is presented in Fig. 69.

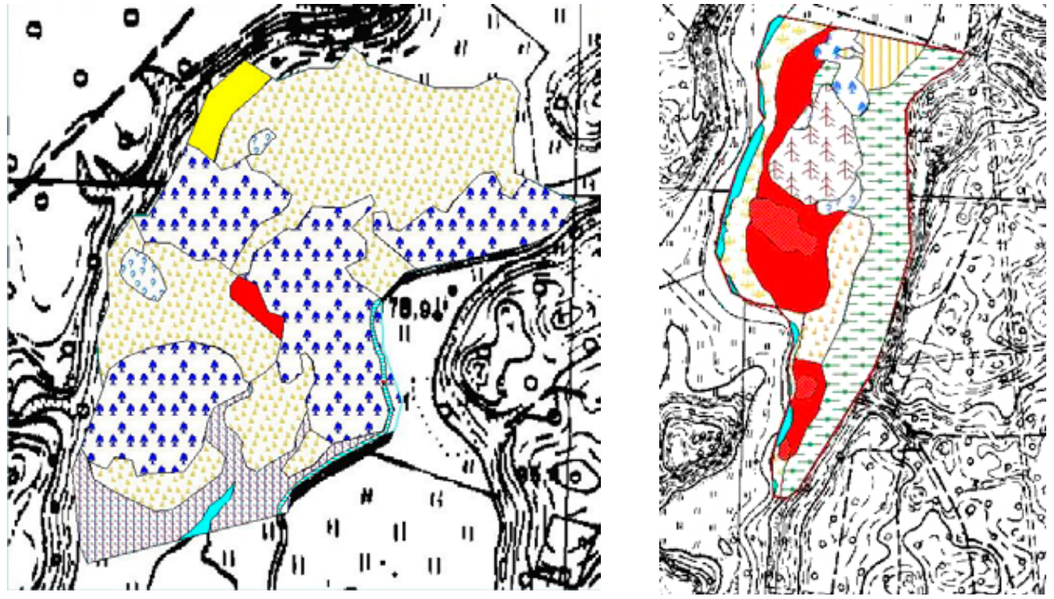


Fig. 70. Actual vegetation of the Nowa Studnica fen. Explanations: 1 – *Cardamino-Chrysosplenietum alternifolii*, 2 – moss fen (mainly *Menyantho-Sphagnetum teretis*), 3 – fen with *Pinus* (*Caricion lasiocarpae*), 4 – *Sparganio-Glycerion*, 5 – *Phragmitetum*, 6 – *Magnocaricion* on seepage, 7 – *Magnocaricion* emmersive, 8 – sedge meadow, 9 – *Calthion* (including degraded), 10 – aquatic plants, 11 – spring alder forest, 12 – *Salix* thicket, 13 – pine forest (*Leucobryo-Pinetum*), 14 – top edge of the spring fen.

Photo 65. Southern part of the Nowa Studnica fen – a moss - sedge vegetation patch with abundant occurrences of *Carex paniculata* (photo D. Horabik).

A mosaic of patches of wet *Calthion* meadows and patches of tall sedge vegetation *Caricetum paniculatae, Caricetum paradoxae, Caricetum acutiformis* and *Caricetum rostratae*, in partwith moss fen elements (e.g., domination of *Sphagnum teres*), are characterized by numerous populations of orchids: early marsh orchid *Dactylorhiza incarnata* and western marsh orchid *D. majalis*, as well as the occurrence of botanical peculiarities: marsh helleborine *Epipactis palustris,* narrow-leaved marsh orchid *Dactylorhiza traunsteineri,* varnished hook-moss *Hamatocaulis vernicosus* and typical for moss patches: *Paludella squarrosa* and *Helodium blandowii.* A zoological peculiarity of the fen is the occurrence of whorl snails – the narrow-mouthed whorl snail *Vertigo angustior* and Desmoulin's whorl snail *Vertigo moulinsiana.*

As part of the active protection measures, the excessive outflow of water from the spring fens was stopped, and the thickets were mown and removed from the small area of the overgrown moss patch. One of the tasks was also to prepare the natural documentation in order to create a reserve, which was then handed over to the competent nature conservation authorities.

Photo 66. Southern part of the Nowa Studnica fen – emmersive moss-sedge vegetation near the Korytnica River (photo D. Horabik).

Within the area of the planned reserve, varied and strongly disturbed hydrological conditions were partly recorded. The most unfavorable water conditions were recorded in the area of the strongly drained spring cupolas in the northern part of the site. Favorable water conditions, conducive to the development of rich fen vegetation, still occur in the close vicinity of the river.

The prevailing hydrological conditions are to a large extent reflected in the conservation status of the peat deposit, especially its surface layer, which determines the nature of the vegetation to a significant degree. The stratigraphic studies carried out within the project on the best-preserved patches of habitat 7230 documented the occurrence of poorly decomposed sedge and sedge-moss peats directly on top of limnic sediments (see Fig. 71).

The analysis of the stratigraphic structure, assessment of hydrological conditions, and phytosociological research conducted as part of the project indicated an urgent need to inhibit the process of erosion and mineralization of peat deposits in the area of the spring fens by means of gates significantly raising the water level and inhibiting the succession of forest and reed vegetation on a small area of habitat 7230 in the northern part of the site. At present, most of the best preserved fragments of habitat 7230, which remain in the vicinity of the river in the southern part of the reserve, do not require mowing.

Photo 67. One of the better preserved patches of moss vegetation in the northern part of the Nowa Studnica fen (photo D. Horabik).

Photo 68. One of the dams – almost totaly overgrown, but still reducing erosion of spring cupolas (photo R. Stańko).

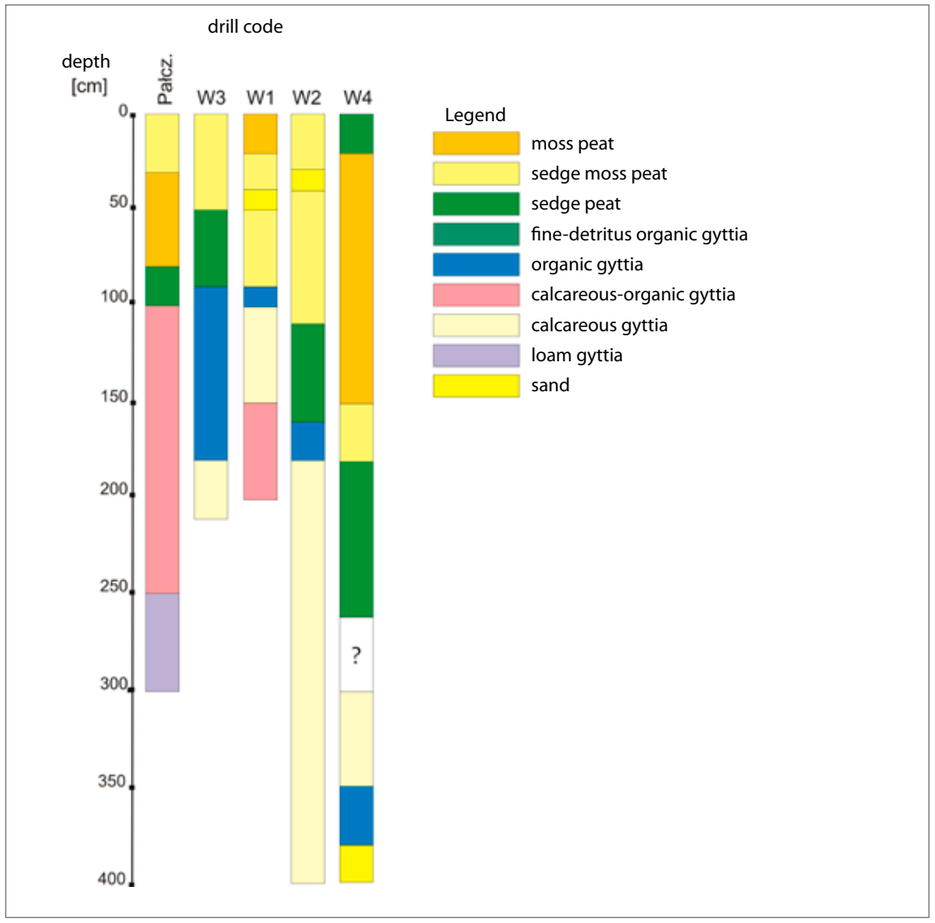


Fig. 71. Stratigraphic profiles of peat and lacustrine formations in the planned Nowa Studnica reserve.

Nowa Korytnica

The site in question occupies a fragment of the Korytnica river valley south-west from the village Nowa Korytnica. It has been developed as an extensive grassland and this function, which varies in intensity, continues to this day. This is related to the use of the area for hunting as well as to the functioning of the agri-environmental program. In the northern part, an unsuccessful attempt at afforestation was made on a part of the fen.

The fen is located in the extension of the Korytnica Valley, about 1.5 km to the west of Nowa Korytnica. The part located on the north-western side of the Korytnica River is under the management of the Drawno Forest Inspectorate, while the southern part is under the management of the Głusko Forest Inspectorate.

Within the vegetation of the Nowa Korytnica fen, plant communities and complexes belonging to the fen, reed, and meadow vegetation classes were identified. The most important role is played by communities with the physiognomy of low sedge and grass reeds. The dominant species are: lesser tussock-sedge *Carex diandra*, beaked sedge *C. rostrata* and common sedge *C. nigra* as well as common cottongrass *Eriophorum angustifolium*. Flora elements characteristic for vegetation of typical alkaline fens (*Caricion davallianae*) are combined with meadow and reed species. The locations of these plant communities are scattered throughout the site, but are more numerous in the southern part of the fen. They have been well preserved mainly in the land depression which passes into the vegetation of an immersive alluvial complex.

Fig. 72. Development status of the fen and its surroundings in 1937.

In the northern part, there is a fragment of a soligenous moss fen vegetation. However, it was degraded in the past by an afforestation attempt (tilling). Presently, a sedge-moss community is regenerating there, of the character of a low sedge flush mire with beaked sedge *Carex rostrata* and lesser tussock-sedge *Carex diandra*. Small patches of soligenous communities, mainly overgrown with clumps of sedges, are also found near the forest edge, further down the valley.

By the river, there are low fens overgrown with sedges and reeds, among which attention should be paid to the reeds with a significant share of softstem bulrush *Schoenoplectus tabernaemontani*. The reeds are also composed of great manna grass *Glyceria maxima* and simplestem bur-reed *Sparganium erectum*.

Within the moss vegetation, the proportion of characteristic species of the *Caricion davallianae* alliance is more pronounced. There is a small population of the marsh helleborine *Epipactis palustris*. A zoological peculiarity of the fen is the occurrence of whorl snails – the narrow-mouthed whorl snail *Vertigo angustior* and Desmoulin's whorl snail *Vertigo moulinsiana*.

The field observations (no hydrological monitoring by means of automatic recorders was carried out) completed during the project period confirmed that there is no need to interfere with the prevailing favorable water conditions. The field conditions (configuration of the terrain and lack of visible drainage ditches) also exclude the possibility of regulating the water conditions.

Photo 69. View of the Nowa Korytnica fens (photo D. Horabik).

Vegetation is partly mown by the Forest Inspectorate, within the implementation of agri-environmental programs, which contributes to maintaining the value of the flora. Some of the fens (leased by the Naturalists' Club) were mown as part of the project. Due to the positive impact on the vegetation, these activities are being continued.

The complex of alkaline fens of the Rurzyca Valley developed in the post-glacial tunnel valley with numerous water reservoirs, some of which already terrestrialized. The valley cuts deep into the vast sandur surface. The northern part of the valley is characterized by numerous active springs and spring cupola fens; these are the springs of the Rurzyca River, a tributary of the Gwda River. Farther down the valley, most often in connection with partially terrestrialized lakes, soligenous flow-through fens with characteristic moss vegetation developed. Currently, the vegetation typical for alkaline fens covers a total area of ca. 60 ha. These sites are the property of the State Treasury and are managed by the Jastrowie and Płytnica Forest Inspectorates.

In the past, most of the fens were used as meadows; now, only small fragments of them are occasionally mown, mainly as part of the implementation of conservation plans. The site has a relatively rich literature covering biocenosis, hydroecological recognition and stratigraphy of fens (e.g. Jasnowska et al. 1987, 1993a, b, c, d, Grootjans et al. 1999, 2015, Wołejko 2000a, b, c, d, e, 2015, Wołejko & Piotrowska 2011, Dylawerska & Dylawerski 2009).

The entire area of the site is located within the boundaries of the system of surface forms of nature protection. It consists of two Natura 2000 sites: **PLH 300017 Dolina Rurzyca** and **PLB 300012 Puszcza nad Gwdą**, as well as four adjacent nature reserves with a total area of over 1,600 ha. On their territory, apart from alkaline fens, almost all types of valuable ecosystems are found: aquatic, mire, meadow, grassland, and forest ecosystems, characteristic for the young-glacial landscape of Western Pomerania.

The fens covered by this project are located within the following nature reserves (Fig. 71):

- **DS** fen is located in the Diabli Skok reserve (Greater Poland Voivodeship (area of 20.98 ha, established in 1961, no conservation plan);
- fens: **A**, **B**, **C**, **D**, **G**, **H** are located within the Wielkopolska Dolina Rurzycy reserve (Greater Poland Voivodeship, established in 2008). The project documentation and conservation plan for this reserve were drawn up by the Naturalists' Club (Wołejko et al. 2010);
- fens: **J**, **K** are located in the Dolina Rurzycy reserve (West Pomeranian Voivodeship, established in 2005, area of 554.68 ha, with a buffer zone of 538.96 ha). The assumptions of the protection plan for this reserve were developed in 2009 (Dylawerska & Dylawerski 2009). Works on the conservation plan for this reserve are underway, implemented by the Naturalists' Club;
- **SM** fen is located in the Smolary reserve (Greater Poland Voivodeship (area of 143.25 ha, established in 1990).

The alkaline fens in the Rurzyca Valley are among the most valuable in the western part of the country. In addition to the outstanding biocenotic values, this includes the currently low level of anthropopressure and the location of fens in a mosaic with other valuable habitats – they form complexes with mires of other types, petrifying springs (code 7220), *Ranunculion fluitantis* rivers (code 3260), and hard-water lakes (code 3140). An important component of the area are also the protected forest habitats, including deciduous slope forests as well as bog forests. The location of all the sites within the boundaries of approved forms of nature protection is an additional asset, guaranteeing the consistent implementation of this protection.

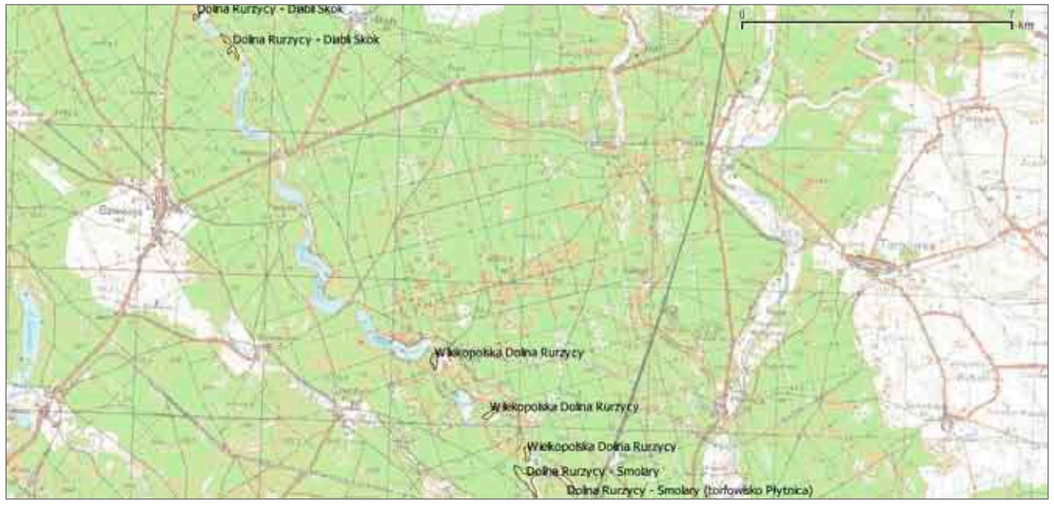


Fig. 73. Location of sites in the Natura 2000 site "Dolina Rurzycy".

The most important biocenosis values of alkaline fens of the Rurzyca Valley are numerous populations of fen orchid *Liparis loeselii* (ca. 1,000 individuals) and varnished hook-moss *Hamatocaulis vernicosus,* which are of significance in Poland and in the EU. National monitoring sites for these species (Chief Inspectorate of Environmental Protection) are located on alkaline fens of Dolina Rurzycy. There are also a number of rare and endangered species, such as the bryophytes: *Meesia triquetra, Cinclidium stygium, Paludella squarrosa, Limprichtia cossonii, Helodium blandowii, Philonotis caespitosa, Philonotis calcarea, Tomentypnum nitens, Sphagnum subnitens,* and *Sphagnum teres*. In the area, numerous populations are formed by species typical for the habitat 7230 i.e.: *Carex diandra, Carex dioica, Carex limosa, Dactylorhiza incarnata, Drosera rotundifolia, Dryopteris cristata, Eleocharis quinquaeflora, Epipactis palustris, Eriophorum latifolium, Ophioglossum vulgatum,* and *Utricularia minor.*

One of the largest populations in Poland is formed by the whorl snails: *Vertigo moulinsiana* and *Vertigo angustior*. Other zoological peculiarities include the representatives of molluscs – *Unio crassus,* butterflies – *Lycaena dispar* and odonata *Ophiogomphus cecili,* and *Sympecma paedisca.*

Dolina Rurzycy is located in the center of an extensive bird sanctuary of international importance – Puszcza nad Gwdą (PLB 300012), designated as part of the Natura 2000 network. These forests are one of the largest breeding sites for birds in Poland: the woodlark, Eurasian eagle-owl, boreal owl and white-tailed eagle; there are also crane, common goldeneye and European nightjar breeding grounds, with regional significance. The large lakes of the sanctuary are an important stopping off point for migrating waterfowl (Kujawa & Mizera 2010). The initial section of the Rurzyca Valley is of particular importance for the preservation of the population of anthropophobic bird species (Jermaczek et al. 2011).

Within the vegetation associated with alkaline fens, the following plant communities were found: *Caricetum diandrae typicum, Caricetum diandrae paludelletosum, Menyantho-Sphagnetum teretis, Cladietum marisci, Caricetum rostratae,* and *Caricetum paradoxae.*

Particular attention should be paid to the biocenotic values of mires situated along the river in the southern part of the Rurzyca Valley (so called Smolary – Płytnica mires) (Figs. 73 and 75).

Photo 70. One of the best preserved alkaline mires in the lower course of the Rurzyca Valley – Smolary (also called "Torfowisko Płytnica") (photo J. Ramucki).

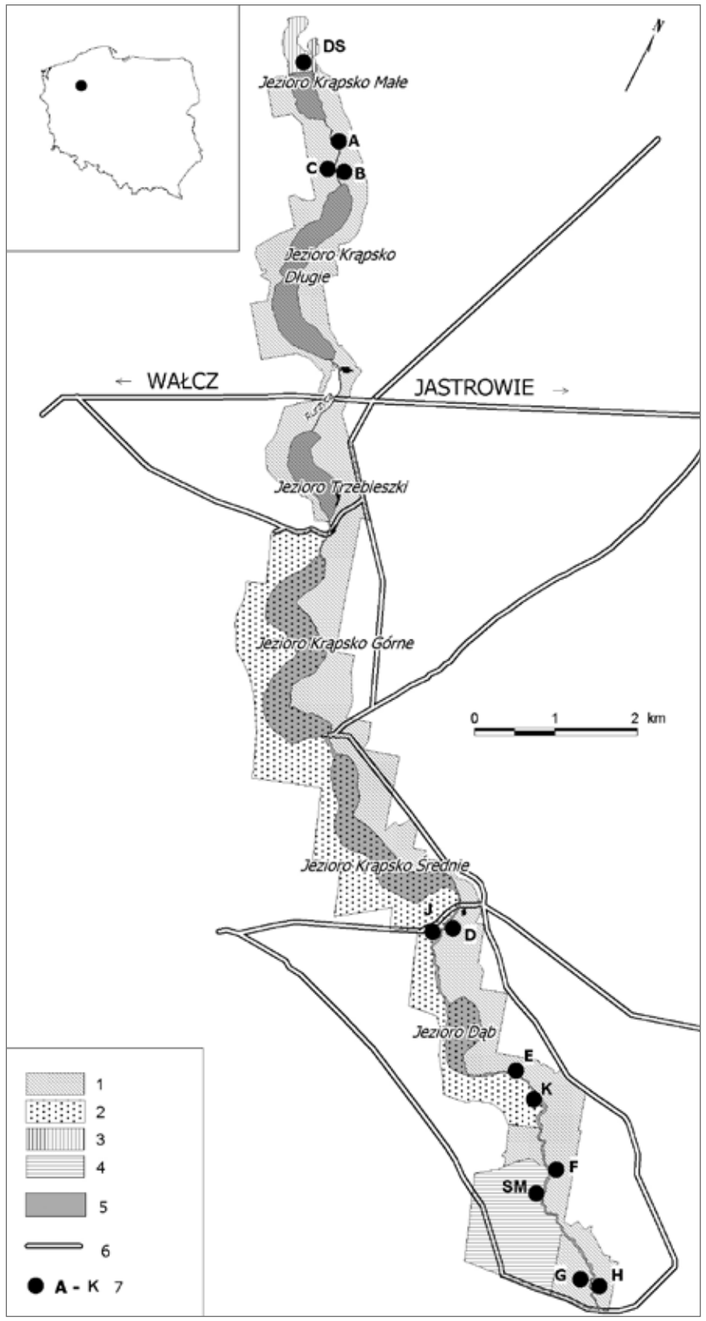


Fig. 74. Location of the studied alkaline fens in relation to the system of nature reserves in the Rurzyca Valley. Explanations: 1 –Wielkopolska Dolina Rurzycy Nature Reserve, 2 – Dolina Rurzycy Nature Reserve, 3 – Diabli Skok Nature Reserve, 4 – Smolary Nature Reserve, 5 – surface water, 6 – roads, 7 – the codes of the investigated mires.

In terms of its origin, the Smolary fen represents an ancient lake type created as a result of overgrowing of the mesotrophic ribbon lakes from the shore. Moss and sedge peats are deposited on top of the thick bed of limnic sediments (Photo 71). As the compacted gyttja sediments underlining the peat body are very poorly permeable, at the final stage of development the fen is supplied mainly with artesian groundwater that flows laterally from the aquifers under the slopes of the valley. In this way – on the surface of this and many other ancient lake fens of the Rurzyca Valley – the development of a variety of soligenous fens was initiated: flow-through moors with peat-forming moss vegetation.

Fens of similar origins are found in other parts of Dolina Rurzycy. These are fens: B, J.

Photo 71. The sharp transition from calcareous gyttia to sedge-brown moss peat shows the beginning of terrestrialization of the Dolina Rurzycy mire (photo A. Szafnagel-Wołejko).

Photo 72. Fen **J** on the banks of the river Rurzyca in the Dolina Rurzycy reserve in 2009 (photo A. Szafnagel-Wołejko).

Another type of fens is the cupola and hanging spring mires that in the past played a very important role in the creation of the alkaline fen environment, especially in the northern part of the valley. Currently, most of the fens show signs of far-reaching degradation as a result of relatively easy intervention in hydrological conditions. An example of stratigraphic section from the spring fen in the Diabli Skok reserve illustrate this situation (Fig. 75).

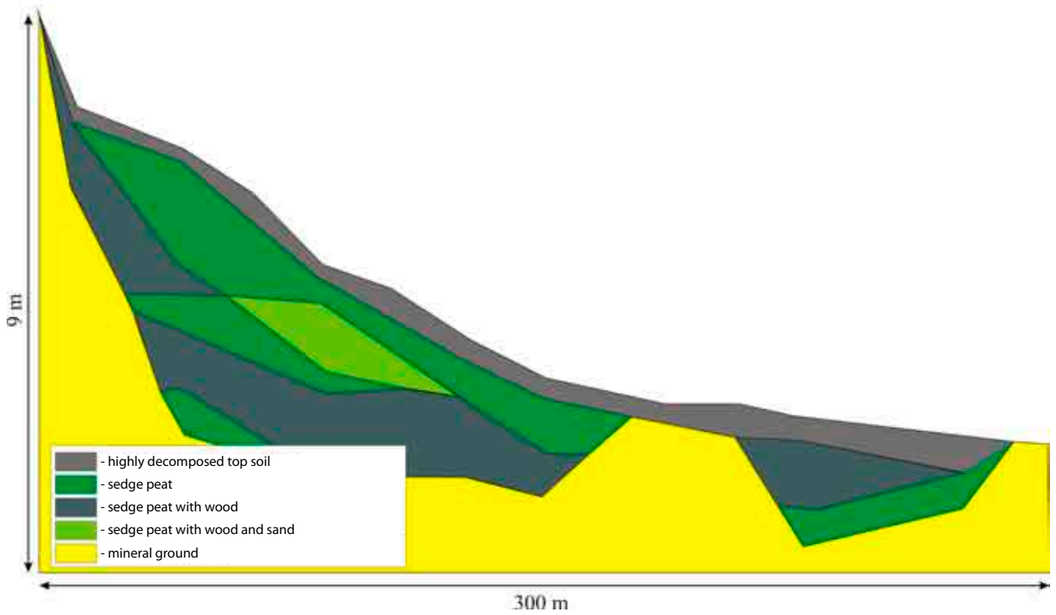


Fig. 75. Cross-sections of the spring fen in the „Diabli Skok" nature reserve (after Grootjans et al. 1999).

On the scale of the whole Rurzyca Valley, the most numerous and best preserved are the alkaline fens in the Wielkopolska Dolina Rurzycy Nature Reserve. The diversity of their vegetation, as well as their surrounding areas, is presented in Fig. 76.

Moss - sedge communities are a characteristic component of the vegetation of the described alkaline fens; these are peat-forming communities in which moss and sedge-moss peats accumulate. The botanical composition is dominated by characteristic species from the *Scheuchzerio-Caricetea fuscae* class, with a significant share of species from the *Caricion davallianae* alliance. Among the fen vegetation, there is a particular richness of taxa under strict protection and listed on the national and regional red lists.

One of the best preserved fens, characteristic for the conditions prevailing in Rurzyca Valley is the fen located at its southern border, separated into two parts by the Rurzyca riverbed (photo 70). In the contact zone with the river, there is a dynamic mosaic of vegetation, creating a gentle transition from fen plant communities, through sedge communities, to reeds and aquatic plants associated with river bends and its current (photo 73). Emmersive fen communities react by changing the position of the fen surface to changes in water content, in this case depending on the water level in the river (photo 73). The permanent existence of these ecosystems is conditioned by the stable – on an annual basis – state of water in the Rurzyca River, which should be associated with the dominant impact of groundwater in the hydrological supply of the valley and the river itself.

Within the Smolary alkaline fen, two well-distinguished moss fen communities were identified. The first – with lesser tussock-sedge *Caricetum diandrae* is divided into two variants: the typical one and the one with the *Paludella squarrosa* moss. The second complex is with bogbean *Menyantho-Sphagnetum teretis*. The patches of both communities form a spatial mosaic – the lesser tussock-sedge association is more commonly found on softer and slightly better hydrated ground, although both comminities are of emmersive in nature, i.e., they float, actively reacting to changes in the water level.

The spatial representation of the vegetation of the "live" part of the studied alkaline fens is complicated by the constant presence of plant communities of tall sedges on small surface areas. The communities dominated by them were classified as *Magnocaricion* of the *Phragmitetea* class, however in the studied area they include characteristic rich fen species (Wołejko & Piotrowska 2011). The character is exemplified by the sedge patches with beaked sedge *Caricetum rostratae* and fibrous tussock-sedge *Caricetum paradoxae*, however the species of this group are also found in other tall sedge associations. The greater tussock-sedge *Caricetum paniculatae* association frequently reflects the influence of spring waters through the

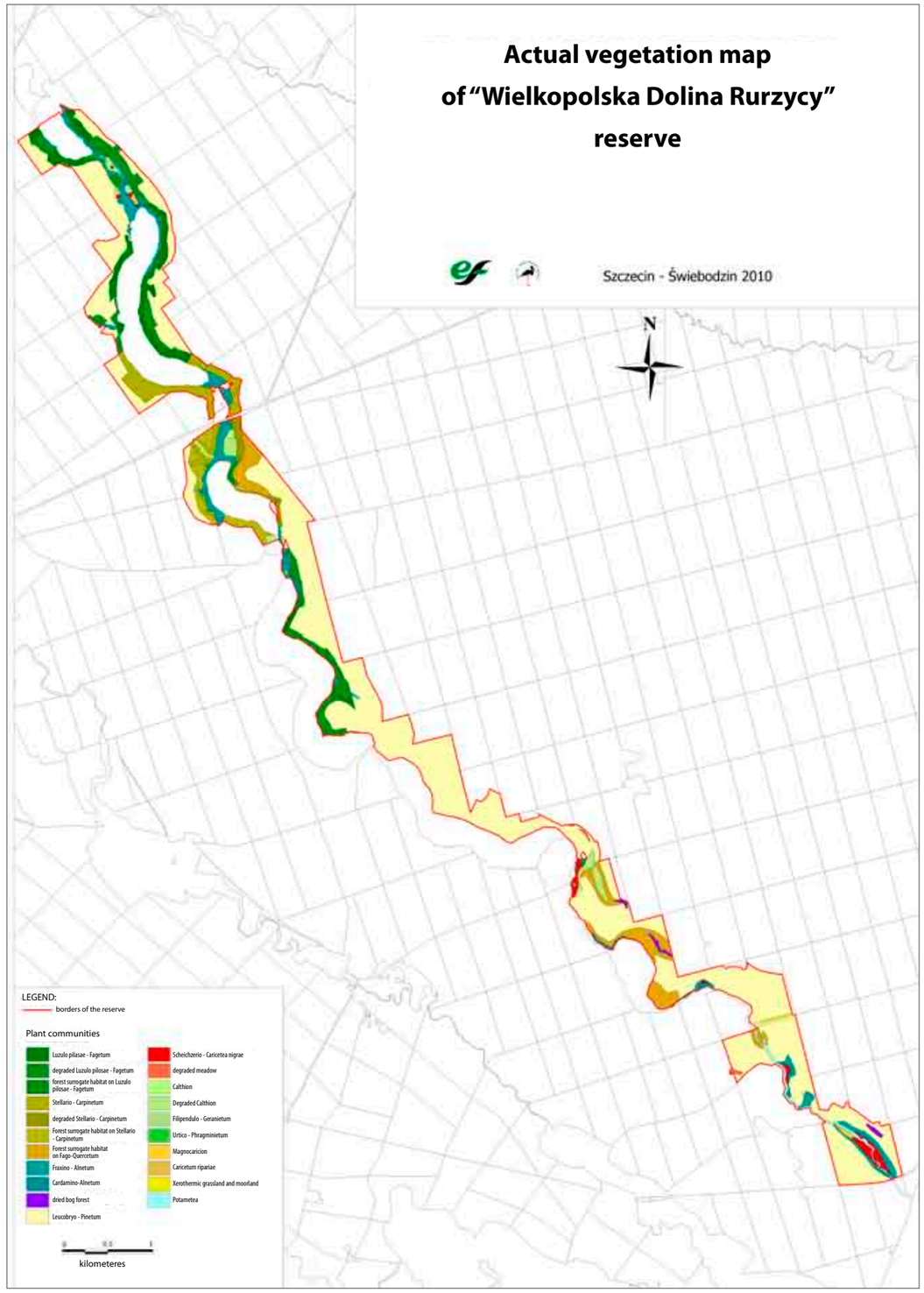


Fig. 76. Vegetation structure of the alkaline fens and their surroundings in the Wielkopolska Dolina Rurzycy Nature Reserve (source: Wołejko et al. 2010, changed).

Photo 73. Stable water levels in Rurzyca, resulting from the massive supply of groundwater to the valley, are responsible for sustainable functioning of the emmersive sedge- and moss fens (photo A. Szafnagel-Wołejko).

presence of characteristic species of the class *Montio-Cardminetea*.

Patches of the lesser pond-sedge *Caricetum acutiformis* association play an important biocenosis and spatial role in the vegetation of the soligenous fens of the Rurzyca Valley. The lesser pond sedge is a species with a relatively wide ecological amplitude and, on the fens in the Rurzyca Valley, it can also be found in large parts of wet moss meadows. On the basis of the photographic material, two communities were distinguished: sedge communities *Caricetum acutiformis*, and moss meadows with lesser pond sedge (Wołejko and Piotrowska 2010).

In the area of the Smolary-Płytnica fen, a patch of the swamp sawgrass *Cladietum marisci* association was also found. It is noteworthy because of its special location – at the border between open fen and streaming waters of the Rurzyca river. Plant communities with sawgrass are usually found in the zoning systems of overgrowing lakes, so their presence in the quick stream of the river should be treated as a regional peculiarity.

The plant communities of alkaline fens in the Rurzyca Valley also include species characteristic of meadow vegetation which, however, occur in small quantities. They are a kind of relic of old attempts to use these fens for economic purposes, which survived despite the fact that often more than 50 years have passed since they were abandoned.

Typical, well-formed communities of wet meadows on peat of the *Calthion* alliance are currently rare within the fens of the Rurzyca Valley. Disruption of the natural water conditions, which preceded attempts of grassland use, is also visible in the succes-

Photo 74. Development of forest communities at mire margins and invasion of trees into rich fen vegetation are the symptoms of hydrological disturbances related to the past agricultural use (photo R. Stańko).

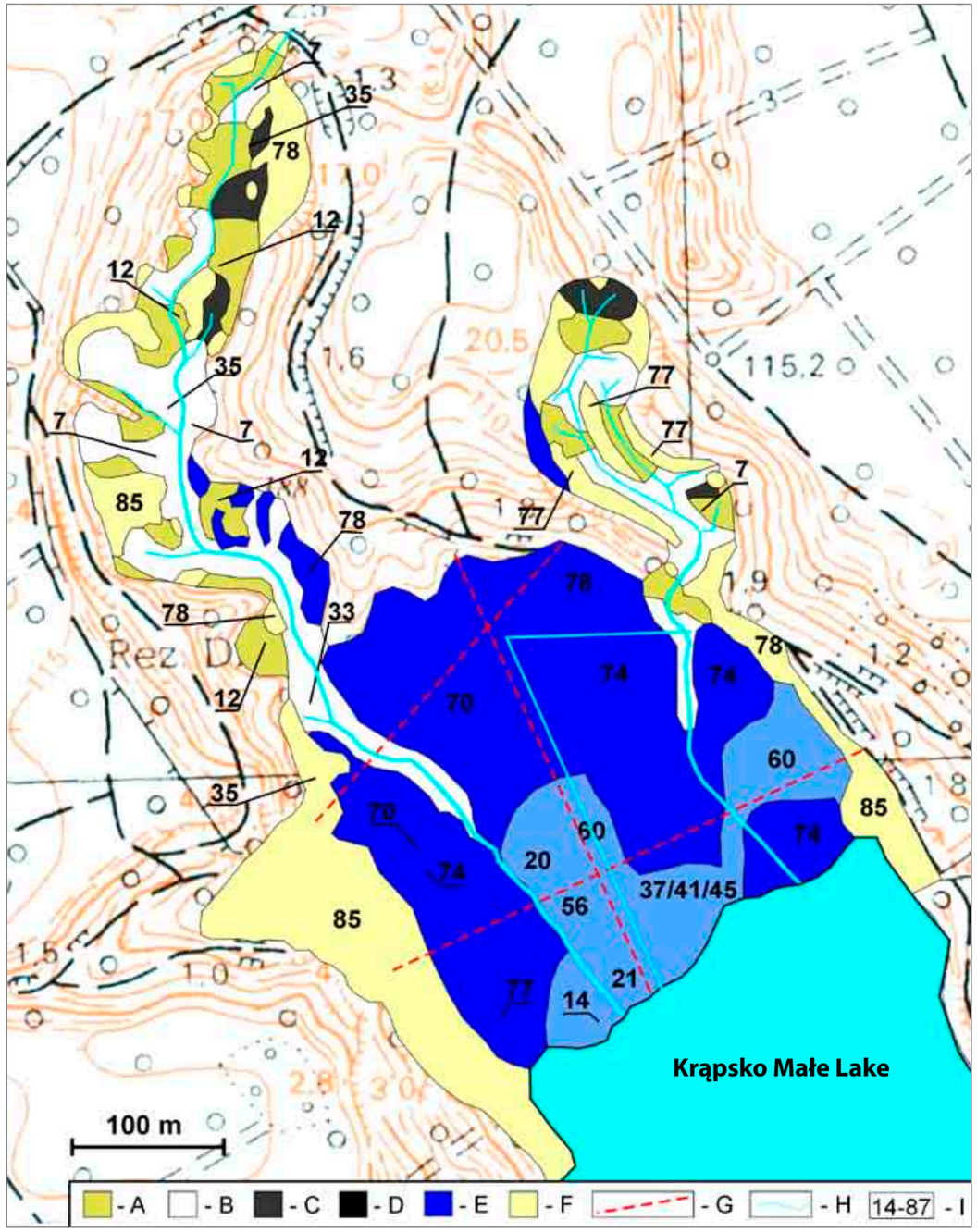


Fig. 77. Relationship between vegetation and abiotic environment in the Diabli Skok Nature Reserve (after: Grootjans et al. 1999, Wołejko 2000a). A – "hard bottoms" of the erosion circusses, B – sandy alluvial deposits, C – "organic" spring cupolas, D – floating mire, E – degraded spring mire, F – mineral islands, landslides, deluvial deposits, G – stratigraphic cross-sections, H – waterbodies,ditches, I – codes of vegetation units: Spring vegetation: (7) *Cratoneuro filicini-Lemnetum trisulcae,* (12) *Cardamino-Chrysosplenietum alternifolii*; Rush and sedge communities: (14) *Phragmitetum australis,* (20) *Caricetum gracilis,* (33) comm. *Glyceria declinata,* (35) *Glycerietum fluitantis cardaminetosum;* Mire vegetation: (37) *Sphagno-Caricetum rostratae,* (41) *Menyantho-Sphagnetum teretis,* (45) cf. *Campylio-Caricetum dioicae,* (36) cf. *Peucedano-Caricetum lasiocarpae;* Wet madows: (60) *Calthion*; Forests: (70, 74) *Cardamino-Alnetum glutinasae,* (77, 78) *Fraxino-Alnetum,* (85) *Luzulo pilosae-Fagetum.*

sive tendencies to forest communities. This is evident in the physiognomy and botanical composition of phytocoenoses, through the presence of black alder and forest characteristic species. The older patches of a community physiologically similar to an ash-alder riparian forest occupy the peripheral part of the fen at the point of contact with the mineral slopes of the valley. However, the analysis of the botanical composition of the ground vegetation reveals remains of rich fen and meadow floral elements, which is also confirmed by the analyses of old maps and archival photographs. As part of the active protection measures on the part of the fen not overgrown by a forest, forest succession is being stopped.

The drainage of spring fens has leads to dramatic habitat changes. Peat-forming moss phytocenoses disappear, and peat mineralization and erosion processes intensify. As a result of the succession, vegetation which takes advantage of the newly created ecological niches develops. Instead of the peat-accumulating, mesotrophic complexes typical for alkaline fens, spring, herbaceous, and forest vegetation develop (Wołejko 2000a). Such a status can now be observed within the fen in the Diabli Skok reserve. The last fragment of alkaline fen vegetation is located on the southern outskirts of the reserve, on the shore of Lake Krąpsko Małe (Fig. 76).

On all other fens of the Rurzyca Valley, combinations of features and phenomena discussed above occur in different configurations and with different intensity. The fens located upstream along the river (sites A, B, C, and D) are more topographically related to spring fens, which had an impact on the nature and intensity of drainage attempts in the past. In the case of some sites (e.g., SM and K) larger flooding of river waters occurs periodically in the bank area. Meadow vegetation residues are more common in fens B, C and D, while forest succession is advanced in fens C, E, F, and K. The identification of these factors was the basis for the implementation of individualized protection measures planned for the individual fens in Dolina Rurzycy.

Project activities were limited mainly to inhibiting succession of forest and thicket vegetation, and renovation of several gates inhibiting excessive outflow of water from the fens.

The stratigraphic research of the Dolina Rurzycy alkaline fens carried out as part of the project confirmed their lacustrine origin. The moderately decomposed sedge-moss peats indicate the past use of the fens on the one hand, and on the other the high vertical mobility of the surface part of the fen along with the changing water level.

Unfortunately, only a few fragments of the valley peatlands have been preserved in relatively good condition. One of them is certainly the so-called "Płytnica" mire (Smolary).

The hydrological conditions of alkaline fen in the Rurzyca Valley, based on the conducted field observations, seem to be optimal, especially in the sections closest to the river. Unfavorable water conditions occur in the higher sections fragments of the fens, currently overgrown mostly with alder trees.

Field observations conducted since 2010 – documented by phytosociological studies – indicate no significant changes in the species composition or spatial distribution of the plant communities. The only worrying recorded process is the expansion of the common alder. Habitat 7230, for the most part, does not require any special protection measures; only the few and small patches require occasional mowing and improvement of their water conditions. Therefore, the activities planned in the project focused mainly on inhibiting tree succession. These activities will need to be continued in the years after the completion of the project.

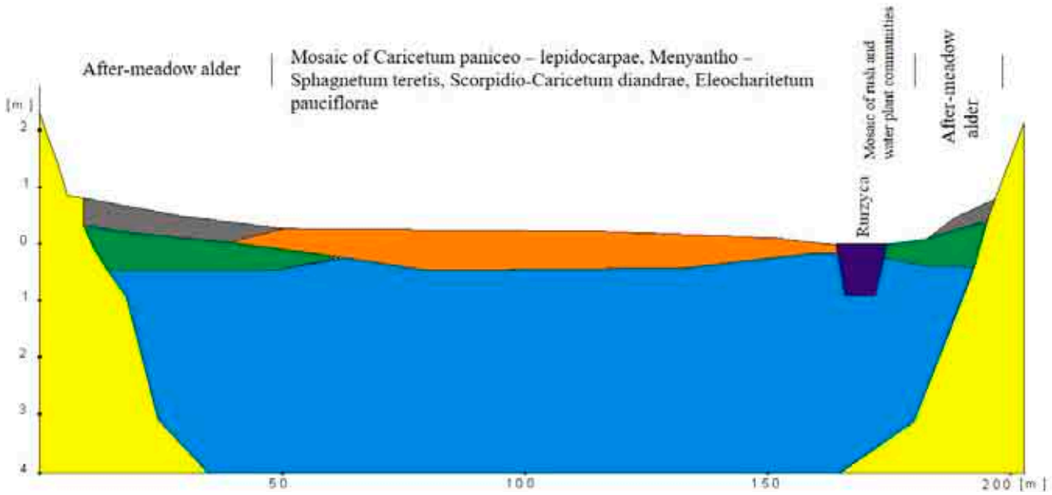


Fig. 78. Stratigraphic cross-section of the Smolary fen.

The patches of alkaline fens in other areas of the valley have been preserved in much worse condition. These patches required additional protective measures involving the mowing and removing of biomass. Due to their condition in the future, it will be necessary to continue active protection.

Photo 75. Alder basal shoots after tree removal on the Płytnica fen represent the main threat to the alkaline fens of the valley (photo R. Stańko).

Natura 2000 site „Dolina Radwi, Chocieli i Chotli" PLH320022

The area includes the central and upper Radew Valleys and the valleys of their spring tributaries from the spring areas to the estuary of the Parsęta River in Karlino. It is mostly a fragment of the Białogard Plain. It consists of a wavy bottom moraine, divided by valleys of small rivers, right-bank tributaries of the Parsęta, the largest of which is the Radew. The clay-sand soils of the area are the substrate of brown earth and podzol soils. In the spring zone of the Radwa River, there are valleys of its small tributaries – the Łęczna and Debrzyca – which flow into the Kwiecko Lake. It is an area of occurrence of alkaline fens and transitional mires, there are numerous spring phenomena with deposition of calcareous sinter, fragments of fertile beech forests and exceptional orchid beech forests on travertine, riparian, and spring alder forests, mixed deciduous forests, and acidic beech forests on the edges and slopes of valleys. In this area, the most interesting (in biocenotic terms) site of the area is located – Dolina Łęcznej koło Zarzewia. Part of the Radew Valley is located within the Pradolina Pomorska (Pomeranian ice marginal valley). In its

side valleys and under steep slopes of the ice marginal valley, groundwaters supplying the alkaline fens are revealed. The remaining alkaline fens covered by the project are situated in this landscape position.

Five small alkaline fens with a total area of approximately 21 ha have been the subject of activities under this project. In the past, about 90% of their area was used as meadows, but now it is not used. They are owned by: the State Treasury and managed by the Bobolice and Polanów Forest Inspectorates.

The fens of the Radew Valley covered by the project were the subject of previous detailed geobotanical surveys (Osadowski i Sobisz 1998, Osadowski 1999, 2000, Osadowski i Fudali 2001).

The area is characterized by an above-average concentration of alkaline fens and is of significant importance both in the region and in the country as a potential place for restoring the population of species that in the recent past were present here, e.g., *Saxifraga hirculus* recorded as early as in 2007. In addition, there are significant populations of species associated with low and alkaline fens, e.g., *Hamatocaulis vernicosus, Paludella squarrosa, Tomentypnum nitens, Helodium blandowii, Limprichtia cossoni,*

Fig. 79. Location of sites in the area of Dolina Radwi, Chocieli i Chotli: Drzewiany and dolina Łącznej.

Fig. 80. Location of sites in the area of Dolina Radwi, Chocieli and Chotli: Zgniła Struga, Lubowo and Kwiecko.

Limprichtia revolvens, Sphagnum warnstorfii, Sph. teres, Sph. subnitens, Juncus subnodulosus, Epipactis palustris, Dactylorhiza majalis, D. maculata, D. incarnata, Ophioglossum vulgatum, Carex lepidocarpa, C. diandra, C. pulicaris, Eleocharis quinquaeflora, Eriophorum latifolium, Juncus alpinus, and *Gymnadenia conopsea*. Alkaline fens occur in complexes with other types of fens, natural eutrophic lakes (3150), petrifying springs (7220), and *Ranunculion fluitantis* rivers (3260).

Zgniła Struga

The fen is located in the valley of a small watercourse of the same name – a right-bank tributary of the Radew River – with a few natural side tributaries and drainage ditches. The waters of the local watercourses, in terms of basic physical and chemical parameters, indicate the predominant type of underground water supply. In terms of pH, these are neutral and alkaline waters (see Table 6).

The Zgniła Struga Valley cuts the right wing of the Radew Valley, which is part of the Pomeranian ice marginal valley. The complex of soligenous fens is covered by slopes and bottom and side branches of the valley. In many places clear spring cupolas have been formed. Patches with typical fen vegetation currently occupy a small part of the site because the fen is cut off by drainage ditches, largely overgrown.

As a result of floristic research and analyses, 91 plant species were recorded in the studied area, including 78 vascular plant species and 13 species of bryophytes.

Vegetation of the Zgniła Struga fen is a mosaic of complexes and plant communities gathering relics of peat-forming vegetation, typical for alkaline spring fens and meadow vegetation, formed after the introduction of meadow use and successive stages developing after the abandonment of use. Small communities of hydrophytes associated with springs and their outflows complete the vegetation picture.

The most important areas in terms of spatial layout and biocenosis are the wet meadow communities of the *Calthion* alliance. They are formed in a specific way, because their floristic composition includes characteristic species of alkaline fens of the *Scheuchzerio-Caricetea fuscae* class. Fen species are present in practically all plant communities. The most interesting plant complex is the moss meadow

Photo 76. Spring fens on the slope of the valley of Zgniła Struga (photo L. Wołejko).

of blunt-flowered rush – *Juncetum subnodulosi*; this is probably the largest location of this association in north-western Poland.

After the meadows use had been abandoned, communities with the physiognomy of tall sedge reeds developed here. These are associations formed by lesser pond sedge *Caricetum acutiformis* and greater tussock-sedge *Caricetum paniculatae*. Strongly drained fragments of the fen are covered by eutrophic reed patches – *Urtico-Phragmitetum*.

Table 6. Physico-chemical parameters of waters supplying the Zgniła Struga fen; measured on 21 August, 2013.

Location	ZG-W1	ZG-W2	ZG-W3	ZG-W4	ZG-W5
Conductivity [µS]	391	315	338	314	261
Temperature [^{0}C]	15	16,5	12,0	12	11,0
pH	6,68	6,89	7,38	7,45	7,05

Photo 77. Young shoots of *Juncus subnodulosus* on the Zgniła Struga fen (photo L. Wołejko).

Due to extensive mowing, the site did not require additional active protection measures during the project implementation.

Lubowo

The Lubowo fen is located in the peripheral part of the fluvioglacial ice marginal valley, at the bottom of the slopes, currently used by the Radew River and its tributaries. In this section, the slopes of the ice marginal valley are high, steep, and cut by ravines. The alkaline fen was created in the terrestrialized bay of Lake Wiejskie in the vicinity of the village of Lubowo. Apart from Lake Wiejskie and the connected Lake Małe, the hydrological conditions affecting the condition of the fen include: a nameless lake near the Lubowo Forest Administration house and a small, relict water reservoir in the center of the fen. The entire system is supplied by intensive groundwater outflows. All these elements are connected with the Drężnianka River, which flows into Radew. Currently the water conditions of the object are significantly influenced by the activities of beavers, in particular by their blocking of the outflow on the Drężnianka River.

Fig. 81. Lubowo fen and its surroundings in 1896 .

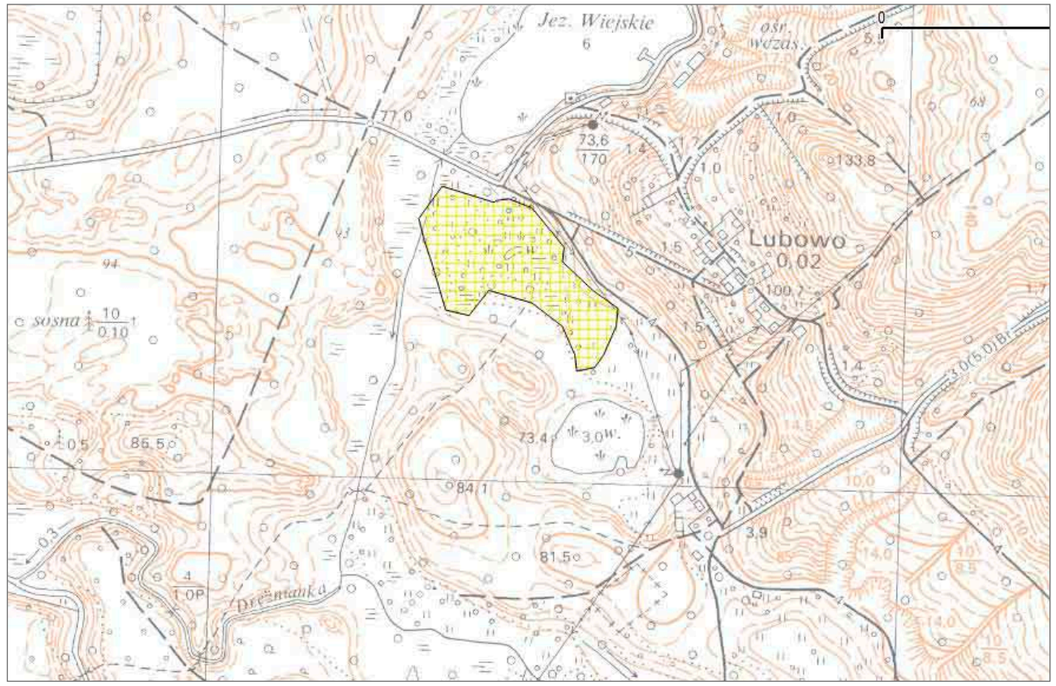


Fig. 82. Current condition of the Lubowo fen and its surroundings.

In the past, the spring fen was partially used as grassland. A map from the end of the 19th century shows the completely woodless character of the fen. Currently, the site is subject to succession towards forest communities. To date, the site has preserved a few and small patches with characteristic moss vegetation, mainly in the vicinity of the relict lake (water reservoir mentioned above).

Most of the area of Lubowo fen is currently covered by the vegetation of swamp forests and thickets. However, the most important element of the vegetation of this object are relics of vegetation of alkaline fens. Fragments of these communities have been preserved in the central, well-hydrated part of the fen that have the character of a quagmire with sedges and a well-developed moss layer. They were categorized as part of the *Caricetum lasiocarpae, Caricetum diandrae and Sphagno-Caricetum rostratae* associations (Osadowski 2000). They represent the more "acidic" part of the moss-rich communities which may be a suggestion of the declining share of alkaline artesian waters in the fen supply. Floristically and phytosociologically related to the sedge-moss communities are the quagmire sedge and fern reeds *Cicuto-Caricetum pseudocyperi*. They occupy small areas on shallow and silty "peat spots".

On the edges of the fen are also relics of wet meadows vegetation of the *Molinietalia* order. At present, as they are practically not used, they have transformed into communities with marsh horsetail (in more humid places), or into herbaceous communities.

Photo 78. Remnants of an open fen in the central part of the Lubowo fen (photo L. Wołejko).

Alder communities dominate spatially in the Lubowo fen and are highly expansive; they include spring alder forests and willow scrubs, also in the spring variety.

Initially planned protective measures consisting in the construction of gates were unnecessary due to the dam built by the beavers leading to a strong hydration of the whole mire complex.

Kwiecko

(= Żurawie Bagno)

The alkaline fen, partially fed by groundwater, is one of several wetlands of various types filling the side valleys and terrain depressions in the area of the Radew outflow from Lake Kwiecko. There are also several other outflowless depressions with small lakes or bogs in the area. The fens are located within a forest complex administered by the Polanów Forest Inspectorate; these are mainly pine forests with some beech. In this forest complex, there are numerous peculiarities of flora and fauna. Particularly noteworthy are the long known sites of the "natural" orchid – lady's-slipper orchid *Cypripedium calceolus*, which are the object of national monitoring (Kucharczyk 2010). In order to effectively protect the above natural values, a nature reserve has been proposed within the framework of this project (Wołejko et al. 2014).

The alkaline fen located in the forest section 611k formed on the surface of an overgrown lake, which in the past filled up a small side channel of the Radew Valley. It was probably a lake with low flow rate, receiving groundwater, still coming to the surface in the southern part of the fen. In its remaining fragments – overgrown with minerotrophic sghagnum mire – an increase in the share of rainwater is observed.

The development process of the alkaline fen and its natural succession towards the moss mire fen is also reflected in the stratigraphy of the peat deposit studied in the project (see Fig. 83).

Photo 79. Fen stratigraphy studies (photo D. Horabik).

Table 7. pH and electrical conductivity of the water supplying the fens of the proposed Kwiecko reserve; measured on 22 August, 2014.

Location code	Oligotrophic lake in the vicinity of pt. K1	Surface watercourse in the vicinity of pt. K18	Transitional moss mire in the vicinity of pt. K18
pH	5,95	6,73	5,57
Electrical conductivity [µS/cm]	10	239	80

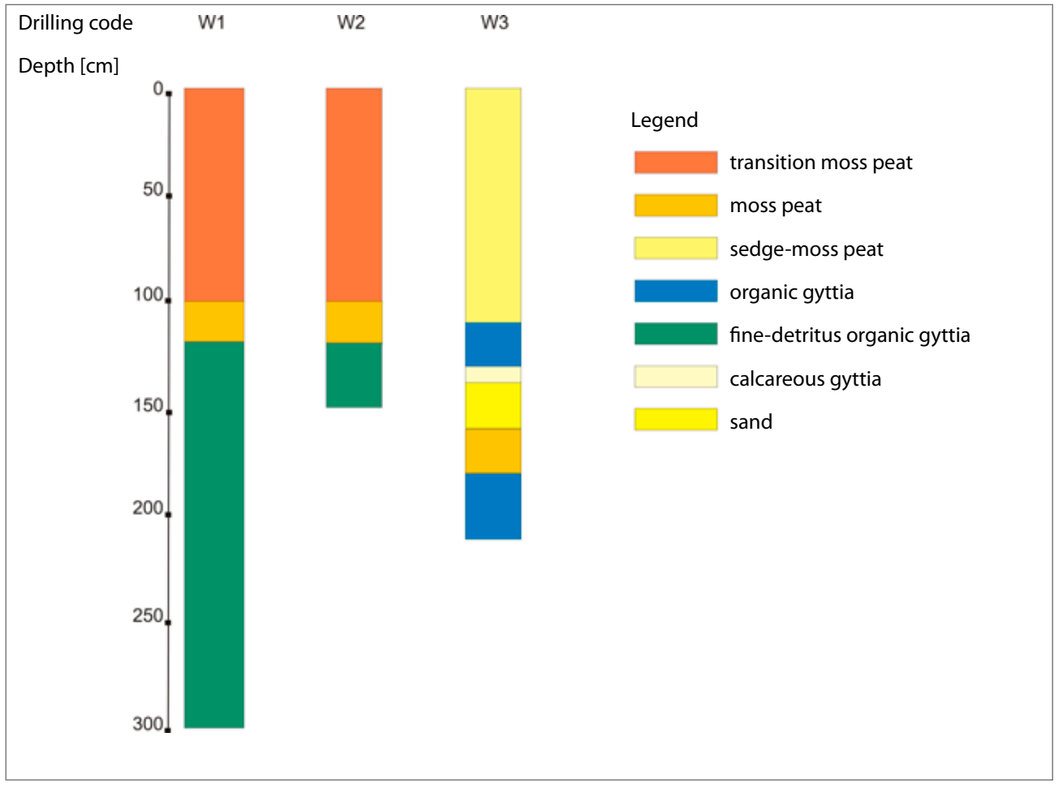


Fig. 83. Stratigraphy of the fen on the basis of peat drillings.

The complex of moss - sedge vegetation is located in the southern part of the 611k forest unit. It is formed by sedge and moss communities, whose common features are a high proportion of brown mosses and minerotrophic peat mosses, supplied by flowing waters with a reaction similar to neutral and strongly hydrated substrate in the form of a floating quagmire. The intermediate phase from aquatic ecosystems to peat moss mire is made up of mesotrophic moss -sedge vegetation that is constantly present in the areas with the highest water content. The central moss -sedge plant complex in the reserve is a peat moss patch with bogbean *Menyantho-Sphagnetum teretis*. In the most humid places, moss patch types of sedge reeds have developed, among which the following associations were identified: greater tussock-sedge *Caricetum paniculatae* and lesser pond sedge *Caricetum acutiformis*. The remaining part of the moss -sedge vegetation is covered with patches disturbed in terms of habitat conditions (mainly hydrological), which manifests itself in the expansion of shrub and woody species, or succession to transitional-peat moss mire communities. In the patches of moss vegetation, valuable and endangered plants of the reserve are concentrated – brown moss and orchids.

During the development of the wetland complex, on a part of the object surface, succession towards the transitional fen took place, the main component of which is the *Sphagno-Caricetum rostratae* association. A part of the moss mire was transformed into a bog birch forest community. In a separate area around the lake, a transitional moss mire with elements of a bog formed (Fig. 83). It is no longer an alkaline fen habitat.

Hydrological disturbances, consisting mainly in artificial acceleration of water outflow from the fen (ditches), contribute to intensification of succession processes towards thicket and forest complexes.

In total, 90 plant species were found on the wetlands of the proposed Kwiecko Nature Reserve, including 67 vascular plant species and 23 species of bryophytes. Of this number, 18 vascular plant species and 17 mosses are protected and endangered. Typical valuable flora of alkaline fens is represented by: *Hamatocaulis vernicosus*, *Helodium blandowii,*

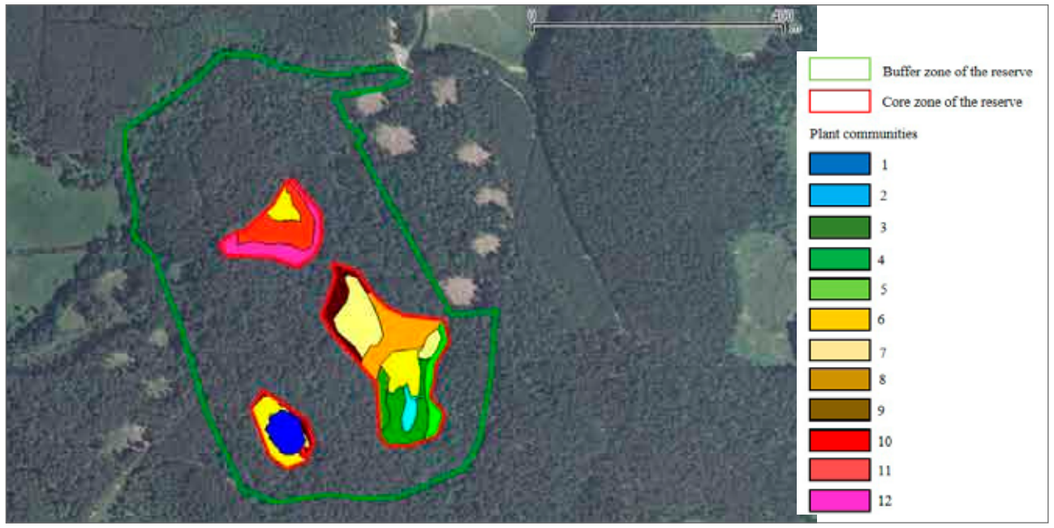


Fig. 84. Explanations: 1 – aquatic plants, 2 – seepage *Magnocaricion*, 3 – *Menyantho-Sphagnetum teretis*, 4 – rich fen with *Salix*, 5 – rich fen overgrown by trees, 6 – *Sphagno-Caricetum rostratae* transitional mire, 7 – transitional mire with *Salix*, 8 – transitional mire with *Pinus*, 9 – mixed managed commercial forest, 10 – initial stage of a *Sphagnion magellanici* bog, 11 – initial form of a bog coniferous forest, 12 – alder forests (source: Wołejko et al. 2014a).

Paludella squarrosa, Limprichtia cossoni, Sphagnum warnstorfii, Sph. teres, Tomentypnum nitens, Carex diandra, C. limosa, Dactylorhiza incarnata, and *Epipactis palustris.*

Drzewiany

The Drzewiany fen is located on a slope of a watercourse valley supplied by springs and slope seepages, deeply cut into the surrounding moraine hills. Despite its small size, the fen is characterized by numerous plant community patches characteristic for alkaline fens and a rich flora of typical species.

Published and unpublished data made available by dr. hab. Zbigniew Osadowski have been taken into account as comparative material for the changes in the flora. There is also a detailed study of the bryophytes flora (Osadowski & Fudali 2001) for this site, including 36 taxa.

As a result of floristic research and analyses, 117 plant species were recorded in the studied area, including 93 vascular plant species and 24 species of bryophytes.

In a study taking into account vegetation of the Drzewiany alkaline fen, Osadowski (2000) identified 5 plant communities: *Campylio-Caricetum dioicae, Eleocharitetum quinquaeflorae*; *Menyantho trifoliatae-Sphagnetum teritis, Caricetum diandrae* typicum and *Scorpidio-Utricularietum heleocharetosum quinquaeflorae*. Since their phytosociological status and nomenclature is not fully established in Poland, and small patches form a complex spatial mosaic on the discussed fen, this study assumes that these are generally well formed carbonate fen communities of the *Caricion davalliane* association. This plant complex occupies a central location in the northern part of the fen. It is a seepage area of calcium-rich groundwaters. The floristic composition of the plant communities is abundant in species characteristic of the *Scheuchzerio-Caricetea fuscae* association and class. These are mostly protected, endangered, and rare plants.

The meadow and post-meadow occupies the peripheral parts of the fen, particularly in the vicinity of its upper, southern edge. The dominant elements are the species characteristic of wet meadows of the *Calthion* alliance. The lack of land use and effects of drainage have resulted in the formation of patches of eutrophic reeds and herbaceous plants (*Urtico-Phragmitetum*), communities with the lesser pond-sedge (*Carex acutiformis*), wood club-rush (*Scirpus sylvaticus*), and meadowsweet (*Filipendula ulmaria*).

As part of the project implementation, natural documentation was prepared for the purpose of establishing a nature reserve and a thicket removal procedure was carried out.

Photo 80. Drzewiany, fragment of the fen covered with low sedge and herbaceous communities (photo R. Stańko).

A belt of alder riparian forest and fragments of alder spring forest are developed in the vicinity of the watercourse that collects water from the fen. The precursors of this complex are the grey willow thickets that develop along the former drainage ditches.

The observations carried out as part of the project have shown a significant improvement of the water conditions within the fen, which should be related to the gates built on ditches. There was also observed an improvement in the condition of species and phytocoenoses characteristic of alkaline fens. Nevertheless, maintaining the current nature of vegetation will require continuing protective measures in the future.

Dolina Łęcznej

Well-preserved alkaline fens, formed under the influence of seepage and spring waters, are located in the valley of the Łęczna River. This is a proposed reserve (Osadowski 1999a). North of the Szczawno Lake, the Łęczna River takes in water from numerous springs and then cuts over 50 m into the surrounding area; after that it flows along a deep ravine to Stary Młyn near Kępsko, from which it flows out as the Debrzyca River.

There are several forms of boreal or sub-boreal moss and sedge communities of the *Caricion lasiocarpae* association, calcicole flush mire of the *Caricion davallianae* association, and meso-oligotrophic moss mires of the *Rhynchosporion albae* and *Caricion fuscae* associations (Osadowski 2000). The predominant type of vegetation characteristic for alkaline fens is the *Caricetum diandrae* association. The vegetation picture is completed by sedge reeds, moss meadows, willow, and alder thickets. The flora of vascular plants is characterized by the occurrence of rare fen species, with particular concentration of alkaline fen species such as fewflower spikerush *Eleocharis quinqaeflora*, lapine rush *Juncus alpinus*, long-stalked yellow sedge *Carex lepidocarpa* and lesser tussock-sedge *C. diandra*, broad-leaved cottongrass *Eriophorum latifolium*, and bogbean *Epipactis palustris*. Fen species which are in danger of extinction on the scale of Pomerania and Poland – such as the flea sedge *Carex pulicaris* and yellow marsh saxifrage *Saxifraga hirculus* (unfortunately recently not observed at the site) – deserve special attention. *Hildenbrandia rivularis* can be found in the river rapids.

Photo 81. Fragment of the fen overgrowing with black alder (photo D. Horabik).

Photo 82. One of several gates built by the Bobolice Forest Inspectorate, effectively improving the water conditions of the entire fen complex (photo D. Horabik).

The observed improvement of water conditions is related to the construction of gates by the local forest inspectorate. A one-off biomass removal treatment contributed to the periodic improvement of the condition proper for alkaline fen vegetation. However, in order for these activities to bring the expected effect, they must be continued.

Natura 2000 site „Mechowisko Manowo" PLH320057

Manowo

A fen complex consisting mainly of alkaline and transitional fens. In the past, it was probably only the parts of the fen along the mineral edges that were used. The *Caricetum diandrae* and *Menyantho-Sphagnetum teretis* associations are predominant among the plant communities typical of alkaline fens. The alkaline fen is one of the most valuable and best preserved in the West Pomeranian Voivodeship. The object is distinguished by a large population of *Liparis loeselii* (about 100 individuals, one of only several sites of this species in the West Pomeranian Voivodeship) and *Hamatocaulis vernicosus*. In addition, there are numerous populations of the following species: *Eriophorum latifolium, Carex limosa, Drosera rotundifolia, Paludella squarrosa*, *Tomentypnum nitens*, *Helodium blandowi, Limprichtia cossonii, Dactylorhiza majalis, Dactylorhiza incarnata, Pedicularis palustris*, *Carex diandra,* and *Carex appropinquata*.

The projected reserve is located within the Białogard Plain in terms of physiography. It is a glaciotectonically pushed front moraine that contains xenoliths of sands and Tertiary clays. The surface of the plain is made up of a slightly wavy bottom moraine, divided by the right tributaries of the Parsęta River. Above the surface of the plain, located from several to several dozen meters above sea level, moraine hills rise up to an altitude of 60 – 70 meters.

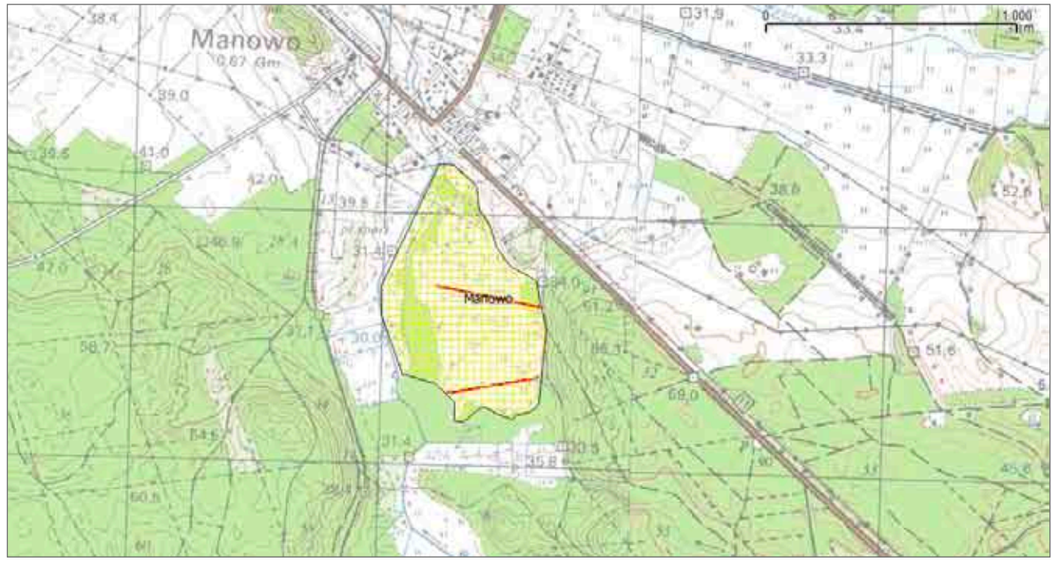


Fig. 85. Location of the Manowo fen along with the course of the research transects.

The fen area is a lake basin entirely filled with organic sediments. The process of terrestrialization of the former water reservoir has been completed relatively recently. The thickness of the peats in individual areas of the fen indicates that the process of overgrowing has started from the eastern side towards the west.

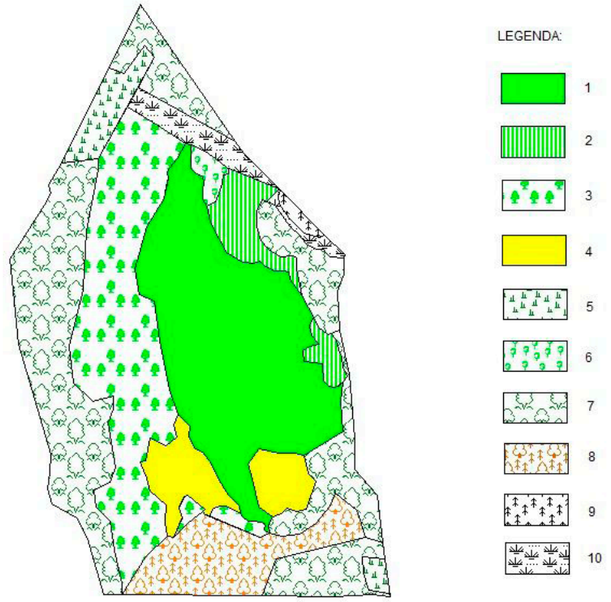


Fig. 86. Map of actual vegetation of the Mechowisko Manowo area. Explanations: 1 – rich fen (mainly *Menyantho-Sphagnetum teretis*), 2 – rich fen with *Phragmites australis*, 3 – rich fen with young alder forest, 4 – transitional mire *Sphagno-Caricetum rostratae,* 5 – degraded *Calthion*, 6 – willow thickets, 7 – riparian forest (mainly *Fraxino-Alnetum*), 8 – mixed bog forest (*Alnus-Picea*), 9 – managed commercial forest, 10 – synanthropic communities under the power line.

Photo 83. General view of the "Manowo" fen (photo D. Horabik).

The complex of moss vegetation of the alkaline and subneutral fen is currently located in the central part of the Manowo fen. However, the analysis of phytosociological material and stratigraphy of peat drillings carried out as part of the project shows that practically the entire fen area of the reserve in the recent past was covered by rich fen vegetation. Floristic similarities to a typical open fen vegetation are also strong strong within a community with the physiognomy of a loose reed as well as a young alder forest. These units surround an open moss patch and should be interpreted as early stages in the succession of moss patches towards forest communities. This succession is accelerated by past partial drainage.

The key and dominant rich fen community of the Manowo mire is *Menyantho-Sphagnetum teretis*. Typical features of the variant are a high proportion of brown mosses and minerotrophic peat mosses, supplied with flowing waters of a reaction close to neutral and strongly hydrated substrate in the form of a floating quagmire. The locations of valuable and endangered plants such as brown mosses and orchids are concentrated in the moss vegetation patches.

Patches of a typical form of the association form a mosaic system with patches of related plant communities, differing in physiognomy by the domination of such species as *Carex diandra, Equisetum fluviatile*, and *Thelypteris palustris*. The flora composition of the moss communities is rich and typical, reflecting the history of natural development and use of the fen. For this reason, the composition of the association is characterized by characteristic species of fens, water reeds, wet meadows, and alder forests.

The complex of moss mire vegetation of the transitional fen developed in the southern part of the open fen. These plant communities have been identified as typical moss mire patches of the beaked sedge and flat-topped bogmoss *Sphagno-Caricetum rostratae*. The elements of moss flora present in their composition make it possible to interpret the development of carpet moss mire as a stage of succession connected with partial drainage of the area, and the detachment of the fen surface from the influence of groundwater.

Forest communities developed in the peripheral part of the wetland basin, in the vicinity of mineral soils and along the Dzierżęcinka River; their development is stimulated by better substrate drainage and a higher trophic level of the habitat. By convention, for the purpose of mapping vegetation, larger patches of marsh alder forests and riparian forests were distinguished; in reality, they form a spatial mosaic reflecting the local diversity of habitat conditions. Black alder and spruce dominate the forests, with occasional small patches of grey alder. The ground vegetation is mainly composed of fen species. In some areas, species from the *Molinio-Arrhenatheretea* class occur in high concentrations, indicating their post-meadow origin.

Tree and thicket wildings were removed as part of the project from the open fen together with young alder trees in the western part of the fen – within the boundaries of the area. Partial mowing operations have been planned and carried out on an ongoing basis, especially on surfaces where reed expansion was observed. In order to improve water conditions, several gates were built on the ditches draining the fen. The natural documentation for the purpose of establishing the reserve and the plan of conservation tasks for the entire Natura 2000 area were also prepared.

Natura 2000 site „Dolina Płoni i Jezioro Miedwie" PLH320006

Dolina Płoni - Żydowo

This complex of soligenous fens, with an area of about 25 ha, is located within the upper part of the Płonia river valley near Żydowo. It is a gorge postglacial valley, crossing the highest moraine range of the Pomeranian phase of the last glaciation. The topographically diverse terrain of the valley is rich in hollows and erosion ravines. The groundwaters found in them at various levels feed numerous springs, soligenous fens, and water reservoirs. These waters are rich in calcium, which is proven by the currently functioning petrification processes and thick deposits of sub-fossil carbonate sinter – travertine (Grootjans et al. 2007).

The fen near Żydowo lies in the local depressions between the moraine hills located in the central part of the valley. The surface of the fen is sloping towards the Płonia River, which also flows along this section of the surface of the former spring fen. Currently, water is drained from the fen by a network of deep ditches. In the past, the area was used entirely as meadows; now it is unused or only partially grazed. The land is mostly privately owned. Thanks to the efforts made within the project, some of the most valuable natural lands were placed under the management of the Regional Directorate for Environmental Protection in Szczecin. The site is located within the boundaries of Natura 2000 PLH320006 areas Dolina Płoni i Jezioro Miedwie. It is also the area of Barlinek-Gorzów Landscape Park.

Dolina Płoni is one of the largest plant sanctuaries on calcium rich habitats in north-western Poland (Bacieczko 1995, Wołejko et al. 2007). These habitats are often of secondary character or are strongly transformed under the influence of anthropopressure, as illustrated by comparative studies of flora and vegetation conducted for many years (e.g., Libbert 1937, Bacieczko 1995, Banaś 1997, Grootjans et al. 2007). The alkaline fen near Żydowo is important for the preservation of the population of an endangered species – *Juncus subnodulosus*. In addition, there are numerous populations of such species as: *Dactylorhiza incarnata, D. majalis, Trollius europaeus,* and *Carex appropinquata.*

In the past, the site was studied in detail (stratigraphy, vegetation, digital terrain model) as part of the Polish-Dutch PIN-Matra project. The Polish partner was the Naturalists' Club, and the results were included in the study by Grootjans et al. (2007). It was also the subject of earlier, fragmentary geobotanical research (Libbert 1938, Bacieczko 1995, 1996, Bacieczko and Wołejko 1997, Banaś 1997, Rzeźnicki 1999). These data were used for comparative evaluation of the direction of changes and the state of vegetation of the fen.

Despite strong degradation, the fen still has a high natural potential and the ability to regenerate.

The project area is located approximately 150 m from the river. Water from the fen area is transported by a dense network of deep drainage ditches. As a result of interference with hydrological conditions, the groundwater level is significantly reduced and the water level varies considerably. The groundwater level in the western part of the area is monitored by means of an automatic recorder.

Fig. 87. Dolina Płoni-Żydowo – location of the research transects and the water level recorder.

Detailed studies on the stratigraphy of the fens were carried out in the western part of the area and within the fen adjacent to the eastern part of the site. The data on the stratigraphy of the fen located in the western part are described in points B18-B20 on the transect "B" covering the whole cross-section of the Płonia Valley (Fig. 88). The fen has the form of a raised cupola. The dominating peats are sedge-reed peats, sometimes interspersed with a layer of moss and sedge-moss peats underlined with calcareous gyttja. Almost the entire profile of peat formations shows the precipitations of calcium carbonate, confirming the spring character of the site. The peats are characterized by quite strong decomposition in the roof part.

Stratigraphic system analyses allowed the history of calcium carbonate deposition to be traced. In the deepest layer of the deposit, a seam of lake chalk is visible. On its surface, in the central and eastern part, sedge and moss peats were accumulated for centuries, while on the western side a layer of travertine was formed. The measurement of calcium carbonate content in the peat profiles (Fig. 89) showed that the accumulation of this chemical compound continued after the transition from the lake phase to the flow-through fen, with short intervals only, registered as stratigraphic levels devoid of $CaCO_3$. An interesting phenomenon is the intensification of travertine accumulation in time in the vicinity of the edge of the valley. The highest content of calcium carbonate was

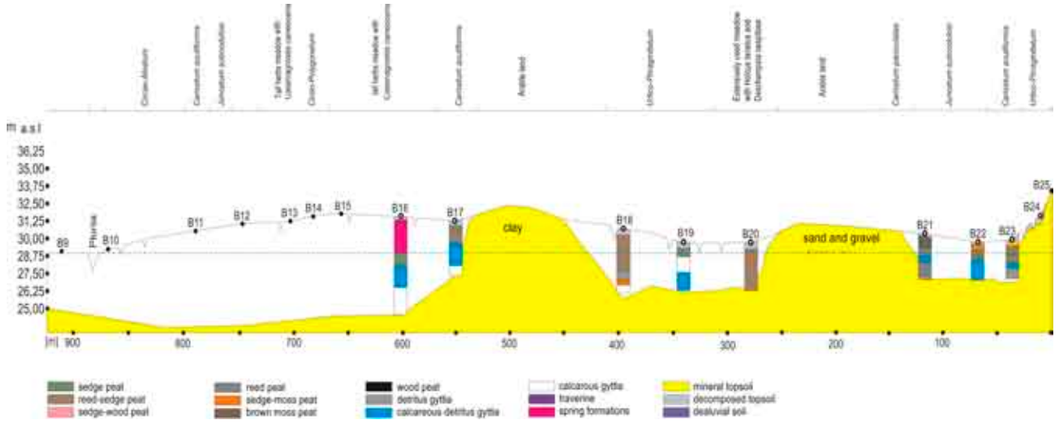


Fig. 88. Height cross-section and selected elements of fen stratigraphy in the Płonia Valley along the line of the longest transect including 2 separate fens (according to Rzeźnicki, 1999 – changed).

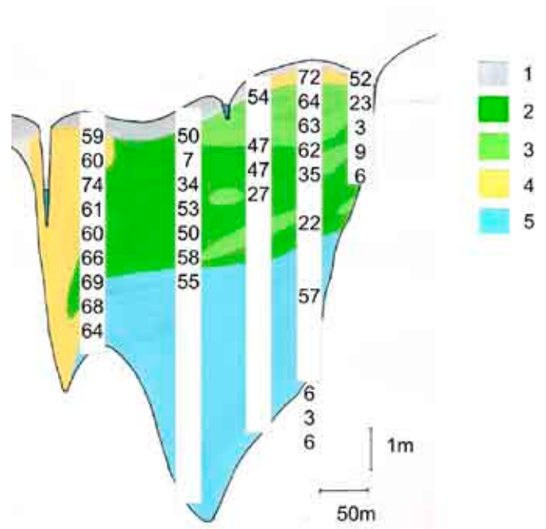


Fig. 89. Stratigraphic transect from valley flanks to the Płonia River near Żydowo. The present Płonia River is clearly artificial here since it cuts through travertine deposits at the right hand side which have been present there for centuries. 1 – degraded top soil, 2 – large sedge peat, 3 – small sedge peat, 4 – travertine, 5 – lake chalk (Grootjans et al. 2007).

found on the eastern side of the valley just below the surface of the fen. This indicates that an intensive accumulation of calcium carbonate has been taking place in recent past.

Relevees taken in 1990 – 91 (Bacieczko 1996), 1996 (Banaś 1997) and 2014 (as part of the project) were used to assess the transformation directions of plant communities and the dynamics of these processes.

The current state is a mosaic of plant communities, among which – spatially predominant – are transformed wet meadow complexes of the *Calthion* alliance. The most important and valuable unit of this group is the bunt-flowered rush *Juncetum subnodulosi* association. The other communities are related to a knotweed-thistle meadow *Angelico-Cirsietum oleracei*. The limitation of use causes degradation of this meadow and development of meadowsweet herbs *Filipendulo-Geranietum* and expansion of sedges and reeds, forming eutrophic land reeds *Urtico-Phragmitetum*.

More typical sedge vegetation is concentrated along the ditches and in the groundwater outflow points. The most common representative is the community of greater tussock-sedge *Caricetum paniculatae*. Smaller areas are occupied by other high sedge associations: *Caricetum acutiformis* and *Caricetum appropinquatae*.

From the river side, tree vegetation with the character of an ash-alder riparian forest enters the fen.

In order to stop the unfavourable changes, mowing activities were restored in the area of the most valuable patches of the habitat, together with building gates on drainage ditches, to improve the water conditions.

The stratigraphic studies carried out in the past have shown strong diversification in the structure of peat deposits and calcareous sinter deposits. Particularly important from the point of view of the possibility of active protection is also the significant variation in the degree of decomposition of the surface layer of peat which for the most part shows signs of advanced mineralization. This situation and the prevailing water conditions are reflected in the nature of the vegetation at the site.

A comparison of relevees taken in the early 1990s with the current state of the vegetation makes it possible to assess the direction of changes in the vegetation of the Żydowo alkaline fen. The following are visible: the disappearance of typical mire species (especially from the *Caricion davallianae* group), the trivialization of the species composition of plant communities and the expansion of common reed and sedge species. The direct cause of these phenomena is the abandonment of the use of wet fen meadows, while the main reason is the excessive drainage of the area, caused by drainage activities repeated at least twice.

Photo 84. Fen cupola in the western part of the site (photo R. Stańko).

Photo 85. One of the 7 gates (dams) built on the deep drainage ditches in the fen cupola in „Płonia-Żydowo" site (photo R. Stańko).

Fig. 90. Automatic water level recorder logs showing the spectacular improvement of the moisture level in the fen after blocking the flow in the drainage ditches.

The protective measures taken as part of the project, consisting in the improvement of the water content and the removal of tree and shrub wildings during mowing, have gradually contributed to the restoration of communities characteristic for habitat 7230 and an improvement of their condition. The direct impact of the construction of dams on drainage ditches, recorded during hydrological measurements, is presented in Fig. 90.

Despite the regulatory works carried out in the past, the site is dominated by the type of groundwater supply rich in calcium salts, which is confirmed by the attached data of the basic physical and chemical parameters in Table 8. It can therefore be assumed that, with the sustained improvement of water conditions, the continuation of extensive mowing use will contribute to a further improvement of the conservation status of the vegetation at the site.

Table 8. pH and electrical conductivity of the water supplying the Płonia - Żydowo fen; measured on 13.06.2014.

Location code	**Ditch item 9**	**Spring reed item 10**	***Caricetum acutiformis* item 12**
pH	7,34	7,68	7,13
Electrical conductivity [µS/cm]	700	665	761
Temperature	13,8	15,2	16,2

SITES IN NORTH – EAST PART OF POLAND

Natura 2000 site „Torfowiska Gór Sudawskich" PLH200017

Rowelska Góra

Natura 2000 site „Dolina Szeszupy" PLH200016

Wingrany, Poszeszupie, Rudawki

Torfowiska Gór Sudawskich soligenous fens with moss and sedge vegetation (Poszeszupie, Rudawki), spring fen (Rowele) and topogenic fen (Wingrany). The Wingrany fen is a rich fen located near a lake, while Rudawki and Poszeszupie are flow-through fens formed on the slopes of the valley. The Rowele fen is located in the spring zone on the slopes of Góra Grabowa. All of them represent the habitat subtype 7230-3 (flow-through and spring fens of northern Poland).

The fens are located north-east (Rudawki, Poszeszupoie, Wingrany) and north-west (Rowele) from Rutka-Tartak, in the strongly undulating post-glacial landscape of the Suwałki Lake District. All of the fens

are concentrated in the Szeszupa Valley and in the valleys of its tributaries. The distance between the patches of fens is 1 – 2 km. Only the Rowele site is located further away – about 5 km to the west from the Szeszupa Valley, near the village of Rowele (cf. Fig 91).

Two of the fens described above (Poszeszupie and Rudawki) lie at the foot of the slope of the heavily drained valley of the Szeszupa River (Neman's catchment area), and the Rudawki fen – in the left-bank branch of this valley. The Rowele fen is located outside the Szeszupa Valley and its tributaries, in the spring zone of the watercourses leading to the Szeszupa River cut with ditches. The Wingrany fen formed over a small kettle lake from which waters are drained via a ditch to Wigra – the tributary of the Szeszupa River. All the patches of the fens were drained in the past; only some of the one-way drainage ditches are now partially overgrown. In the past, the described fens were mown; currently, they are unused enclaves surrounded by agricultural areas.

Within the boundaries of the sites discussed in this Report, many rare and protected species were found during the studies conducted in the years 2010 – 2014. Among the vascular plants, of particular interest are: creeping sedge *Carex chordorrhiza*, dioecious sedge *C. dioica*, bog-sedge *C. limosa*, Baltic marsh-orchid *Dactylorhiza baltica*, early marsh-orchid *D. incarnata*, *D. ruthei*, common sundew *Drosera rotundifolia*, marsh helleborine *Epipactis palustris*, slender cottongrass *Eriophorum gracile*, common twayblade *Listera ovata*, marsh lousewort *Pedicularis palustris*, felwort *Swertia perennis*, flatleaf bladderwort *Utricularia intermedia*, and lesser bladderwort *U. minor*. Species protected under the Habitats Directive are also particularly important in the area: fen orchid *Liparis loeselii*, yellow marsh saxifrage *Saxifraga hirculus*, and fleshy starwort *Stellaria crassifolia*. Protected moss species are also present, e.g., varnished hook-moss *Hamatocaulis vernicosus*, Blandow's helodium moss *Helodium blandowii*, *Palustriella* sp., three-ranked spear-moss *Pseudocalliergon trifarium*, hooked scorpion moss *Scorpidium scorpioides*,

The vegetation of these sites is mainly made up of moss sedge communities with beaked sedge *Carex rostrata*, red fescue *Festuca rubra*, *Poa* spp., bog groove-moss *Aulacomnium palustre*, and woolly

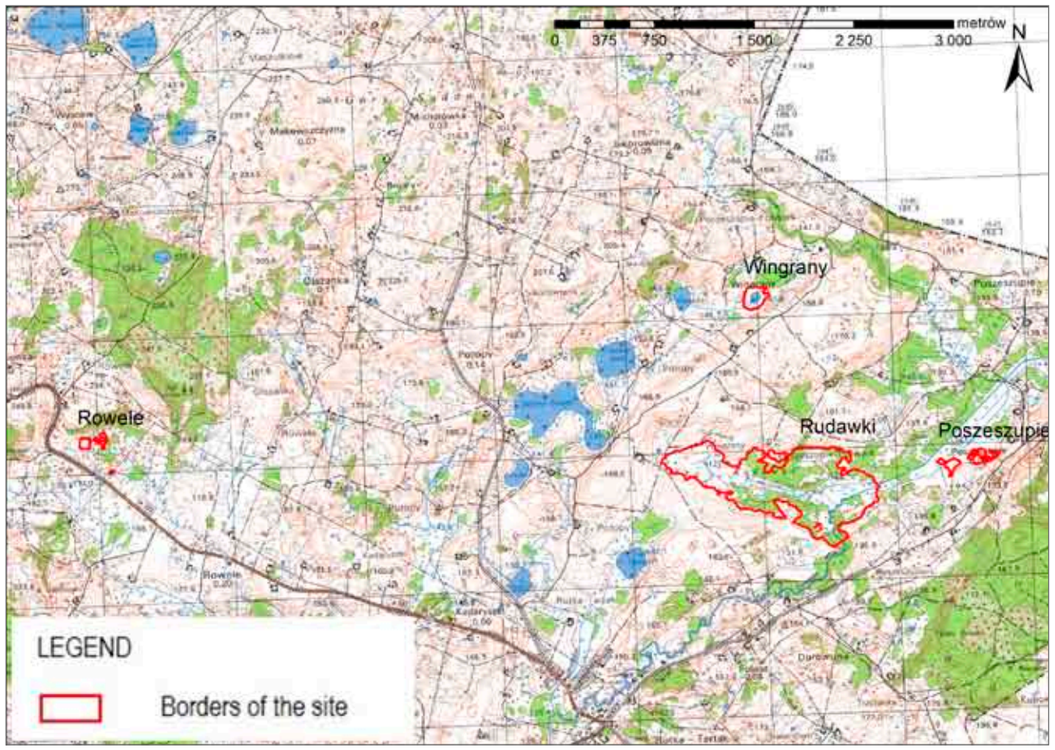


Fig. 91. Location of the fens of the Góry Sudawskie upland on the background of a topographic map (red line – area of the sites).

feather-moss *Tomentypnum nitens*, with a high occurrence of meadow species. Part of the area is occupied by the mossy tall sedge communities of *Caricetum acutiformis* or *Caricetum elatae*. There are also mosques with slender sedge *Carex lasiocarpa*, traditionally considered as a subassociation with hooked scorpion moss *Scorpidium scorpioides*, and less frequent are the moss patches with a slightly different species composition of the herb and bryophyte layers (e.g., bog-sedge *Carex limosa* and Cosson's limprichtia moss *Limprichtia cossonii*). In addition, small parts of the fens are covered by subneutral moss mires with *Sphagnum teres* (*Menyantho-Sphagnetum teretis*). Expansion of tall perennials, willows, birches and alders is visible in some places. On the Rowele fen, the moss -sedge vegetation is composed of the plant communities of the *Caricetum paniceo-lepidocarpae* association with greater tussock-sedge *Carex panicea*, long-stalked yellow sedge *Carex lepidocarpa*, Cosson's limprichtia moss *Limprichtia cossonii*, yellow starry feather-moss *Campylium stellatum*, and pointed spear-moss *Calliergonella cuspidata* as well as frequent occurrence of meadow species (for this reason they are locally related to moor-grass meadows with varying water content). Within each site, there are also local depressions with *Chara* spp.

Active protection tasks focused mainly on removing shrubs and mowing open parts of the moss patch (cf. chapter 1.5.1).

The natural values of the area were discussed, among others, in the studies by Kawecka (1991), Kawecka and Karczmarz (1993), Pawlikowski and Jarzombkowski (2010), Pawlikowski and Wołkowycki (2010), Pawlikowski et al. (2009), and Wołejko et al. (2012).

The surface of most patches of the fens remained perfectly hydrated during several years of observations (cf. Fig. 92 and 93).

The water level after the construction of the beaver dam in 2014 on the main drainage ditch (which is marked by a systematic increase in hydration) ranged from 20 cm below the ground surface to approx. + 15 cm. This fact does not mean the flood of the area of fen, but indicates the natural vertical movement of the fen in a state of good hydration and demonstrates the proper preservation of its function. The water level is balanced all year round and no summer lows have been found, which also confirms the high degree of naturalness of the fen. The small amplitude of fluctuations in the water table enables complete saturation of the peat profile due to capillary hypopriety and the availability of water for plants throughout the growing season. The relatively stable level of groundwater on alkaline fens is clearly associated with the activity of beavers in this area in recent years, which underlines the negative impact of one-way drainage ditches in the absence of their activity.

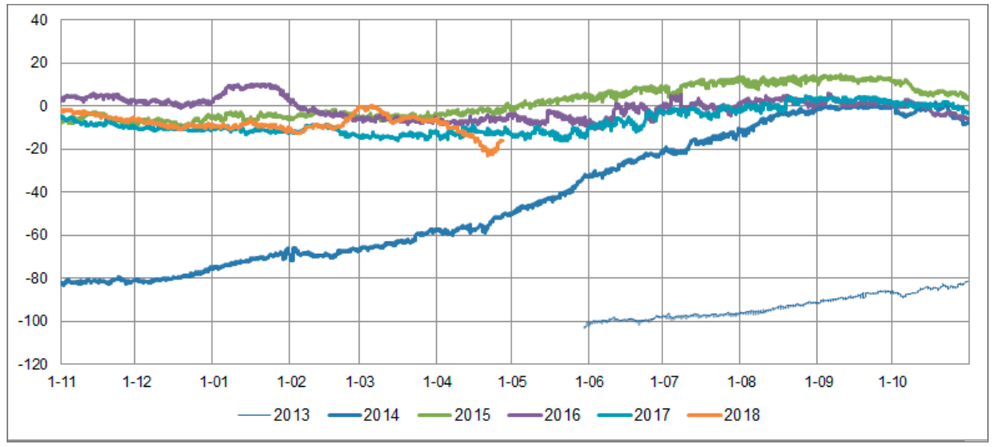


Fig. 92. Groundwater level fluctuation in hydrological years 2013-2018.

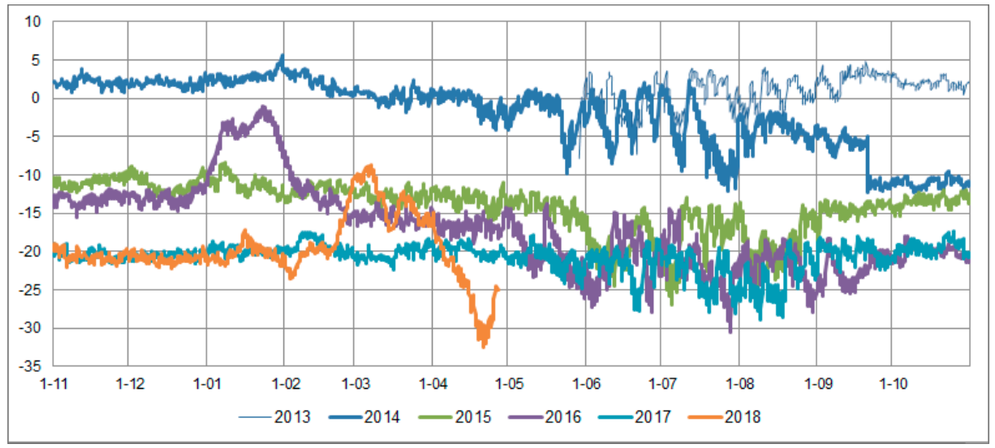


Fig. 93. Groundwater level fluctuation in hydrological years 2013-2018.

The measurement of the groundwater table slightly below the main beaver dam, which is within the range of the impact of another, periodic dam confirms the above thesis. The full impoundment maintained almost until the end of the 2014 hydrological year affected the relatively constant and high water level in this place. After moving the main dam a bit up the valley, it was noticed that the ditches were cleared and the water levels in the place were systematically reduced. In the following years, only periodic damming occurs during the thaw period, the impact of which lasted about 1 month. Despite the negative impact of the drainage network, the fen patch is well hydrated due to capillary infiltration, and the availability of water for plants, despite small summer falls, is ensured. Nevertheless, in places where the beavers' activity was not sufficient, the biological "dams" on the ditches were used, which also positively influenced the level of hydration.

The stratigraphic studies confirmed the occurrence of well-preserved peat deposits composed of various types of moss, sedge-moss, and sedge peats sometimes underlined with calcareous and organic-calcareous gyttja.

At present, on each of the patches of the habitat, successive processes leading to a reduction of the habitat range are observed. Most of them are caused by a disturbance of water conditions in the fens as a result of the construction of one-way drainage systems. The open fens are overgrown with trees and shrubs – in particular, birch, alder and willow. As a result, they are replaced by shrub and forest plant communities from the dynamic alder forest type. This process is most pronounced at the edges of the moss patches, in the immediate vicinity of areas overgrown by trees. In the patches where systematic land use was implemented in subsequent years, the vegetation of the moss patches is preserved in good condition. Furthermore, some of the patches of the habitat are within the range of beaver activity (Wingrany, Rudawki).

So far, however, their activity in most cases has not caused any changes in the hydration of the fens. The exception is the Rudawki site, where locally as a result of the transformation of water conditions first by human activity (one-way drainage ditches), and in the following years by beavers (dams on ditches) can be seen. Some of the moss patches were flooded and degraded, and reed communities developed in these areas. In some of the sites, moss patch vegetation is additionally subject to reed expansion (Wingrany, Rudawki), and within the boundaries of the Rowele site and on parts of the Poszeszupie and Rudawki sites, an increased presence of meadow species is observed, which is also related to the transformation of water conditions in the area of fens and the former use of these areas as meadows.

One of the elements of active protection here was the "biological damming" on drainage ditches in order to stop the excessive outflow of water.

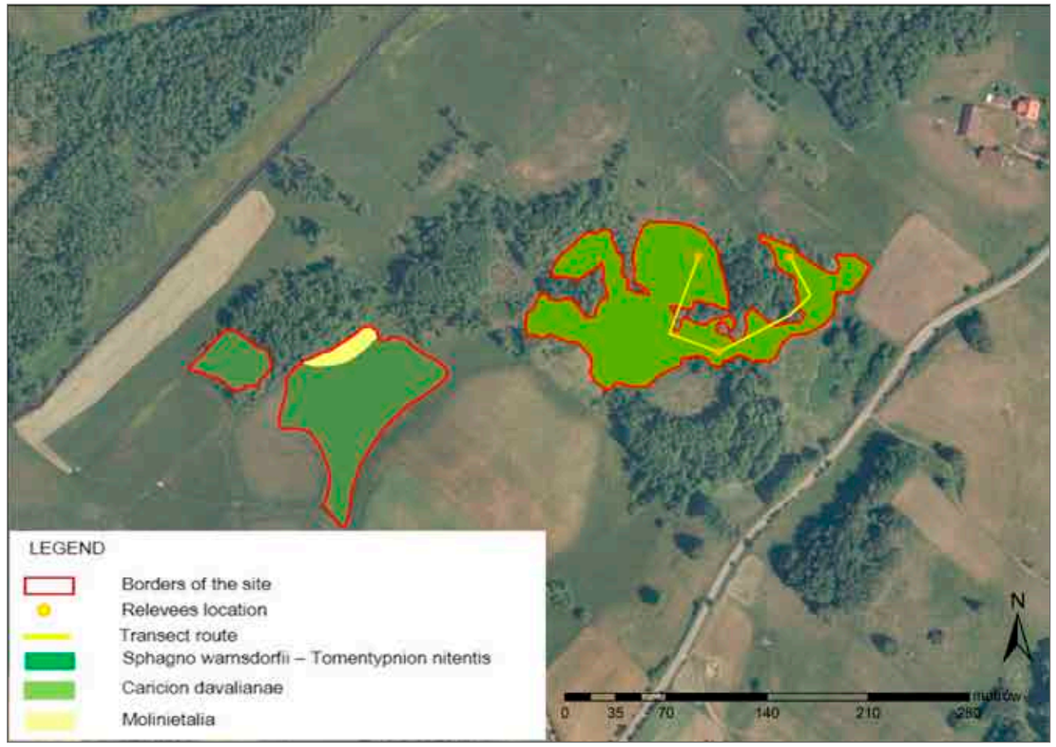


Fig. 94. Actual vegetation map on Poszeszupie.

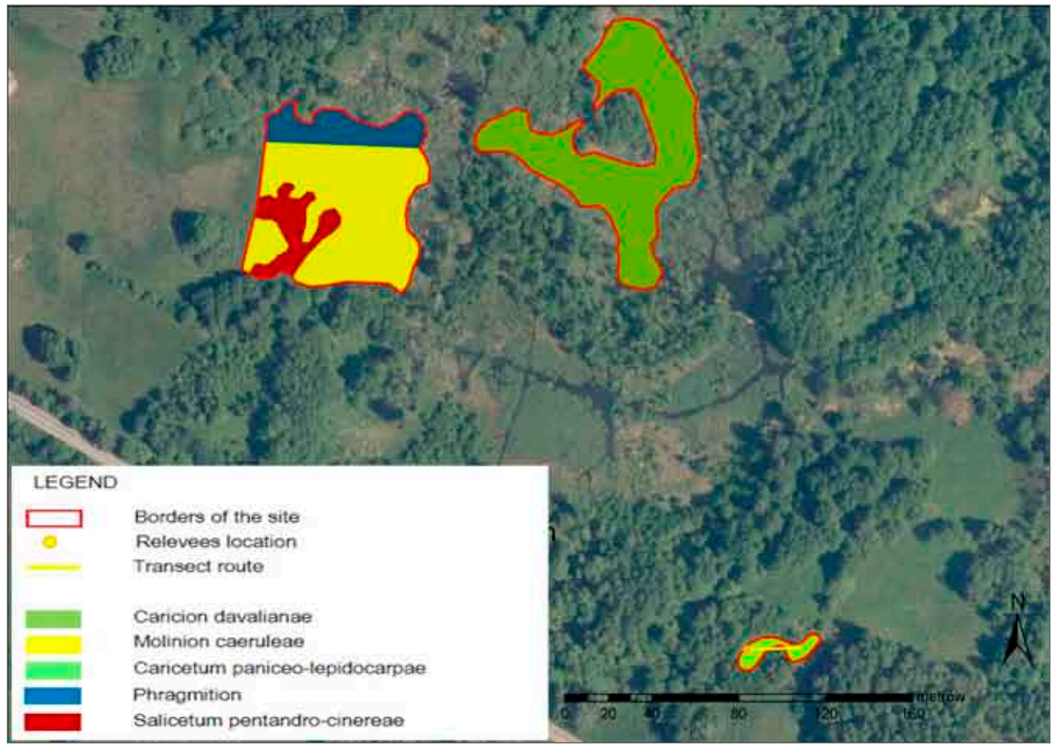


Fig. 95. Actual vegetation map on Rowele.

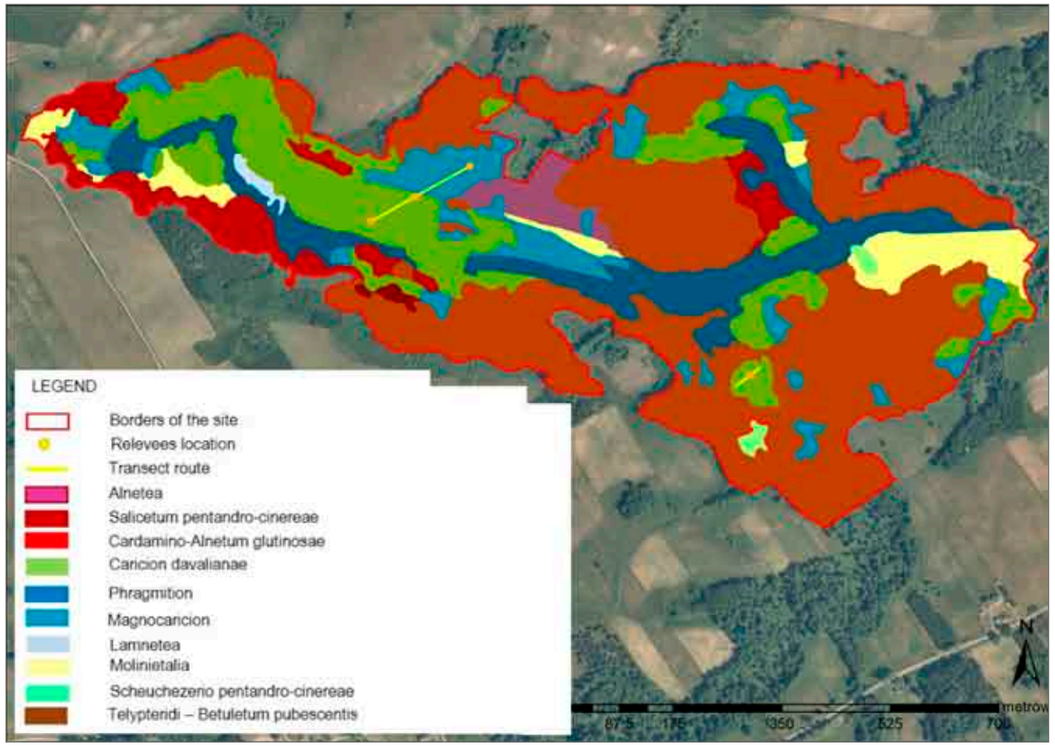


Fig. 96. Actual vegetation map on Rudawki.

Fig. 97. Actual vegetation map on Wingrany.

Photo 86. „Biological damming" with *Carex paniculata* in order to hinder the outflow (photo W. Spychała).

Photo 87. Poszeszupie (photo F. Jarzombkowski).

Photo 88. Active conservation measures on Rowele (photo F. Jarzombkowski).

Photo 89. Rudawki (photo F. Jarzombkowski).

Photo 90. Wingrany (photo F. Jarzombkowski).

Bagno Parchacz

Bagno Parchacz is located in the southeastern part of an extensive soligenous fen, located between the steep slope of the Rospuda Valley and Lake Okrągłe, now dominated by forest communities. It is an alkaline flow-through fen located on a deep peat bed and represents habitat subtype 7230-3.

The site is located in the Rospuda Valley on the northern shore of Lake Okrągłe, south-east of the village of Stara Kamionka (cf. Fig. 98).

Bagno Parchacz lies within a strongly overgrown fen complex, mostly covered by forest communities formed as a result of secondary succession (pine bog forest, pine, and birch bog forest). The complex is located in an agricultural landscape; only to the south of Lake Okrągłe, are there forest areas in a mosaic with agricultural lands used with various intensity.

In the past, the fen was mown, but in the second half of the twentieth century this activity was gradually abandoned for economic reasons. Currently, the area of open fens accounts only for a small percentage of the vast complex. The remaining part of it is occupied by forest communities that developed in the process of secondary succession caused by the lack of use of the fens. The abandonment of use in recent years has also been influenced by the high water content of the area. In the forest part of the complex, there are traces of former peat extraction (poorly recognizable overgrown exploited peatlands).

The formation of fens in the overgrowing lakes of the Rospuda tunnel valley is characteristic for postglacial areas. The resulting glacial tunnel valley was filled with water after the glacier had subsided. In the next phase, the bottom of the tunnel valley was covered with a layer of several meters of gyttja. Thanks to the sealing of the valley bottom, the groundwater level increased and the resulting peat mass was protected against excessive drying during the summer water depression. Depending on the prevailing vegetation, various layers of peat were deposited. Since

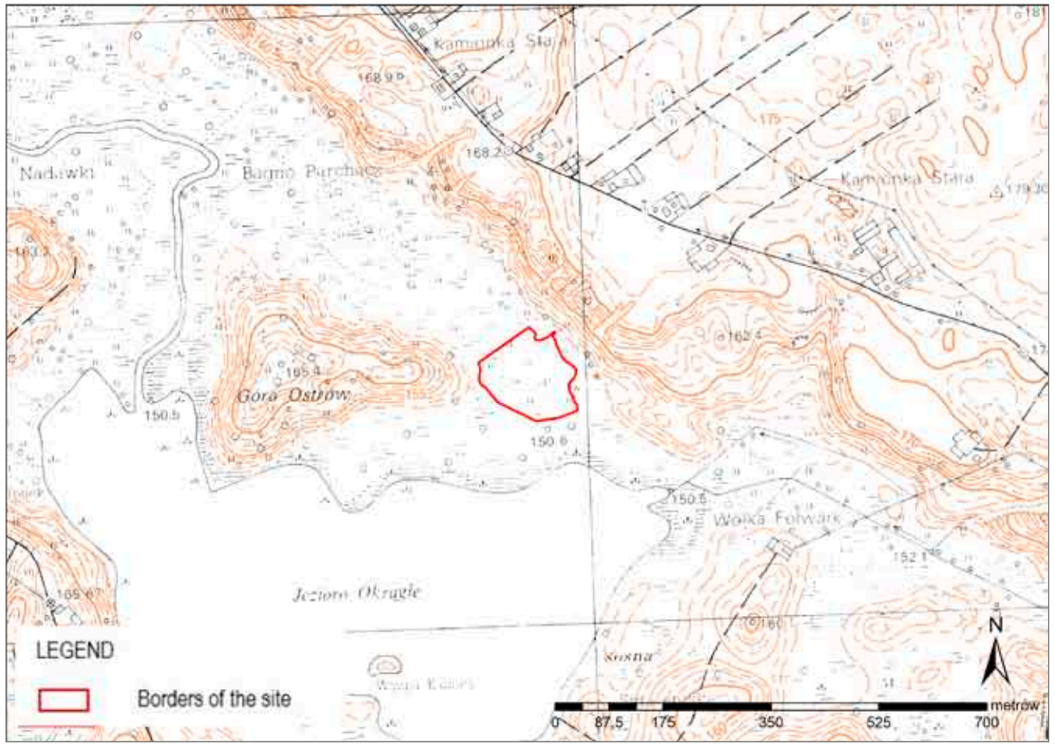


Fig. 98. Location of Bagno Parchacz on the background of a topographic map.

2011, there has been a high flood of the fen (water was about 40 cm above ground level) caused by beaver activity and a high incidence of water accumulation in the Rospuda hydroelectric power plant in Małe Raczki.

Currently, the vegetation composition of Bagno Parchacz is dominated by mossy sedge patches with slender sedge *Carex lasiocarpa,* fibrous tussock-sedge *C. appropinquata* and beaked sedge *C. rostrata*, with massively occurring bogbean *Menyanthes trifoliata*, and local prevalence of marsh fern *Thelypteris palustris.* These are communities with an indefinite syntaxonomic position in the *Scheuchzerio-Caricetea nigrae* class. The vegetation of Bagno Parchacz was significantly transformed as a result of hydrological changes caused by the damming by the hydroelectric power plant in Małe Raczki and beaver activity. Due to the long-term and relatively high flooding, we observe the withdrawal of the species with poor water submersion tolerance, the development of tufty sedges, and the rebuilding and depletion of the moss layer.

Prior to flooding, the habitat was dominated by low and medium sedges (mainly the slender sedge *Carex lasiocarpa*), locally initial moss patches of *Eleocharitetum quinqueflorae* (sometimes with a high proportion of bog-sedge *Carex limosa*), and plant communities similar to *Caricetum diandrae*. The following species were also noted: fen orchid *Liparis loeselii*, alpine bulrush *Baeothryon alpinum*, dioceous sedge *Carex dioica*, great sundew *Drosera anglica* and common sundew *D. rotundifolia*, white adder's mouth *Malaxis monophyllos*, and marsh lousewort *Pedicularis palustris.* During the study in 2014, the aforementioned species were not found to be present, with the exception of slender sedge. The species composition of the moss layer has changed radically. Many moss species of moss had previously been found, such as the rare *Cinclidium stygium*, varnished hook-moss *Hamatocaulis vernicosus*, tufted fen-moss *Paludella squarrosa*, and woolly feather-moss *Tomentypnum nitens* or Warnstorf's sphagnum *Sphagnum warnstorfii*. Among the dominants there were: Cosson's limprichtia moss *Limprichtia cossonii,* pointed spear-moss *Calliergonella cuspidata*, giant spear-moss *Calliergon giganteum*, common green bryum moss *Bryum pseudotriquetrum*, and *Sphagnum teres.* The tufting of the fen caused a clear differentiation of the moss layer. Currently, the mosses mostly occupy sedge tufts, with the dominance of pointed spear-moss *Calliergonella cuspidata*, while at the foot of the tufts (often underwater) there is a fairly high number of heart-leaved spear-moss *Calliergon cordifolium*. There has been a significant decline in the species variety of mosses and there are no rare species. Within the habitat, there has been a strong expansion of trees and shrubs (downy birch *Betula pubescens*, grey willow *Salix cinerea*, common alder *Alnus glutinosa*), and common reed *Phragmites australis*. There are also observable changes in the direction of the development of large sedge reeds.

Activities in the field of active protection focused mainly on removing shrubs from and mowing an open parts of the fen (see Chapter 1.5.1).

The natural values of the area are discussed only in the studies by Jarzombkowski and Pawlikowski (2012), Jarzombkowski & Pawlikowski (2012), and Wołejko et al. (2012).

The vegetation of Bagno Parchacz was significantly transformed as a result of hydrological changes caused by the damming by the hydroelectric power plant in Małe Raczki and beaver activity. Due to the long-term and relatively high flooding (in 2014 – approx. 40 cm over ground level), we observe the withdrawal of the species with poor water submersion tolerance, the development of tussock-forming sedges, and the change and depletion of the moss layer.

The observations indicate that the process of transformation of alkaline fens into reed and forest communities plays a dominant role. Apart from fen flooding, an additional factor contributing to the development of reed communities was the abandonment of use as meadows in the past, resulting in the development of tall, tufty sedges and the expansion of trees and shrubs. In the current situation, the only way of stopping and slowly reversing this process is to restore the use of the fen (removing trees and shrubs, mowing of the sward). The high water level on the fen recorded since 2012 has been gradually decreasing, but it is still a phenomenon hindering the use of the rich fen patch. Given the low snowfall and the low rainfall in recent years, it is likely that water levels will continue to fall.

The stratigraphic studies confirmed the existence of a well-preserved peat deposit built by various types of sedge-moss and sedge peats underlined with calcareous gyttja.

Fig. 99. Actual vegetation map of Bagno Parchacz.

Photo 91. Bagno Parchacz (photo E. Gutowska).

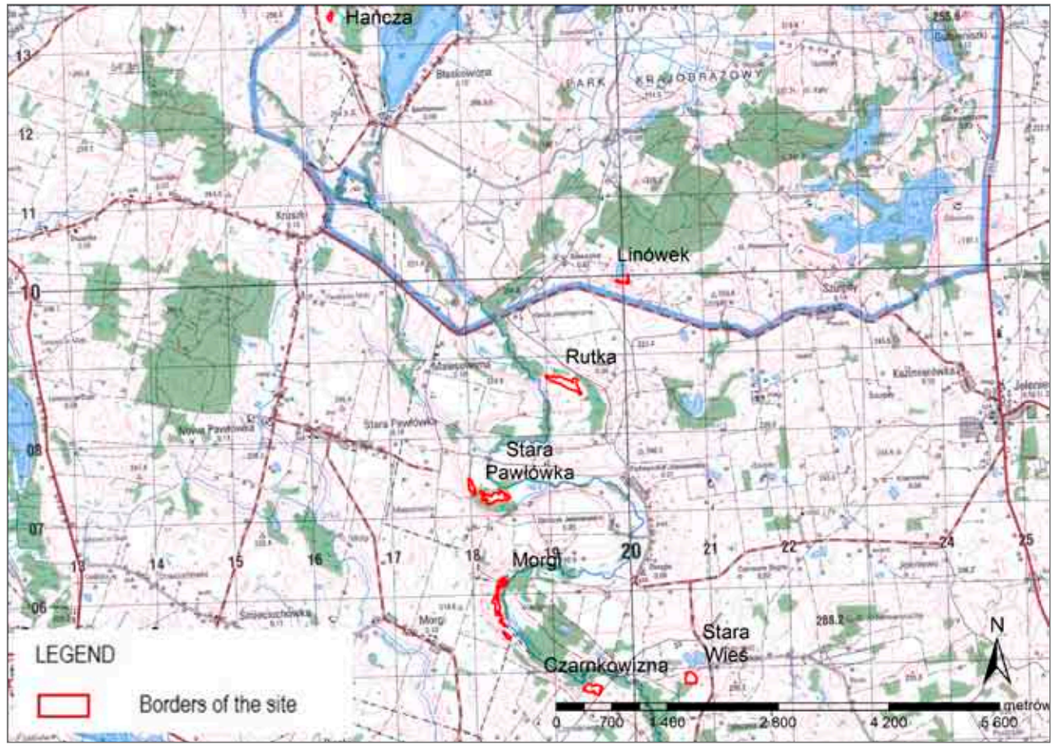


Fig. 100. Location of all sites sites on the background of a topographic map.

Natura 2000 site „Ostoja Suwalska" PLH200003

Hańcza, Linówek

Natura 2000 site „Jeleniewo" PLH200001

Czarnkowizna, Stara Wieś, Morgi, Rutka, Stara Pawłówka

The fens of the Czarna Hańcza Valley are located between Lake Hańcza and the village of Stara Wieś, in the upper course of the river or in its immediate vicinity (cf. Fig. 100). Most of the patches of the habitat are concentrated in a strongly meandering part of the valley over a length of ca. 10 km.

The described area belongs to the Neman river basin. The main river that drains water from the area is the Czarna Hańcza that flows through the largest lake in the vicinity – the Hańcza. All patches of the habitat are located in the vicinity of agricultural lands. These are usually pastures descending to the boundaries of the fen and arable fields located at higher elevations. In the vicinity of the fens, there are also small forest (alder) and shrub complexes. Currently, the fens in the Black Hańcza Valley are mostly unused enclaves surrounded by areas used for agriculture. Only a part of the sites (Rutka, Hańcza, Morgi) is occasionally used for grazing cows. In the past, these fens were used more intensively – they were mown and used for grazing and to acquire peat for heating households (Czarnkowizna, Stara Pawłówka). For some of the fens, there were also attempts to make them productive by drying them out, as evidenced by the existing network of drainage ditches.

The presence of soligenous fens in the valley is due to the particular conditions of the water supply, in particular the constant inflow of groundwater with a high calcium content. Such conditions are created in the part of the main Czarna Hańcza Valley located at the foot of the slopes and in some of its branches. One of the patches is a topogenic peatbog (Linówka) and is dependent on lake waters of a specific chemical composition.

Within the boundaries of habitat 7230 patches, many rare and protected species were found during the studies conducted in the years 2010 – 2014. Among the vascular plants, of particular interest are: alpine bulrush *Baeothryon alpinum*, creeping sedge *Carex chordorrhiza*, dioecious sedge *C. dioica*, bog-sedge *C. limosa*, swamp sawgrass *Cladium mariscus*, Baltic marsh-orchid *Dactylorhiza baltica*, common spotted orchid *D. fuchsii*, great sundew *Drosera anglica*, fen orchid *Liparis loeselli*, Jacob's-ladder *Polemonium caeruleum*. Protected bryophyte species are also common, e.g., *Cinclidium stygium*, varnished hook-moss *Hamatocaulis vernicosus*, hooked scorpion moss *Scorpidium scorpioides*.

The vegetation of the described fens is a mosaic of patches representing the *Scheuchzerio-Caricetea nigrae* class, more or less typically related to the *Caricion davallianae* alliance with the sedge species of medium height (including the plant communities of *Carex lasiocarpa* and *Carex rostrata* in the herbs layer with species of the genus *Drepanocladus* spp, pointed spear-moss *Calliergonella cuspidata*, and woolly feather-moss *Tomentypnum nitens* in the layer of mosses). Dominating plant communities with Cosson's limprichtia moss *Limprichtia cossonii*, yellow starry feather-moss *Campylium stellatum*, greater tussock-sedge *Carex panicea* and long-stalked yellow sedge *C. lepidocarpa* (*Caricetum paniceo-lepidocarpae* association), and numerous meadow species as well as low grasslands with fewflower spikerush *Eleocharis quinqueflora*. In the depressions, there are *Chara* spp. charophyte communities. Large sedges, such as the lesser pond-sedge *Carex acutiformis* or tufted sedge *C. elata*, account for a larger share of the vegetation. Small areas are also occupied by patches with the physiognomy of moss mires, related to transitional mires.

Active protection tasks focused mainly on removing shrubs and mowing open parts of the moss patch (cf. chapter 1.5.1).

The natural values of the area were discussed, among others, in the studies by Sokołowski (1973), Kawecka & Karczmarz (1993), Pawlikowski (2008), Pliszko (2012), and Wołejko et al. (2012).

The surface of most patches of the fens remained perfectly hydrated during several years of observations (cf. Figure 108).

The water level ranged from approx. -10 cm to approx. +30 cm after the construction of beaver dam on the Czarna Hańcza river, which indicates an increase in hydration, later manifested in a slight flooding. Before the impoundment the level of groundwater on the fen remained close to the ground, it was very stable and fluctuated within a few cm. This indicates the proper functioning of the fen. In subsequent years, the increase in the hydration of habitat 7230 was not associated with the flood of river waters, but it was flooding caused by the groundwater leveling up due to high level of the Czarna Hańcza river waters. This is important because often river waters have

Fig. 101. Actual vegetation map of Czarnkowizna.

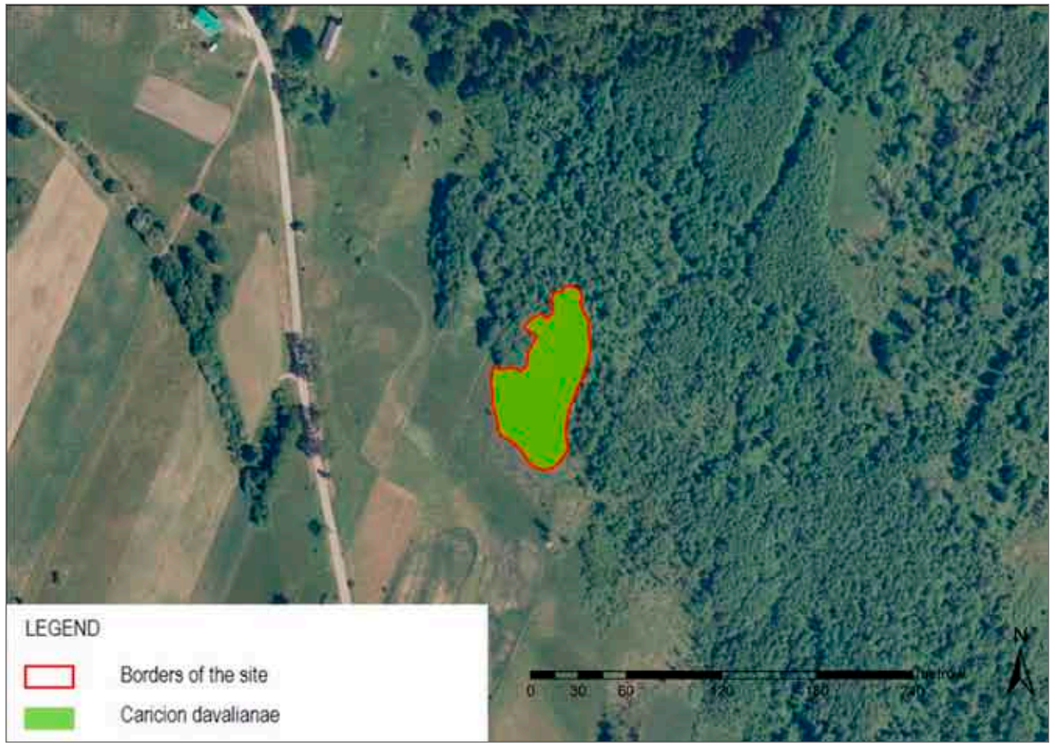


Fig. 102. Actual vegetation map of Hańcza.

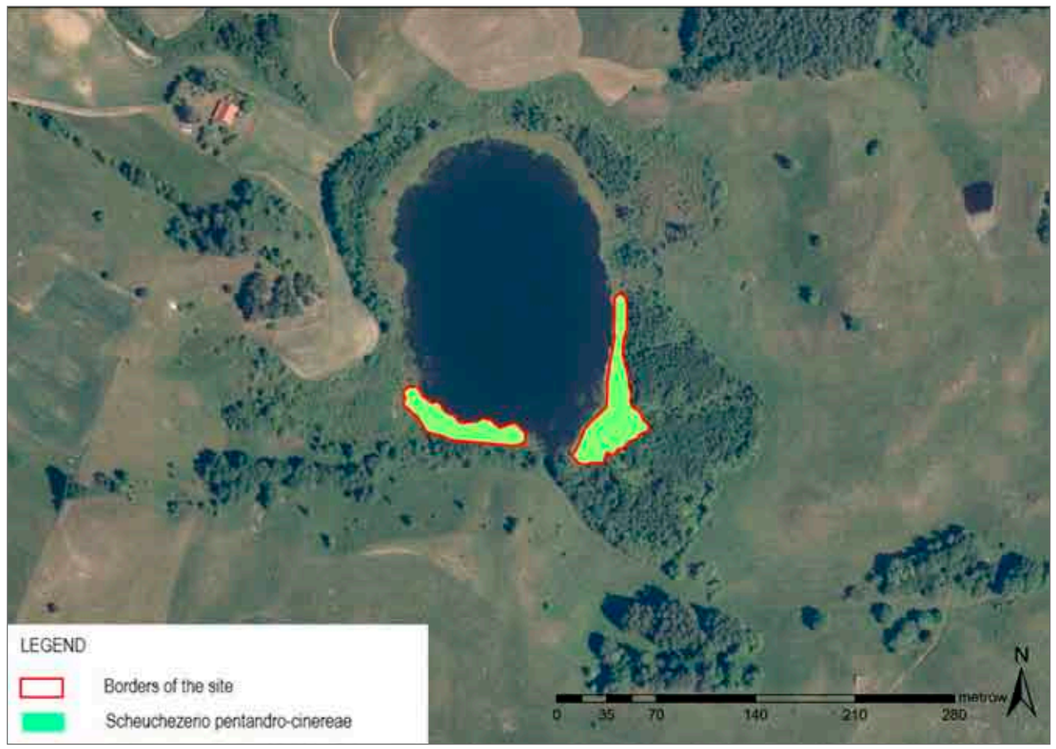


Fig. 103. Actual vegetation map of Linówek.

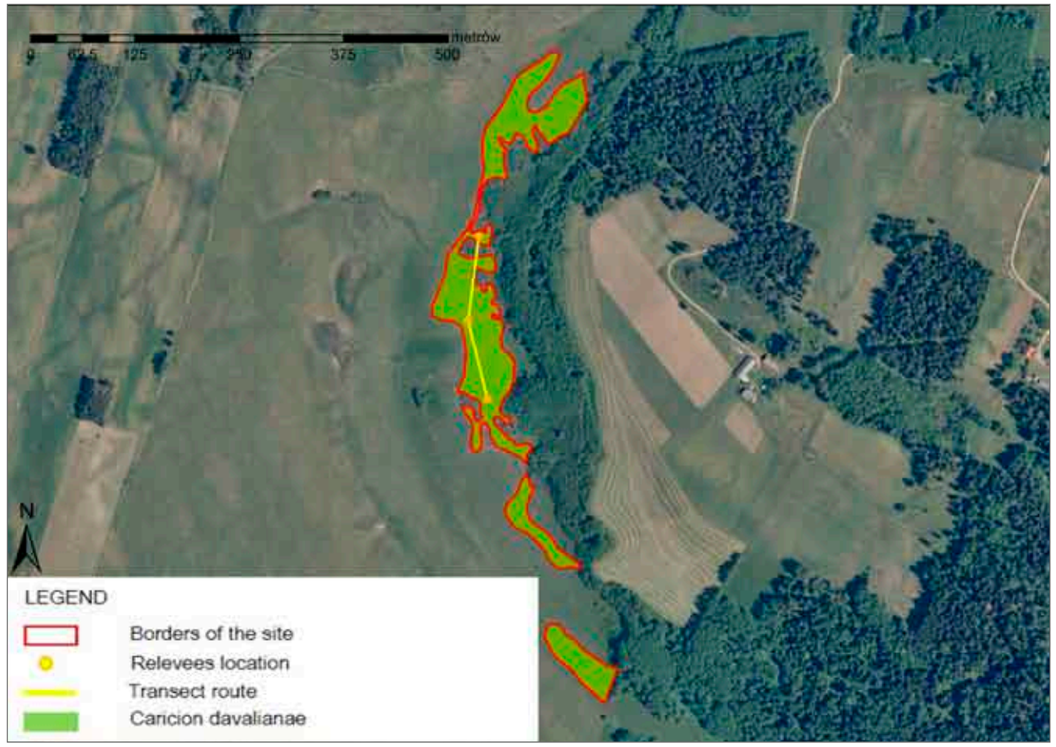


Fig. 104. Actual vegetation map of Morgi.

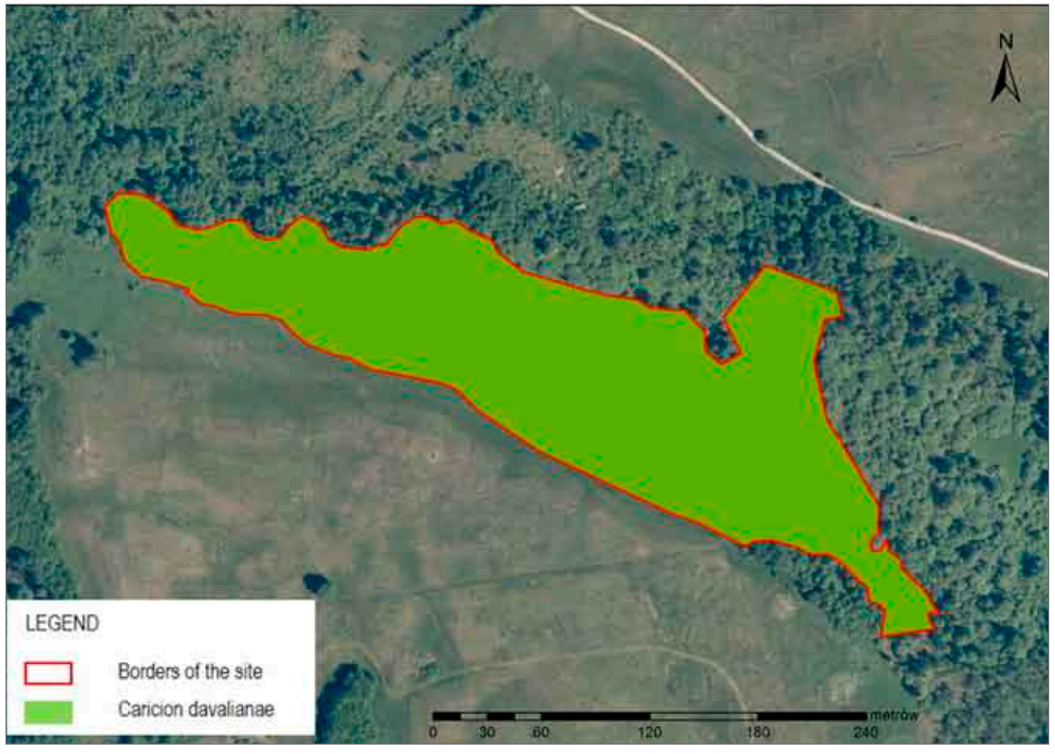


Fig. 105. Actual vegetation map of Rutka.

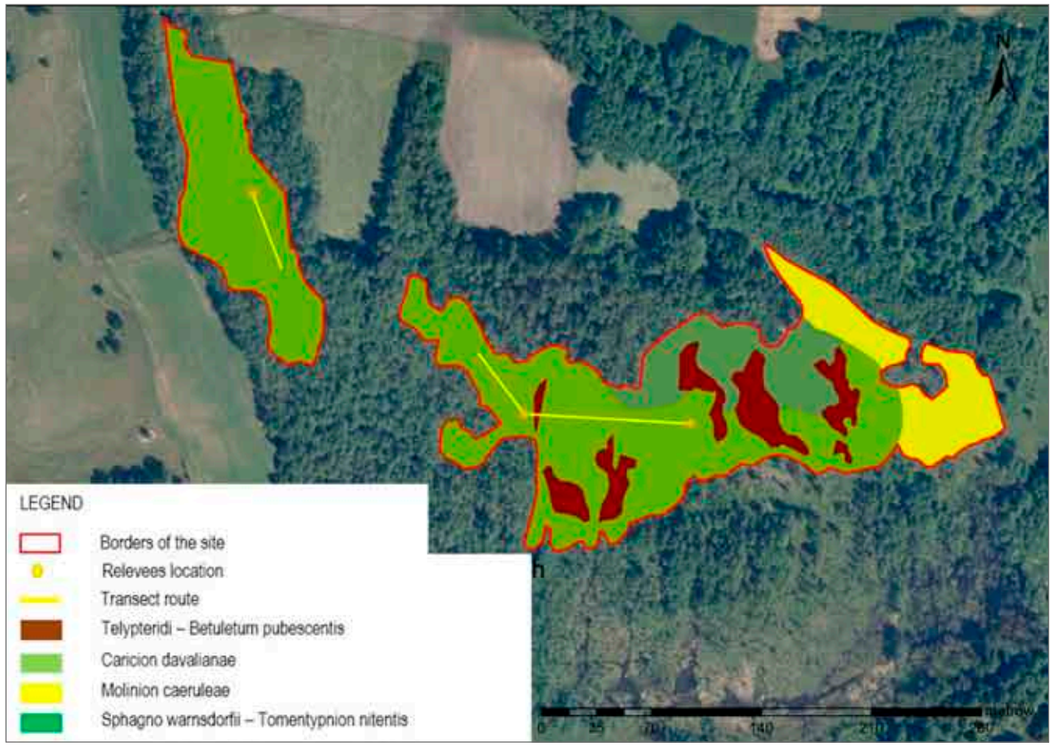


Fig. 106. Actual vegetation map of Stara Pawłówka.

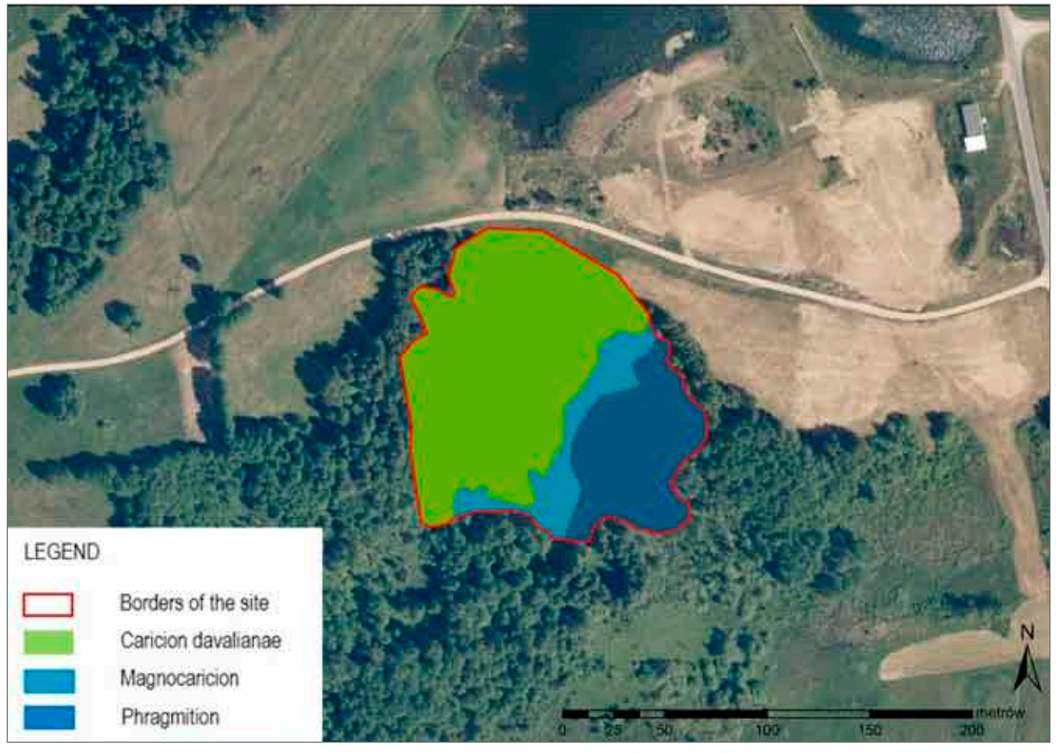


Fig. 107. Actual vegetation map of Stara Wieś.

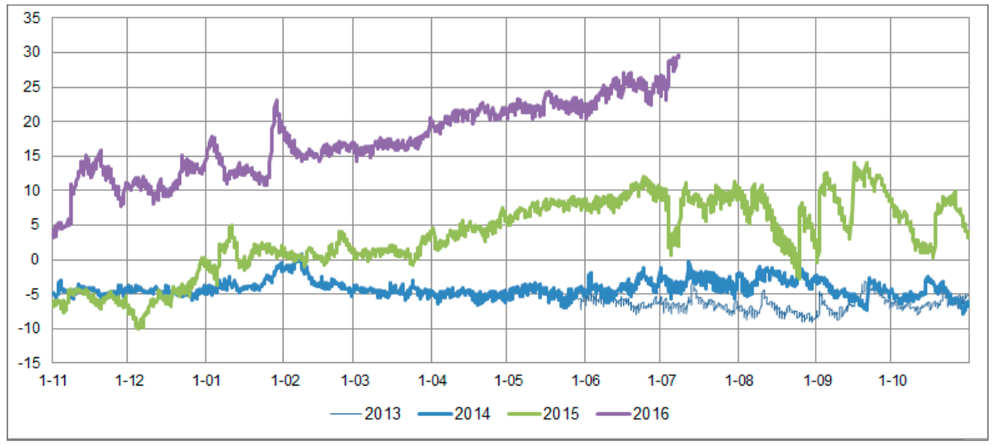


Fig. 108. Ground water fluctuations on Morgi fen in hydrological years 2013-2016.

different chemical characteristics from groundwater feeding fens - the reservoir leads to degradation of vegetation, while flooding allows the ecosystem to function.

The stratigraphic studies confirmed the occurrence of well-preserved, although largely shallow, peat deposits composed of various types of moss and sedge-moss peats sometimes underlined with calcareous gyttja.

Observations show that the status of the plant communities of the alkaline fens in all the patches has improved as a result of the removal of tree and

Photo 92. Czarnkowizna (photo F. Jarzombkowski).

Photo 93. Linówek (photo F. Jarzombkowski).

Photo 94. Morgi (photo F. Jarzombkowski).

Photo 95. Stara Pawłówka (photo F. Jarzombkowski).

shrub wildings. At each of the sites, however, succesion processes are still observed (overgrowing by trees and shrubs – mainly birch and willow) leading to a decrease in the range of the habitat. In the patches where systematic land use was implemented in subsequent years, the vegetation of the moss patches is preserved in very good condition. In the locations which are not used, the development of shrub and forest plant communities from the dynamic group of alders swamps is observed. This process is most pronounced at the edges of the moss patches, in the immediate vicinity of areas overgrown by trees. In addition, some of the sites are within the range of beaver influence. So far, however, their activity has in most cases not resulted in changes of water supply to the fens. The exception is Stara Wieś, where the south-eastern part of the moss patch was degraded as a result of the transformation of the water conditions by beavers. A *Phragmitetum australis* community developed here. At present, there is a network of beaver channels with small water level increase and large lodges. Moss patch vegetation has been preserved only in the northern, central, and south-western part of the site.

Photo 96. Stara Wieś (photo F. Jarzombkowski).

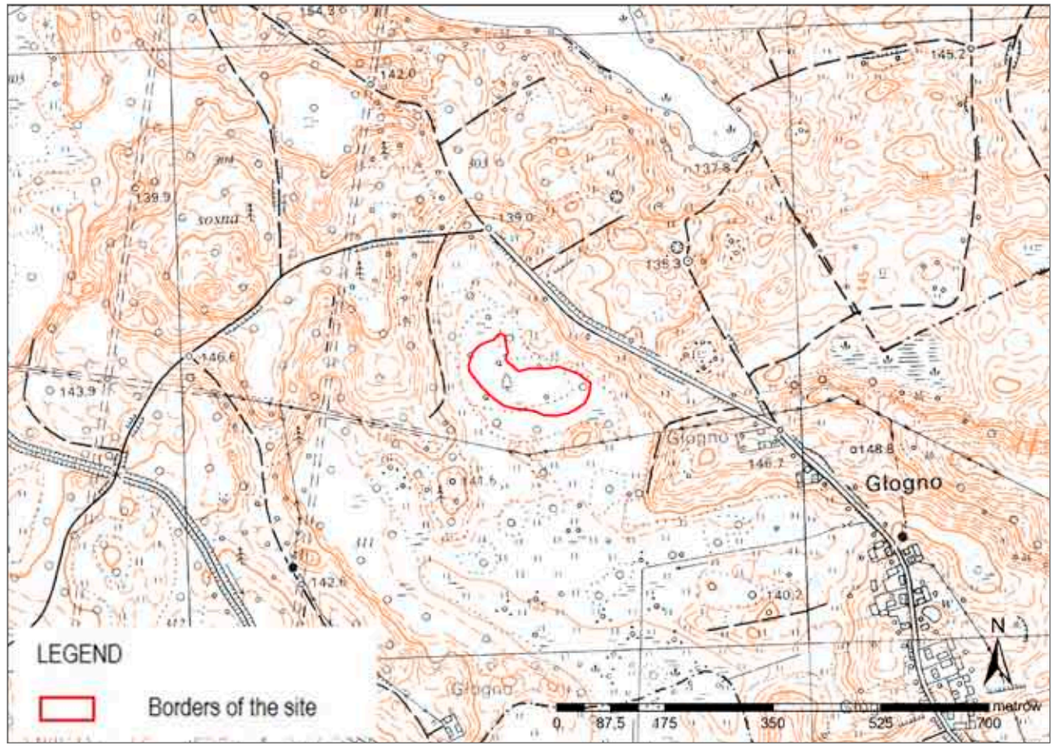


Fig. 109. Location of the site on the background of a topographic map.

Głógno

Torfowisko Głógno is a small alkaline fen located in the pocket of a subglacial tunnel valley occupied by lakes, and in the vicinity of Głógno – mostly overgrown with forest communities. Vegetation consists of moss-sedge communities, locally with the participation of reeds and herbaceous species. The habitat represents subtype 7230-3.

The fen is situated in an agricultural landscape within a small kettle depression (a fragment of an old post-glacial tunnel valley), heavily overgrown with common alder *Alnus glutinosa* and downy birch *Betula pubescens.*

Głógno fen is located in the Vistula river catchment area, in the basin of the Pisa River and catchment area of the Krutynia River, not far from the Level I watershed (Vistula, Pregoła, and Neman). The part of the depression where the Głógno fen is located is drained by one-way drainage ditches located to the south. The habitat is well hydrated, with locally strongly hydrated patches where the water level is periodically maintained even above the ground level. The fen patch is surrounded by shrubs with an undergrowth of trees and forest communities overgrowing the remaining part of the basin depression (including initial birch bog forests from the dynamic group of alder forests and actual alder forests). In the area, apart from forest communities, there are also multiple grasslands. In the past, the fen was mown, but this activity was gradually abandoned for economic reasons.

The plant cover of Głógno is dominated by communities of mossy sedge patches mostly composed of beaked sedge *Carex rostrata* and slender sedge *C. lasiocarpa*, and in the outer parts of the habitat and locations with a stronger secondary succession – with the dominance of marsh fern *Thelypteris palustris,* water horsetail *Equisetum palustre*, and common cottongrass *Eriophorum angustifolium*. There are also local patches of *Carex limosa, Eleocharis quinqueflora*, and marsh arrowgrass *Triglochin palustris*. The habitat contains many valuable and protected species. The orchid family is represented by i.e. *Liparis loeselii*. The habitat is characterized by a high proportion of low and medium sedges, in addition to the already mentioned: *Carex chordorrhiza, Carex dioica, C. flava.* The moss layer is very well developed with multiple species, with the predominance of brown mosses and the participation of peat mosses tolerating alkaline conditions, mainly composed of the varnished hook-moss *Hamatocaulis vernicosus*, pointed spear-moss *Calliergonella cuspidata*, *Sphagnum teres*, and woolly feather-moss *Tomentypnum nitens*.

The plant communities of the Głógno fen represent the *Caricion davallianae* alliance, and on part of the surface they transform into *Menyantho-Sphagnetum teretis* moss mire patches. There are signs of secondary succession throughout the entire fen area, especially within the boundary area of the patch, where the habitat transitions into initial forest communities with common alder *Alnus glutinosa* and downy birch *Betula pubescens*, and then into a narrow strip of alder forest surrounding the site. Scots pine *Pinus sylvestris* and Norway spruce *Picea abies* appear individually. The shrubs are quite numerously represented by rosemary-leaved willow *Salix rosmarinifolia*, and – less often – by grey willow *Salix cinerea* and bay willow *S. pentandra*. Within the fen, there are slight signs of habitat acidification, with species such as *Oxycoccus palustris*, *Andromeda polifolia, Drosera rotundifolia,* and peat mosses tolerant of alkaline conditions – *Sphagnum teres* and *S. warnstorfii*. Expansive species include the marsh fern *Thelypteris palustris*, which occurs on a large area, and in some cases – common reed *Phragmites australis*, which does not show a high tendency to spread. The mossy tufts, which appear at the foot of the trees, are inhabited by species typical of transitional fens, and sometimes it is possible to observe the expansions of herbaceous plants and the development of patches with *Thelypteris palustris*.

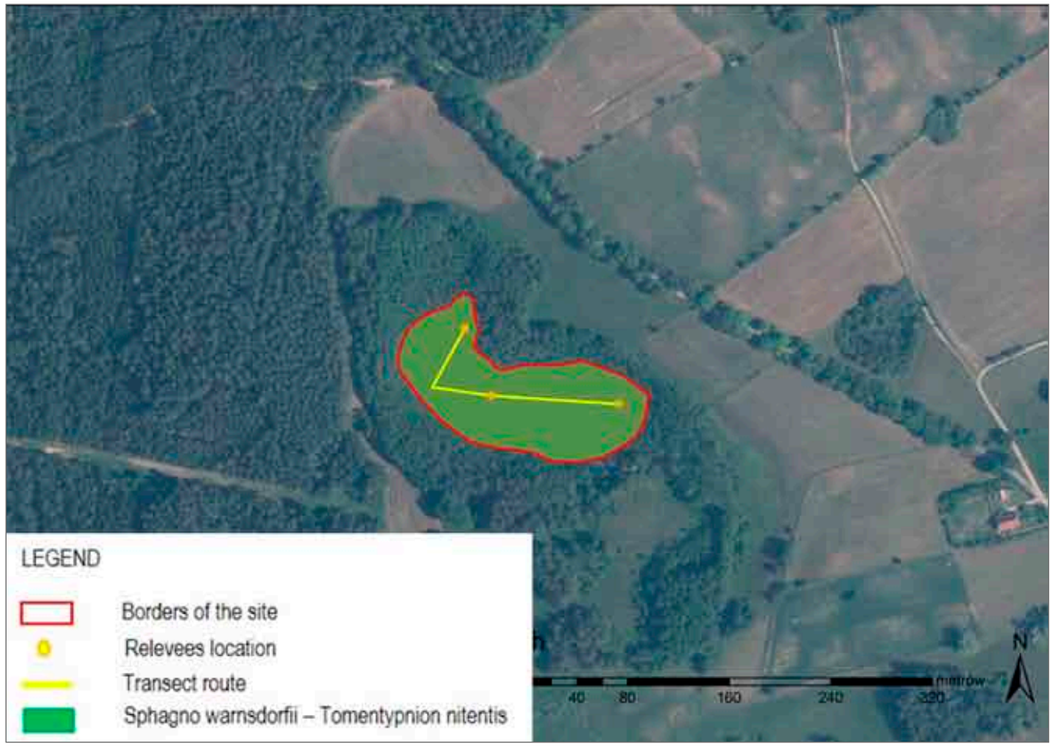


Fig. 110. Actual vegetation map of Głógno fen.

Photo 97. Torfowisko Głógno (photo F. Jarzombkowski).

Active protection tasks focused mainly on removing shrubs and mowing open parts of the moss patch (cf. chapter 1.5.1).

The natural values of the area were discussed only in the study by Wołejko et al. (2012).

The surface of Torfowisko Głógno remained stably hydrated throughout the year during the period of several years of observations. Water level fluctuated just below ground level which means that there are no significant hydrological disturbances in the fen; this was largely due to the activity of beavers that blocked the outflow from the drainage ditch leading out water from the fen. As a result, a stable, high level of groundwater was maintained within the fen basin.

The stratigraphic studies confirmed the occurrence of well-preserved, although largely shallow, peat deposits composed of various types of moss and sedge-moss peats underlined with calcareous gyttja. The peat profile confirms the long-term development of the fen in the form of sedge-moss communities on the site of an overgrowing water reservoir. For technical reasons, the drilling was made only to the depth of 2 m, however the deposit of organic sediments is much larger.

Natura 2000 site "Torfowisko Zocie" PLH280037

Zocie

Torfowisko Zocie is an ancient lake fen with moss-mire and moss vegetation. It is a mosaic of transitional plant communities between moss patches, mossy forms of quagmires, and minerotrophic moss mires. The fen represents two habitat types: 7230 Mountain and lowland alkaline fens in the form of flush mires, sedge and moss patches, subtypes 7230-3, and 7140 Transitional fens and quagmires (mostly with vegetation of *Scheuchzerio-Caricetea*) and intermediate stages between them.

The fen is located in a small forest complex with a predominance of pine trees, but in the immediate vicinity of the fen it is dominated by alder forests and forest communities from a dynamic group of alder forests. The site is quite clearly distinct from its surroundings (cf. Fig. 111).

Torfowisko Zocie (Zocie fen) is located in the southeastern part of a small forest complex, within an ancient lake basin. It is located in the Vistula river basin, in a local watershed separating the Lega river catchment area from the west and the Rospuda river catchment area from the east. On the eastern and southern sides, the fen is surrounded by agricultural lands, and on the northern and western sides – by forest communities. In the past, the fen used to occupy a larger area, but due to the drainage its range was slightly reduced. The drained areas were transformed into wet meadows which, for the most part, after abandoning of their use, transformed into forest and shrub communities as a result of secondary succession. From the south and east, the fen is surrounded by drainage ditches, with two more connected ditches draining the southern part of the site.

Currently, the open fen has been preserved only in the ancient lake part of the basin. Within the area, there are local expansions of the common reed *Phragmites australis* as well as patches with broadleaf cattail *Typha latifolia* and purple moor-grass *Molinia caerulea*. Secondary succession is also visible in some places, and the most numerous of the trees is the downy birch *Betula pubescens*. Due to difficulties in the management and the low value of the hay produced (used only for animal bedding), the majority of the fen was not used or was mown only sporadically.

Torfowisko Zocie developed within the kettle basin in the process of terrestrialisation of a small post-glacial lake. The lake basin was gradually made shallower by the accumulation of gyttja. Then, depending on the prevailing conditions and vegetation of the fen area, the layers of peat deposited varied. The central part of the object is a strongly hydrated quagmire that transitions into a moss mire and then into moss-sedge communities and further into forest communities.

Torfowisko Zocie is an extremely valuable habitat for many rare and protected species associated with fens. Its mosaic layout (patches of minerotrophic moss mires, moss patches, and bryophytic forms of quagmires and various transitional states between them) creates favorable conditions for the occurrence of specific plant species, rare both in Poland and in Europe. Over 40% of the fen flora is composed of rare, endangered, and protected species (Bloch-Orłowska, Pisarek 2005). These include:

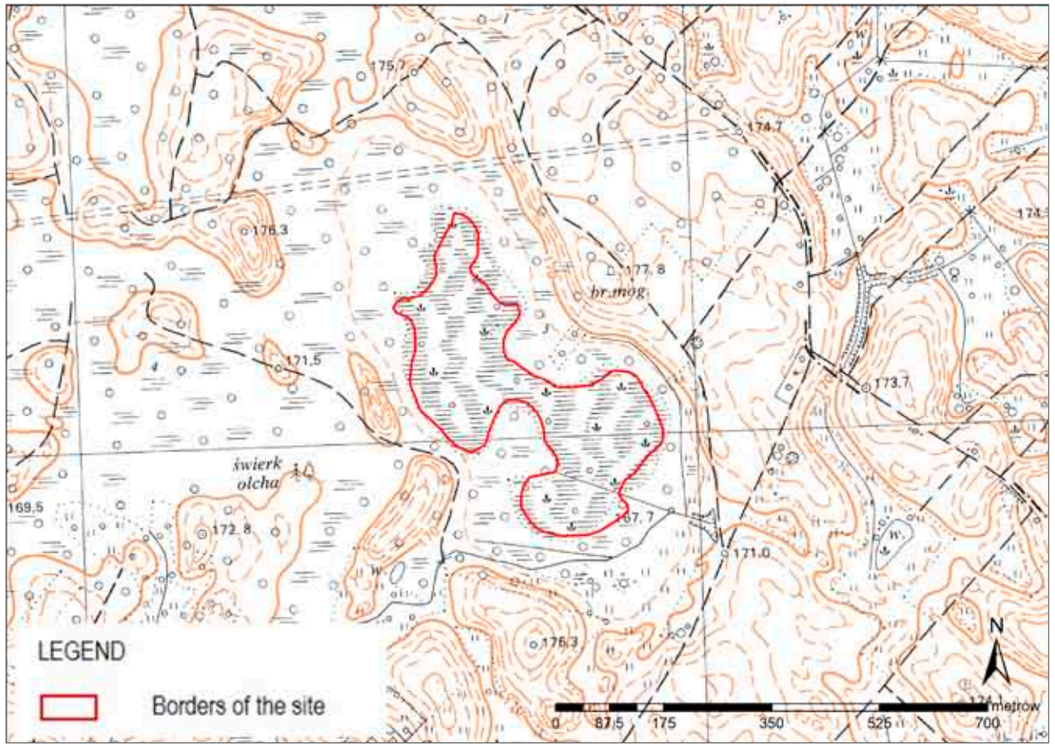


Fig. 111. Location of Torfowisko Zocie on the background of a topographic map.

Hammarbya paludosa, *Liparis loeselii*, *Dactylorhiza incarnata*, *Epipactis palustris Baeothryon alpinum*, *Drosera anglica*, *Drosera rotundifolia*, *Carex limosa*, *C. chordorrhiza*, *C. dioica*, *Eleocharis quinqueflora*, *Scheuchzeria palustris*, *Rhynchospora alba*, *Utricularia intermedia* and *U. minor*, *Betula humilis*, and near the site – black crowberry *Empetrum nigrum*. Particularly noteworthy is the extremely rich layer of mosses which include such species as *Aulacomnium palustre*, *Bryum neodamense*, *Calliergon giganteum*, *Campylium stellatum*, *Cinclidium stygium*, *Hamatocaulis vernicosus*, *Limprichtia cossonii*, *Limprichtia revolvens*, *Pseudocalliergon trifarium*, *Scorpidium scorpioides*, the extremely rare small capsule dung moss *Splachnum ampullaceum*, *Straminergon stramineum*, *Tomentypnum nitens*, as well as peat mosses: *Sphagnum teres*, *Sph. fuscum*, *Sph. subsecundum*, and *Sph. warnstorfii*. The literature also lists other species of vascular plants and mosses, however their occurrence was not confirmed in the Zocie fen (Bloch-Orłowska, Pisarek 2005); these are: *Carex demissa, C. heleonastes, C. microglochin, Eriophorum gracile, Tofieldia calyculata, Pedicularis sceptrum-carolinum*

Fig. 112. Fragment of a historical topographic map of 1938.

and mosses: *Campyliadelphus elodes, Meesia triquetra*, *Paludella squarrosa*, and *Sphagnum balticum*.

The vegetation of the Zocie fen is formed by moss mire and moss patch communities. They are a system of intertwined plant communities with the physiognomy of a bog moss mire (diversified in terms of species), dominated by the *Sphagnum teres* and *Sph. angustifolium*, partially related to the *Menyantho-Sphagnetum teretis* association, moss patches with a high number of brown mosses (mainly *Campylium stellatum* and species of the *Limprichtia* genus) with *Carex lasiocarpa* and *C. limosa*, and in the patches with very high water content – transitional communities between moss patches and mossy forms of *Thelypteridi-Phragmitetum*. Alpine bulrush *Baeothryon alpinum* and other species typical for fens are also common in the plant communities. In heavily hydrated areas, the vegetation is typical for alkaline fens (patches with *Scorpidium sorpioides*, *Campylium stellatum*, *Chara* spp., and *Utricularia* spp.), often found in mosaics with small but numerous patches with the *Eleocharis quinqueflora*. The moss layer is well-developed and diversified in terms of species and space. It includes both mosses tolerant of water submersion (three-ranked spear-moss *Pseudocaliergon trifarium*, hooked scorpion moss *Scorpidium scorpioides*, giant spear-moss *Calliergon giganteum*), partially submerged, and mosses growing in areas above the water level. The group of mosses is dominated by *Campylium stellatum*, *Limprichtia cossonii, Sphagnum teres,* and locally – *Scorpidium scorpioides.* In addition to the species mentioned above, the moss layer includes *Aulacomnium palustre*, *Cinclidium stygium*, *Hamatocaulis vernicosus*, *Limprichtia revolvens*, *Splachnum ampullaceum* (an extremely rare species), *Straminergon stramineum*, *Tomentypnum nitens*, peat mosses: *Sph. fuscum*, *Sph. subsecundum, Sph. warnstorfii* and other, more common, species. The layout of the plant communities in the central part of the fen is stable; the changes taking place in this area concern the slow entry of peat moss tolerating the alkaline reaction. In the extreme parts of the fen, the development of vegetation settling on a slightly acidic and acidic soils is observed, using rainwater to a large extent. Most common are species of moss peats typical for transitional fens and bogs (e.g., S*phagnum angustifolium*, *Sph. capillifolium*, *Sph. contortum*, *Sph. cuspidatum*, *Sph. magellanicum*, *Sph. russowi*), in the herbaceous layer, there are numerous instances of *Oxycoccus palustris*, *Ledum palustre*, and locally *Empetrum nigrum*. Trees are also found (*Betula pubescens* and *Pinus sylvestris*), especially in the northwestern part where the fen is shallower and borders on forest communities. Farther away from the edge of the site, the vegetation system shows some stabilization. The transitional communities with higher water content with *Scheuchzeria palustris* and *Rhynchospora alba* smoothly transition into the communities typical for low fens and form a specific mosaic of habitats 7140 and 7230. Expansion of the common reed *Phragmites australis*, purple moor-grass *Molinia caerulea*, and broadleaf cattail *Typha latifolia* is locally observed.

Active protection tasks focused mainly on removing shrubs and mowing open parts of the moss patch (cf. chapter 1.5.1).

The natural values of the area were discussed, among others, in the studies by Abromeit et al. (1898 – 1940), Steffen (1913), Bloch-Orłowska & Pisarek (2005), Kruszelnicki (1999, 2001), Jarzombkowski & Pawlikowski (2012), and Wołejko et al. (2012).

The surface of Torfowisko Zocie remained stably hydrated throughout the year during the period of several years of observations. Water level fluctuated in the range of few cm which means that there are no hydrological disturbances in the fen. This was largely due to the activity of beavers that blocked the outflow from the drainage ditches surrounding the fen and maintained a stable and high groundwater level within the fen basin.

The stratigraphic studies confirmed the occurrence of well-preserved, although locally shallow, peat deposits composed of various types of moss and sedge-moss peats underlined with calcareous gyttja. The peat profile confirms the long-term development of the fen in the form of sedge-moss communities on the site of an overgrowing lake. For technical reasons, the drilling was made only to the depth of 2 m, however the deposit of organic sediments is much larger.

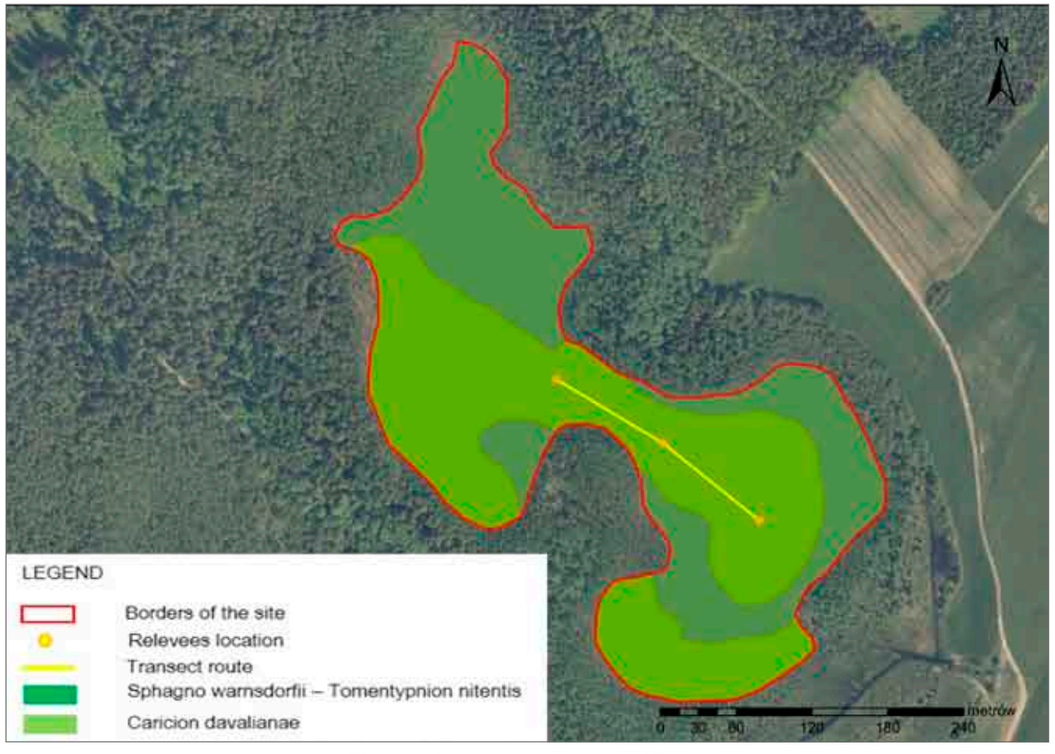


Fig. 113. Actual vegetation map of Zocie.

Photo 98. Zocie fen after conservation measures (photo K. Kotowska).

Trępel

Trępel is a fragment of a fen and lake complex stretching east of Olsztynek, between the lakes of Pluszne Wielkie and Maróz. It includes an ancient lake alkaline fen located in a depression between Lake Staw and Lake Niskie (cf. Fig. 114). Moss patches occur as a mosaic with well-preserved quagmires and represent the habitat subtype 7230-3.

Trępel lies in the extreme western part of a vast forest complex with a large number of lakes. It was formed in one of the legs of the post-glacial tunnel valley as a result of the shallowing and overgrowing of the water reservoir. In order to develop the lake and the fen for use, a drainage ditch was dug in the northern part of the depression, draining the water to Lake Staw, located towards the north-west. In the past, the fen was mown, but in the course of time this activity was gradually abandoned for economic reasons. Currently, the area of the open fen is being mown again in order to limit the overgrowth by shrubs, trees, and reeds. The drainage ditch was blocked and the central part of the fen was swamped again.

Within the boundaries of the Trępel fen, many rare and protected species were found during the studies conducted in the years 2009 – 2014. Special attention should be paid to the species listed in Annex II of the Habitats Directive: fleshy starwort *Stellaria crassifolia* and varnished hook-moss *Hamatocaulis vernicosus*. Torfowisko Trępel was formed in the leg of a post-glacial tunnel valley as a result of the succession of the lake accelerated by human activity. After the abandonment of mowing and partial shallowing of the ditch – as a result of overgrowing – changes in the structure of fen vegetation took place. Currently, the central part of the fen has been subject to secondary swamping, and the vegetation has locally acquired tall sedge characteristics with a well-developed moss layer. The vegetation includes *Scheuchzerio-Caricetea nigrae* class communities that are mossy sedge reeds and quagmires (*Caricetum diandrae*; ass. *Helodium blandowii-Carex acutiformis*), locally related to *Magnocaricion* (*Caricetum acutiformis*). The habitat in its northern and central part is well hydrated; the water is level with the ground or it forms small local pools. The southern part is slightly

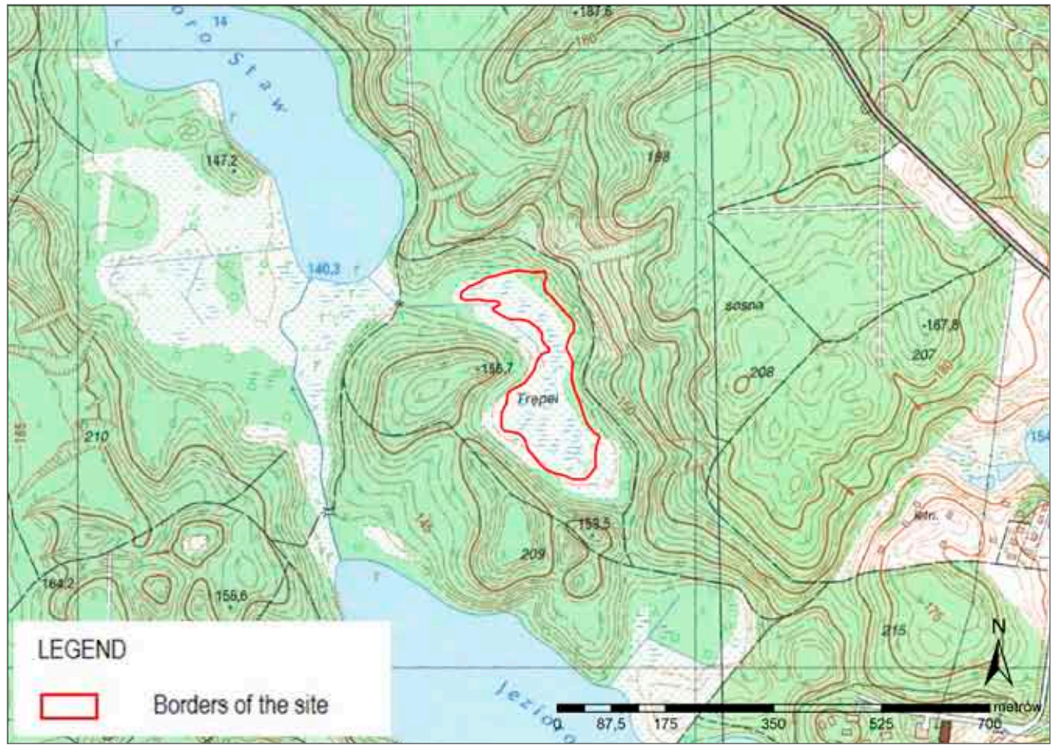


Fig. 114. Location of Torfowisko Trępel on the background of a topographic map.

Fig. 115. Fragment of a historical topographic map of 1929.

dry, with a visible expansion of trees and shrubs and *Phragmites australis* reeds. The northern part is dominated by moss communities with the predominance of *Carex rostrata*, *Festuca rubra,* and *Equisetum fluviatile,* and in the moss layer –*Calliergonella cuspidata*, *Marchantia polymorpha*, *Aulacomnium palustre*, and *Plagiomnium ellipticum,* less frequently with *Tomentypnum nitens* and *Hamatocaulis vernicosus.*

In the central part of the peatbog there are patches with the dominance of *Carex acutiformis* with *Galium uliginosum* and, locally, *Menyanthes trifoliata,* while the southern part is dominated by mossy reeds with *Carex rostrata*, *C. acutiformis*, *Eriophorum angustifolium*, and *Thelypteris palustris* – the moss layer including *Calliergon giganteum*, *Calliergonella cuspidata*, *Marchantia polymorpha*, *Plagiomnium ellipticum*, and *Helodium blandowii* as well as *Aulacomnium palustre.* At the edge of the fen, particularly in the southern part, there are group shrubs of *Salix cinerea* as well as loose wildings and undergrowth of *Alnus glutinosa*. In other parts of the fen, common alder *Alnus glutinosa*, grey willow *Salix cinerea* and seedlings of Scots pine *Pinus sylvestris* are found individually. Common reed *Phragmites australis* enters locally, reaching up to 40% density, and there are also small surface areas of borad-leved cattail *Typha latifolia*. Within the whole surface of the habitat, there are also single, rather high tufts of *Carex paniculata* and, less often, low tufts of *C. appropinquata* and *C. diandra*.

Active protection tasks focused mainly on removing shrubs and mowing open parts of the moss patch (cf. chapter 1.5.1).

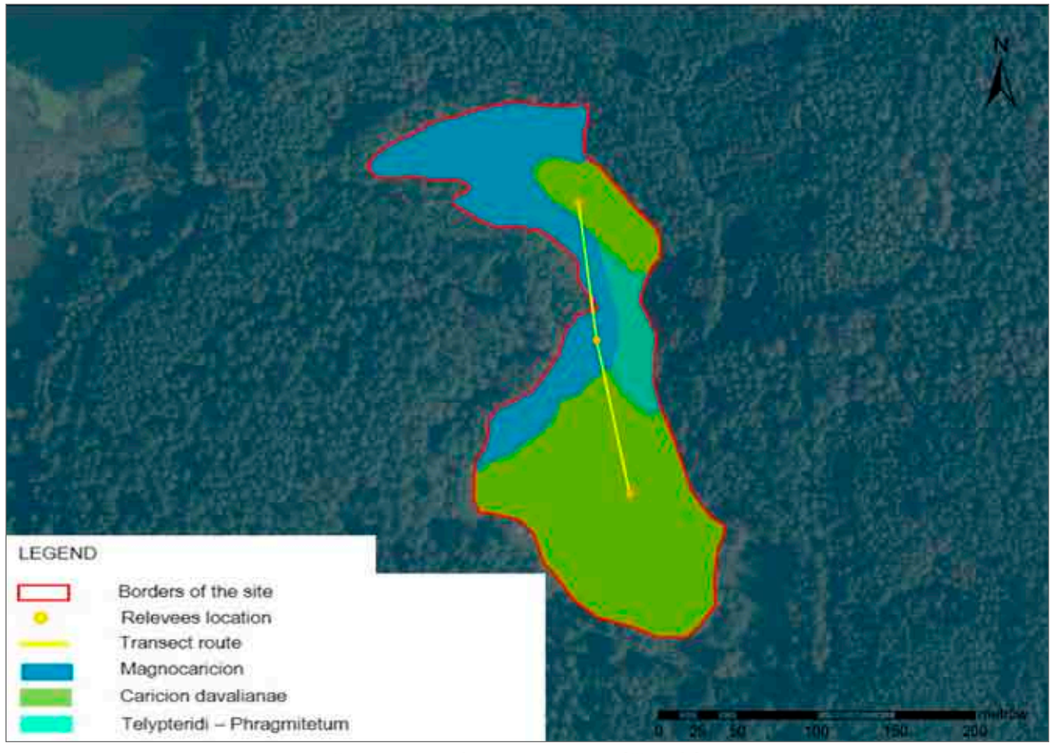


Fig. 116. Actual vegetation map of Trępel fen.

Photo 99. One of the gates in the system of dams built on this fen (photo W. Spychała).

The natural values of the area are discussed only in the studies by Jarzombkowski and Pawlikowski (2012) and Wołejko et al. (2012).

The surface of Torfowisko Trępel remained stable during the period of several years of observations in spring (cf. Fig. 117), with summer drops, which manifested themselves mainly in the southern part of the fen. Water level fluctuated in the range of 10 cm up to 50 cm below ground level which means though that there are no significant hydrological disturbances in the fen, but only at the measurement site which was located in the northern part of the patch of habitat 7230. Where there was a decrease in the level of groundwater, tree and shrubs vegetation entered the area – this was eliminated as part of the protection measures. A damming gate was built on the fen, as a result of which the groundwater level is also more even in the southern part of the mire.

Photo 100. Trępel fen (photo F. Jarzombkowski).

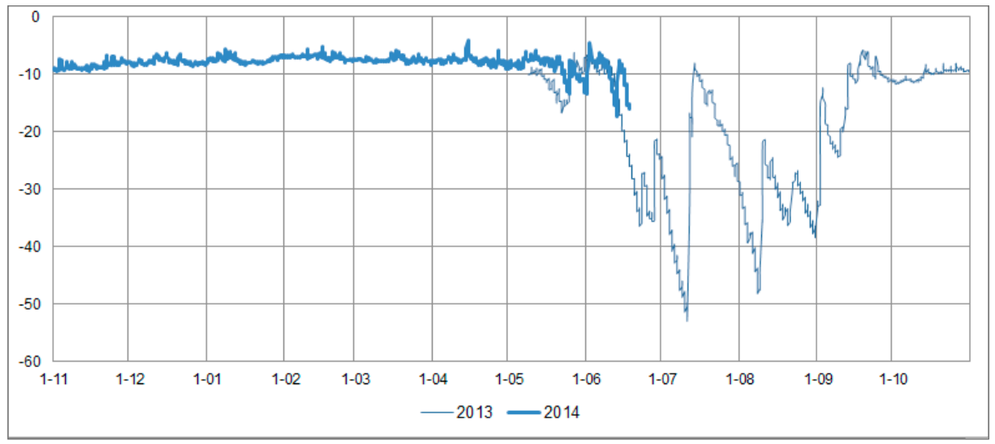


Fig. 117. Changes in groundwater level in Trępel fen in hydrological years 2013-2014.

The stratigraphic studies confirmed the existence of a well-preserved peat deposit built by various types of moss and sedge-moss peats underlined with calcareous gyttja. The peat profile confirms the long-term development of the fen in the form of sedge-moss reeds on the site of an overgrowing water reservoir. For technical reasons, the drilling was made only to the depth of 2 m, however the deposit of organic sediments is much larger.

The fens near Jeleniewo are lakeside low fens with moss-mire and moss vegetation (Dziabel, Sumówek) or typical moss patch vegetation (Lake Purwin). Habitat 7230 occurs in the form of moss-sedge communities overgrown with bushes and trees, representing the habitat subtype 7230-3 (flow-through and spring fens of northern Poland), and locally in the transitional form to habitat 7140 (transitional fens and quagmires).

The described fens are located north of Jeleniewo and are distributed within a radius of approximately 5 km. All of them lie on the shores of small lakes: Dziabel, Purwin, and Sumówek, in the strongly undulating post-glacial landscape of the Suwałki Lake District (cf. Fig. 118).

The fen of the Jeleniewo area lie within the midfield fen and lake enclaves, surrounded by higher-lying agricultural lands – meadows, pastures, and cultivated fields. Small forest (alder) and shrub complexes are present in land depressions, in the immediate vicinity of lakes and moss patches. In the past the described fens may have been used occasionally, but they are not used regularly at present.

During the studies conducted in 2010 – 2014, many rare and protected species of plants and mosses were found. Among the vascular plants, the following are of note: alpine bulrush *Baeothryon alpinum*, creeping sedge *Carex chordorrhiza*, dioecious sedge *C. dioica*, bog-sedge *C. limosa*, Baltic marsh-orchid *Dactylorhiza baltica*, early marsh-orchid *D. incarnata*, slender cottongrass *Eriophorum gracile*, fen orchid *Liparis loeselii*, flatleaf bladderwort *Utricularia intermedia*, and lesser bladderwort *U. minor*. Present are also several protected species of bryophytes: *Cinclidium stygium*, varnished hook-moss *Hamatocaulis vernicosus*, Blandow's helodium moss *Helodium blandowii*, tufted fen-moss *Paludella squarrosa*, twisted bog-moss *Sphagnum contortum*, *S. teres*, Cosson's limprichtia moss *Limprichtia cossonii*, and woolly feather-moss *Tomentypnum nitens*.

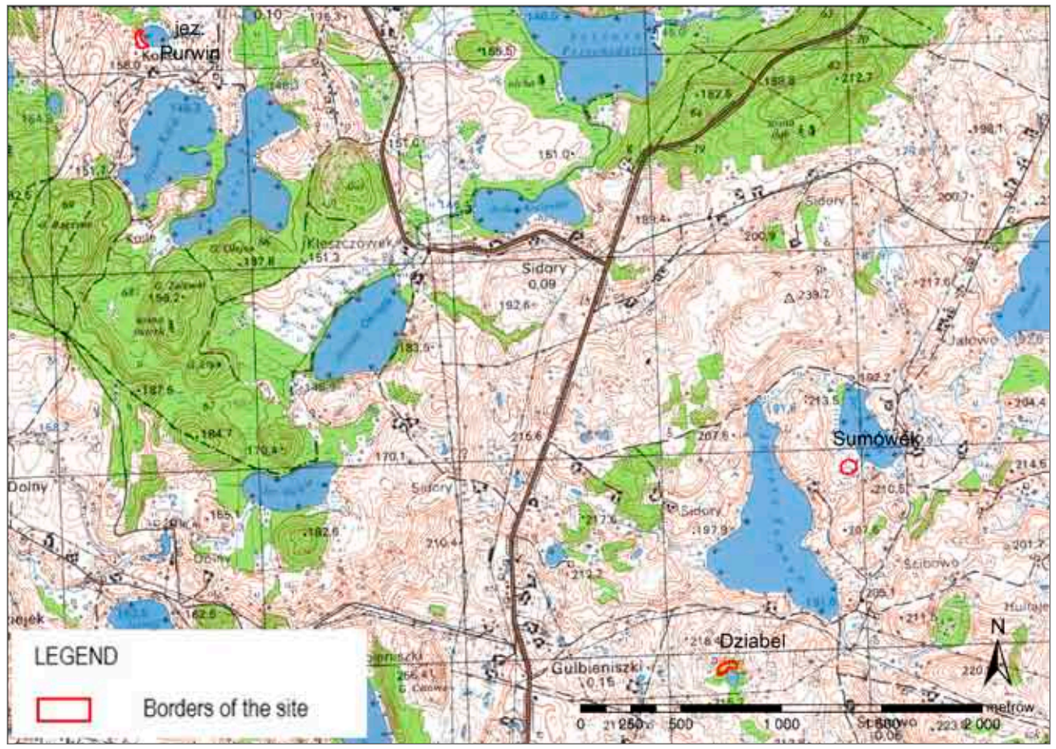


Fig. 118. Location of the fens around Jeleniewo on the background of a topographic map.

The vegetation of these sites is mainly formed by subneutral moss-mires with peat mosses from the *subsecunda* section and with the *Sphagnum teres* (*Menyantho-Sphagnetum teretis* association), and less frequently with other peat mosses as well as moss-sedge communities with *Carex lasiocarpa*, *Campylium stellatum*, *Limprichtia cossonii*, and *Calliergonella cuspidata*. *Caricetum paniceo-lepidocarpae* plant communities with numerous species of the order *Caricetalia davallianae* are also present here. In almost all sites, the moss -sedge vegetation decreases as a result of the expansion of the peat mosses.

Active protection tasks focused mainly on removing the shrubs and mowing open parts of the moss -sedge communities (cf. chapter 1.5.1).

The natural values of the area were discussed, among others, in the studies by Gałka & Apolinarska (2014), Kawecka & Karczmarz (1993), Pawlikowski (2008), Sokołowski (1973), and Wołejko et al. (2012).

The fens around Jeleniewo formed around the lakes and are primarily dependent on their water levels. In the second half of the 20th century and at the beginning of the 21st century, due to the decrease in the water table in lakes in the entire region, the water table also decreased in the fens. Unfortunately, there are currently no effective tools to counteract this process as it would require effective water management at the level of the entire catchment that takes into account the needs of all the stakeholders, but the current policy is geared towards the drainage of habitats. During the course of the project, the water level in the alkaline fens near Jeleniewo remained stable, although it should be slightly higher.

The stratigraphic studies confirmed the occurrence of well-preserved peat deposits composed of various types of moss and sedge-moss peats underlined with reed and shrub elements. The peats were often underlined with thick layers of calcareous gyttja, and their profile confirms the long-term development of the fen in the form of sedge-moss reeds on the sites of overgrowing lakes.

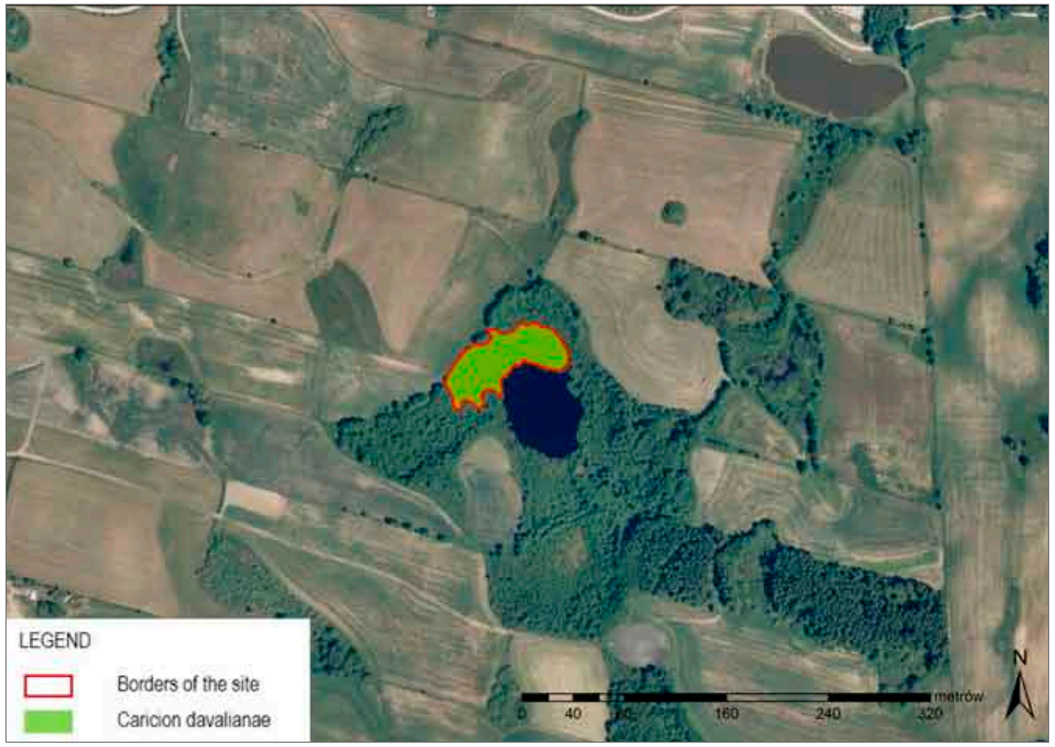


Fig. 119. Actual vegetation of the Dziabel fen.

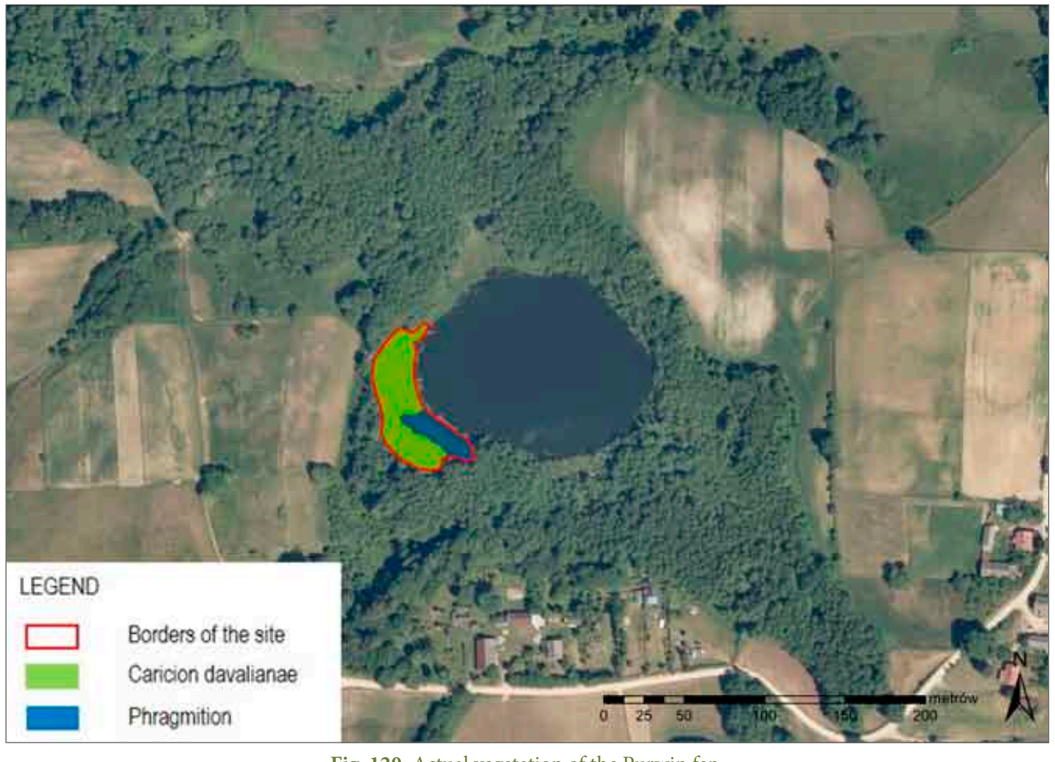


Fig. 120. Actual vegetation of the Purwin fen.

Fig. 121. Actual vegetation of the Sumówek fen.

Photo 101. Torfowisko Dziabel fen (photo F. Jarzombkowski).

Kopaniarze

Torfowisko Kopaniarze (Kopaniarze fen) is a soligenous fen formed on the edge of the Wel River valley. The fen is located on the left bank of the Wel River, in a forest complex stretching along its banks in the section between Lake Tarczyńskie and the fish pond complex near Malinów (cf. Fig. 122).

The Torfowisko Kopaniarze fen is located in a forest complex, in the immediate vicinity of wet forests (mainly *Circaeo-Alnetum* ash-alder riparian forests, willow thickets, and alder forests of the *Alnetea glutinosae* cl., locally birch bog forest *Betuletum pubescentis*) occurring in the vicinity of the Wel River. The water relations of the valley have been significantly transformed. The river was partially regulated, and the lower areas were drained to create grasslands or to extract peat that was used as heating fuel.

Torfowisko Kopaniarze is a part of a once much larger alkaline fen. As a result of the abandonment of grassland use, combined with changes in water conditions in the region (drainage of wetlands and river regulation, mainly in the 19th and 20th centuries), treeless wetlands started to overgrow with trees and shrubs. Over the last century, the habitat has disappeared on ca. 80% of the former open area of the fen.

Torfowisko Kopanierze is characterized by its unique floristic values. Many rare and endangered species of vascular plants and mosses, including a range of glacial relics, can be found there. The rare orchid species deserve special attention: *Liparis loeselii*, *Gymnadenia conopsea*, *Malaxis monophyllos*, and *Dactylorhiza baltica*. Other species protected under EU law include *Saxifraga hirculus* and *Hamatocaulis vernicosus*. Among the relics, there are also rare in the country: *Paludella squarrosa*, *Tomentypnum nitens* and *Helodium blandowii*.

Vegetation of the best-formed patches of the Kopaniarze fen is mainly composed of moss-sedge plant communities of the *Scheuchzerio-Caricetea nigrae* (*Festuco rubrae-Caricetum rostratae*) class, with the dominance of *Carex rostrata*, *Menyanthes trifoliata*, *Festuca rubra*, *Calliergonella cuspidata*, and *Plagiomnium ellipticum*, with relation to the reeds of the *Magnocaricion* alliance. There are also patches of vegetation related to the *Menyantho-Sphagnetum*

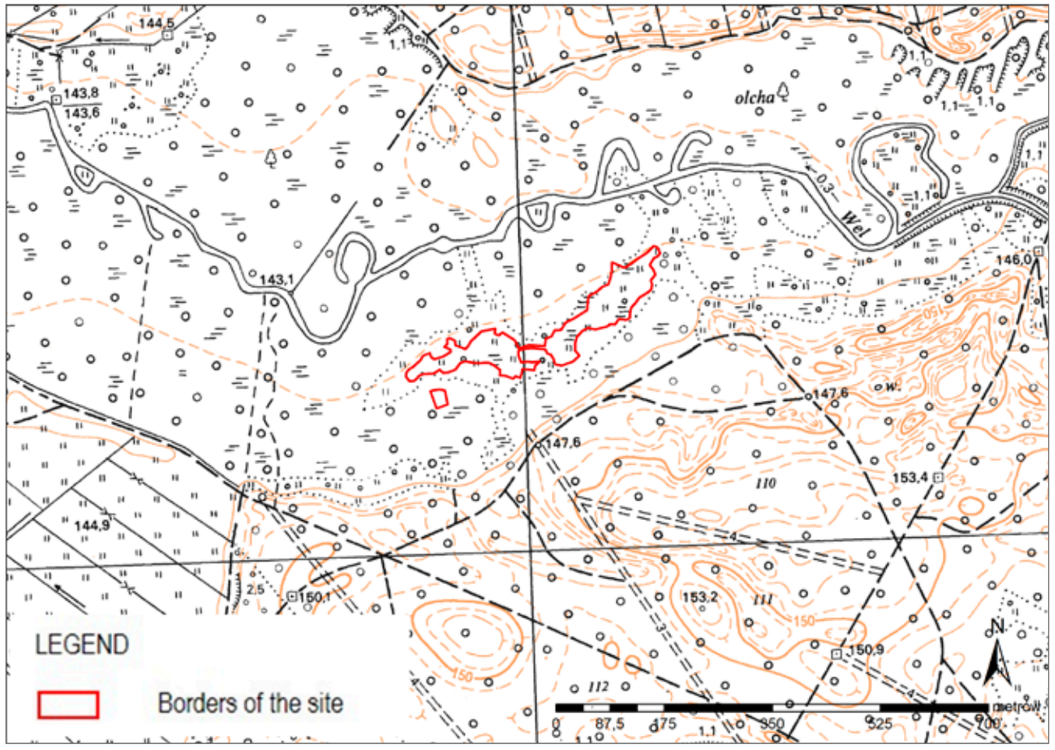


Fig. 122. Location of Torfowisko Kopaniarze on the background of a topographic map.

Fig. 123. Historical topographic map from 1911.

teretis association and sometimes to *Thelypteridi-Phragmitetum*, as well as dried forms with *Molinio-Arrhenatheretea* meadow vegetation.

Active protection tasks focused mainly on removing the shrubs and mowing open parts of the moss patch, as well as improvement of water conditions by the construction of gates (cf. chapter 1.5.1).

The natural values of the area were discussed, among others, in the studies by Cyzman & Kosowicz (1993), Szczepański (1998, 1999), and Wołejko et al. (2012).

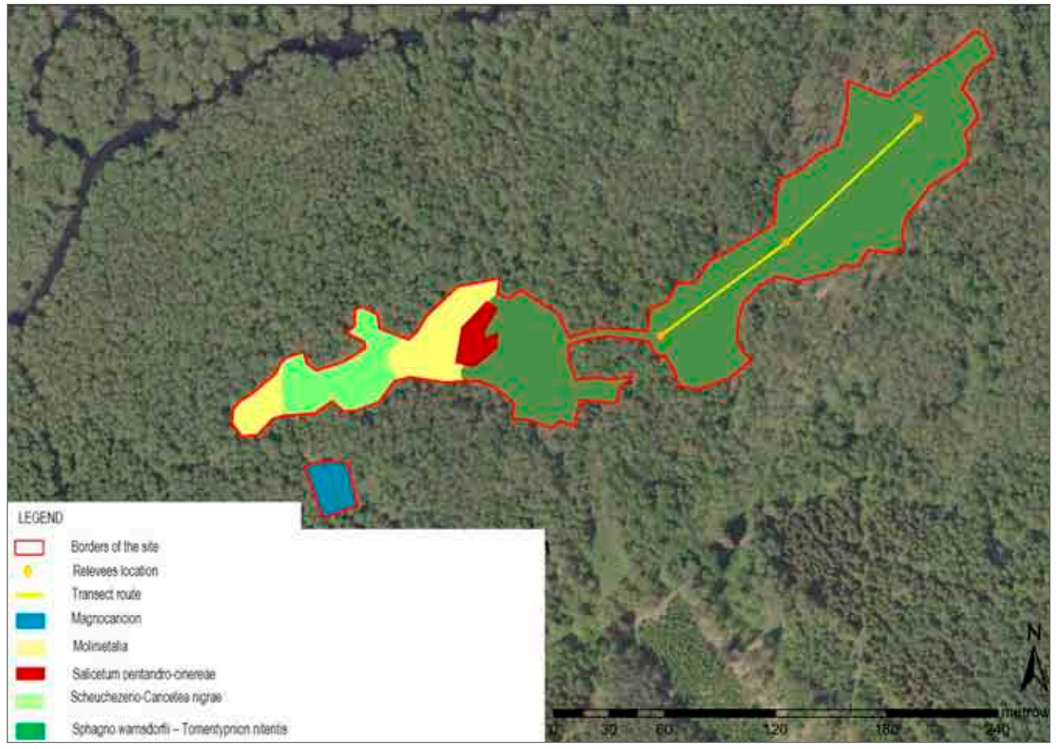


Fig. 124. Actual vegetation of the Kopaniarze fen.

The eastern part of Torfowisko Kopaniarze in the period of several years of observation remained stably hydrated in the spring (Fig. 125), with summer drops. The western part of the fen, in turn, was poorly hydrated for most of the year, and the water level fell below 50 cm already in late spring. The water level at the measurement site ranged from 20 cm below the ground surface in early summer to 10 cm in the autumn, indicating minor hydrological disturbances of the fen. After the construction of the gates, the water level of the fen was evened out during the summer season, resulting in greater water availability for the vegetation on the fen. In dried spots where there is no direct impact of the drainage ditches, the development of meadow and tall forb vegetation related to fen vegetation was observed.

The stratigraphic studies confirmed the existence of a well-preserved peat deposit built by various types of moss and sedge-moss peats underlined with calcareous gyttja. The peat profile confirms the long-term development of the fen in the form of sedge-moss vegetation. Due to the drying, in some spots the top layers of the peat have become degraded in recent years (western part of the fen).

Photo 102. Gate on a ditch – Kopaniarze fen (photo: W. Spychała).

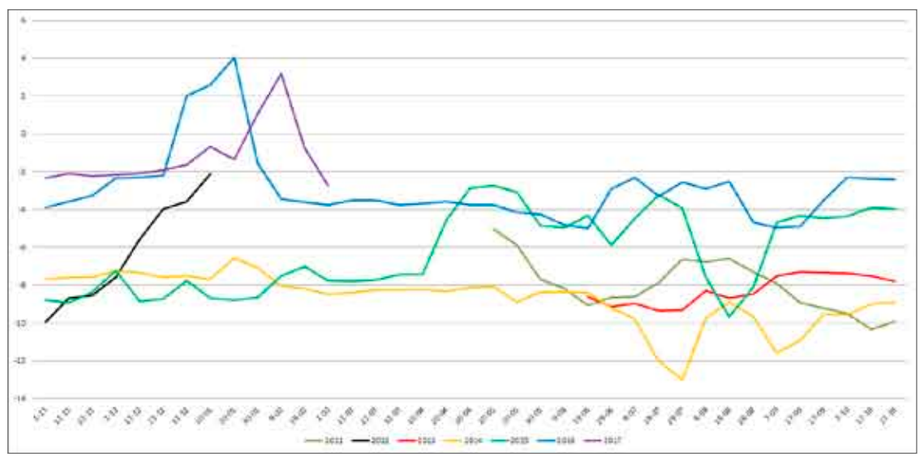


Fig. 125. Changes in the groundwater table on the Kopaniarze fen in 2011 - 2017.

Photo 103. Torfowisko Kopaniarze fen (photo F. Jarzombkowski).

Łosiniany, reserve „Stare Biele"

In the site there are patches of 7230 habitat that was covered by conservation measures within the project. Torfowisko Łosiniany is a fen complex located on a gentle slope of the Świsłocza Valley (tributary of the Neman). Groundwater seepage occurs on the slope, which enabled the development of alkaline fen – represented by 7230-3 subtype. The fen is located on the edge of the Świsłocza Valley, which is wide in this section, and its leftbank tributary (Dopływ spod Łosinian). The spring character of the area is emphasized by groundwater seepage on the slope of the valley. Fen is located north of the village of Łosiniany, at the eastern end of the Knyszyn Primeval Forest (cf. Fig. 126).

The second fen – Stare Biele – is located in local depression of melting glacier-origin basin in seepage area of Derazina – small stream, Słoja tributary. The surrounding of the fen is bog forrest complex located south-west of Trzcianno Nowe village, in eastern part of Knyszyn Primaveral Forest. Fen together with surrounding forrest communities since 1987 is a nature reserve.

The Torfowisko Łosiniany fen is surrounded by spring alder forests, found in a mosaic with wet meadows, fresh and moor-grass meadows, and small patches of mat-grass swards. A larger part of the fen in the northern section of the site (with a large population of *Swertia perennis*) was ploughed at the beginning of the 20th century and an alder culture was established there. The area is characterized by numerous springs, drained spots, and small watercourses flowing into Świsłocza river. By the western border of the site, at the edge of the valley, there is a beaver reservoir, formed as a result of their activities at the top of the previously existing spring cupola. In the past, the patches of open fens and meadows within the boundaries of the fen were used for hay mowing and grazing, but they were gradually abandoned for economic reasons. Currently, these areas are overgrown with shrubs and trees. In addition, a significant part of the fen, which is managed by the State Forests, has been afforested. At present, it is a place of development of stands dominated by black alder, which are over a dozen years old.

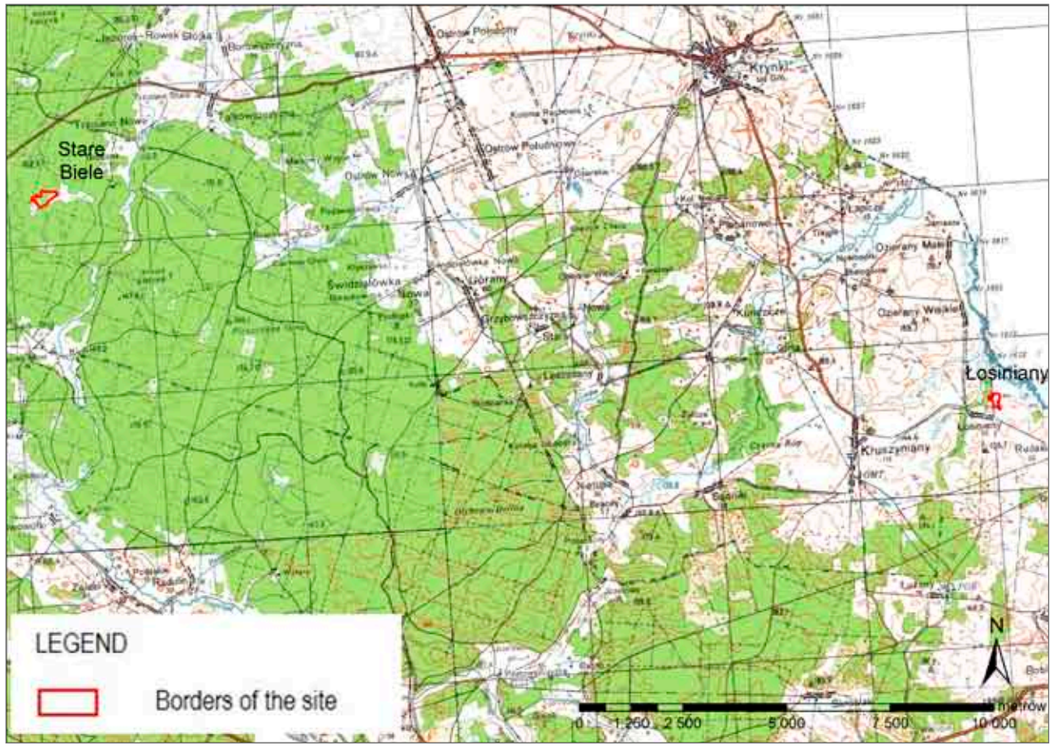
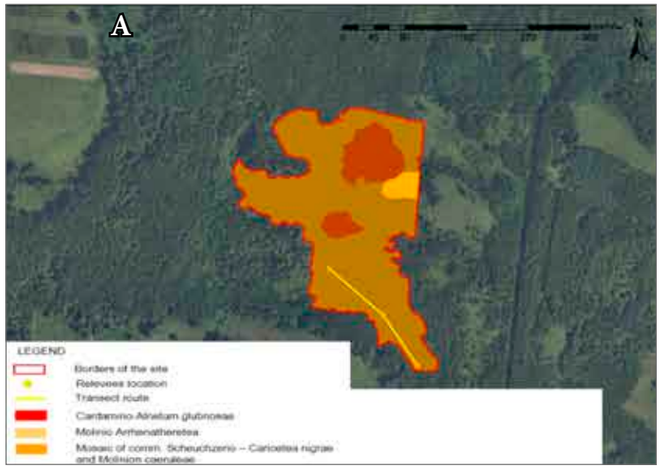


Fig. 126. Location of Torfowisko Łosiniany on the background of a topographic map.

Stare Biele fen is surrounded by pine-beech bog forest, which in its north part has an alder characteristic. Open patches of the mire after abandoning of agricultural use (mowing) are overgrown by trees and shrubs becoming an initial stage of forest communities. Now the habitat is fragmented. Within the boundaries of the fen, many rare and protected species were found during the studies conducted in the years 2009 – 2014. Among the vascular plants, the significant population of felwort *Swertia perennis* deserves special attention. It is probably the largest population of this species in Poland (in 2010, over 5000 individuals were recorded here), currently threatened due to the transformation of the habitat into an alder culture. The fen is also home to several species of orchids: *Dactylorhiza incarnata, Epipactis palustris*, and *Liparis loeselli.* One of the most valuable components of the site's bryflora is a glacial relic – *Tomentypnum nitens*. Among vascular plants of Stare Biele *Salix lapponum* and *Dactylorhiza incarnata, Epipactis palustris, Drosera rotundifolia, Pedicularis palustris.*

The vegetation of the Torfowisko Łosiniany fen is composed of both typical fen as well as meadow and forest communities. Due to the high level of terrain complexity, they are found in a complicated mosaic. The best hydrated patches (especially in the southern and central part of the fen) are dominated by sedge-moss plant communities of the *Scheuchzerio-Caricetea nigrae* class, with the predominance of *Carex lepidocarpa*, *Carex panicea*, *Carex rostrata*, *Festuca rubra*, *Tomentypnum nitens*, *Limprichtia revolvens* s.l., *Fissidens adianthoides*, and *Plagiomnium ellipticum*, representing mostly the *Caricetum paniceo-lepidocarpae* association. In some places they are transformed into patches of reeds of the *Magnocaricion* alliance. In their vicinity, on a decay substrate, there are communities of wet meadows from the *Calthion* and of the *Molinion* association with variable moisture content. Due to the abandonment of use, the patches of wet meadows have largely acquired a herbal physiognomy, now strongly overgrown by shrubs. On small mineral hills, there are fresh meadows of the *Arrhenatheretalia* order. Matgrass swards



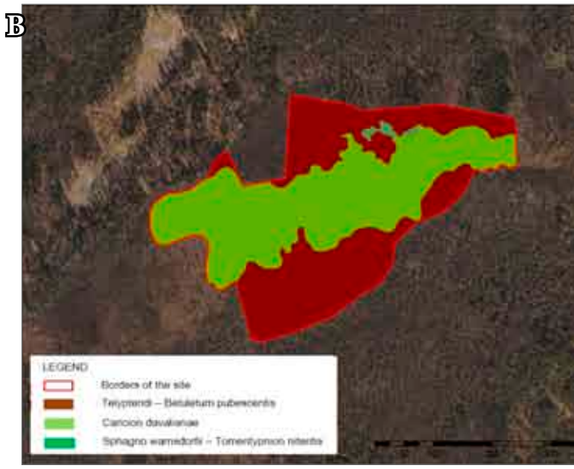


Fig. 127. Actual vegetation of the Łosiniany (A) and Stare Biele (B) fen.

– which represent the *Nardetalia* order – also occupy small areas. Surrounded by open fen and meadow patches, there are spring alder forests with numerous seepages. The vegetation of Stare Biele consists of poor fen communities in some areas becoming an initial stage of the dynamic form of alder forest. The majority of the area of the fen is occupied by sedge-moss communities of *Scheuzerio-Caricetea nigrae* class with *Carex elata* and *C. appropinquata* domination with some fragments with tight *Betula pubescens* thickets and some fragments occupied by willow (*Salix* spp.) thickets. Within whole 7230 patch, *Phragmites australis* appear with evident expansion in a north-east part of the fen. In the north part of the mire, a small patch of *Caricion davallianae* order is present that is now subject of fragmentation and dominated with *Carex rostrata, C. nigra, Menyanthes trifoliata* and *Epipactis palustris* as well as *Salix rosmarinifolia* and meadow species.

This patch is characterised by well developed, rich in species moss layer built by brown mosses such as *Tomentypnum nitens, Paludella squarrosa, Calliergonella cuspidata* and sphagnum species tolerating alkaline conditions such as *Sphagnum teres* and more rarely *S. warnsdorfii*.

Stare Biele mire is a subject to negative vegetation changes due to unstable water conditions and advanced succession and eutrophication. Lack of consent to conducting conservation measures such as trees and shrubs removal, mowing of expansive reed and tall sedges and halting the water outflow by building gates on a ditch – is leading to further habitat fragmentation, a decrease of its area and losing of rare species (including critically endangered *Salix lapponum*). Active protection measures focused mainly on removing the shrubs and mowing open parts of the moss patch (cf. chapter 1.5.1). The natural values of the area were discussed only in the studies by Pawlikowski and Wołkowski (2010) and Wołejko et al. (2012).

The surface of the Łosiniany fen remained stably hydrated during the observation period (cf. Fig. 128), and only during the summer a slight decrease in the groundwater level was observed. The water level ranged from +10 cm up to even 40 cm below the ground surface. The fact that the greatest fluctuations in the water table and its deficiency for plants occur during the growing season indicate some disturbances, however, taking into account the nature of the vegetation, which is a mosaic of fen species in the lowlands and wet meadows in the area located above, it can be concluded that the level of hydration is appropriate for a given combination of habitats and ensures their proper functioning. It seems that such conditions – resulting from many years of changes in the hydrological relations of the region (drainage of the area, drainage of water courses, groundwater, and underground water drawing) – are now sufficient to maintain the biodiversity-related to alkaline fens in this area.

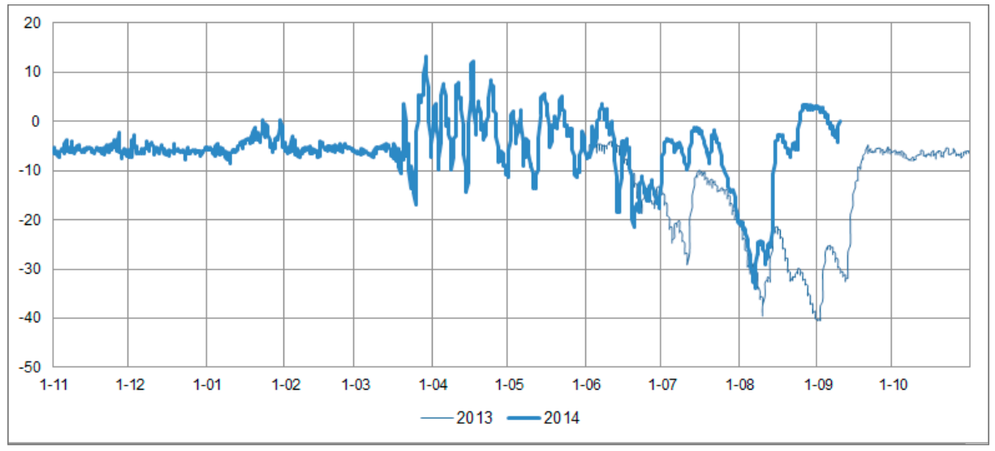


Fig. 128. Changes of the groundwater table on the Łosiniany fen in the hydrological years 2013 – 2014.

The stratigraphic studies confirmed the existence of a well-preserved peat deposit built by various types of moss and sedge-moss peats. For years the fen has been developing in the form of mossy sedge patches supplied by water seepages rich in calcium carbonate flowing from the slope of the Świsłocza Valley.

No wood was found in the peat, indicating the fact that the trees on the fen appeared over the last several decades.

Photo 104. Torfowisko Łosiniany fen (photo F. Jarzombkowski).

Natura 2000 site „Ostoja Augustowska" PLH200005

Augustów - Ogródki, Boruski, Żyliny, Płaska, Kobyla Biel, Przewięź, Kalejty, Rospuda, Sarnetki, Sawonia Mostek

Natura 2000 site „Ostoja Wigierska" PLH200004

Lake Kruszyn

Torfowiska Puszczy Augustowskiej are soligenous low fens with moss-sedge or moss mire vegetation. Some of them are of ancient lake origin (sites: Augustów - Ogródki, Borsuki, Żyliny, Płaska), others have developed on the banks of existing lakes (Kobyla Biel, Przewięź, Kalejty, Jazy, Lake Kruszyn), and others in the valleys of rivers and watercourses (Rospuda, Sarnetki, Sawonia-Mostek).

The fens lie to the north and north-east of Augustów, between the Rospuda Valley, the Augustów Canal, along which a large part of the sites is located, and the Czarna Hańcza Valley and Lake Wigry, in the Augustów Primeval Forest. They are scattered over a fairly large area. The distances between the closest sites range from 1 to 15 km (cf. Fig. 129).

The described area lies on the border of the Neman and Vistula River basin, where the Czarna Hańcza River and the Augustów Canal, which are hydrological axes of the Polish part of the Augustów Primeval Forest, are considered the Neman's tributaries, and the Rospuda River is located in the Vistula catchment. The moss patches of the Augustów Primeval Forest are a part of mid-forest fens or fen and lake complexes that occupy land depressions surrounded by higher-lying forest lands. All the sites are under significant influence of groundwater flowing from the mineral edge of the area. These fens were used for hay mowing in the past, but are now not used regularly.

The natural values of the Rospuda Valley have been discussed in many publications (e.g., Sokołowski 1988, 1996, Pawlikowski et al. 2010, Karczmarz and Sokołowski 1988, Jabłońska et al. 2011), and for this reason this study takes into account only the remaining alkaline fen patches of the Augustów Primeval Forest. Within the boundaries of these fens, during the studies carried out in the years 2006 – 2014, many rare and protected species were found. Among the vascular plants, the following are worth mentioning: *Aldrovanda vesiculosa*, *Baeothryon alpinum*, *Betula humilis*, *Carex chordorrhiza*, *C. dioica*, *C. limosa*, *Cladium mariscus*, *Dactylorhiza baltica*, *D. fuchsii*, *D.*

Fig. 129. Location of the fens of the Augustów Primeval Forest on the background of a topographic map.

incarnata ssp. ochroleuca, *D. ruthei*, *D. anglica*, *Empetrum nigrum*, *Eriophorum gracile*, *Malaxis monophyllos*, *Pedicularis palustris*, *Salix lapponum*, *Utricularia intermedia*, and *U. minor*. In addition, the species protected under the Habitats Directive are of particular importance in the area: the fen orchid *Liparis loeselii*, yellow marsh saxifrage *Saxifraga hirculus*, and fleshy starwort *Stellaria crassifolia*. Protected moss species are also present, e.g., *Bryum neodamense*, *Campylium stellatum*, *Cinclidium stygium*, *Hamatocaulis vernicosus*, *Helodium blandowii*, *Meesia triquetra*, *Paludella squarrosa*, *Pseudocalliergon trifarium*, *Scorpidium scorpioides*, *Sphagnum contortum*, *S. fuscum*, *S. teres*, *S. warnstorfii*, *Limprichtia cossonii*, and *Tomentypnum nitens*.

The vegetation of the described fens is quite varied. It is made up mainly of moss patches belonging to the following associations: *Caricetum paniceo-lepidocarpae, Caricetum diandrae,* and *Caricetum lasiocarpae*, as well as moss patch plant communities with *Limprichtia cossonii*, *Campylium stellatum*, *Carex lasiocarpa*, *C. panicea*, *C. limosa*, and *Baeothryon alpinum*. Within them the patches of subneutral moss mires of the *Menyantho-Sphagnetum teretis* association develop, as do groups with *Eleocharis quinqueflora*. In some sites plant communities with *Carex elata* are more commonly found. Locally found are also *Cladietum marisci* and various transitional forms to large sedge reeds (mostly with the lesser pond sedge *Carex acutiformis*), or reed communities (e.g., with shrubby birch *Betula humilis* and willows). Some of the sites are also dominated by plant communities with the dominance of *Carex rostrata*, *Festuca rubra*, *Aulacomnium palustre*, *Tomentypnum nitens*, and numerous meadow species. The communities of *Caricetum appropinquatae*, and *Caricetum paniculatae* occupy smaller areas.

Active protection tasks focused mainly on removing the shrubs and mowing open parts of the moss -sedge vegetation (cf. chapter 1.5.1).

The natural values of the area were discussed, among others, in the studies by Bogdanowicz (1977), Ludera (1932), Pawlikowski (2010), Tyszkowski (1991, 1992), and Wołejko et al. (2012).

The surface of most patches of fens remained perfectly hydrated during several years of observations (cf. Fig. 140).

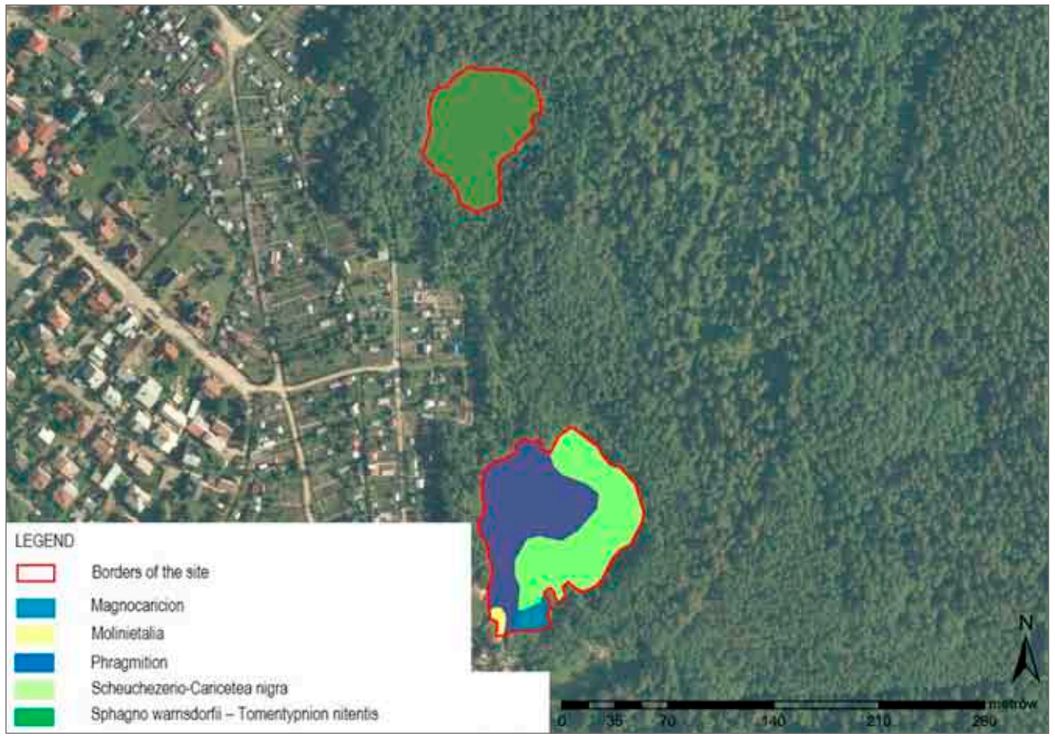


Fig. 130. Actual vegetation of the Augustów - Ogródki fen.

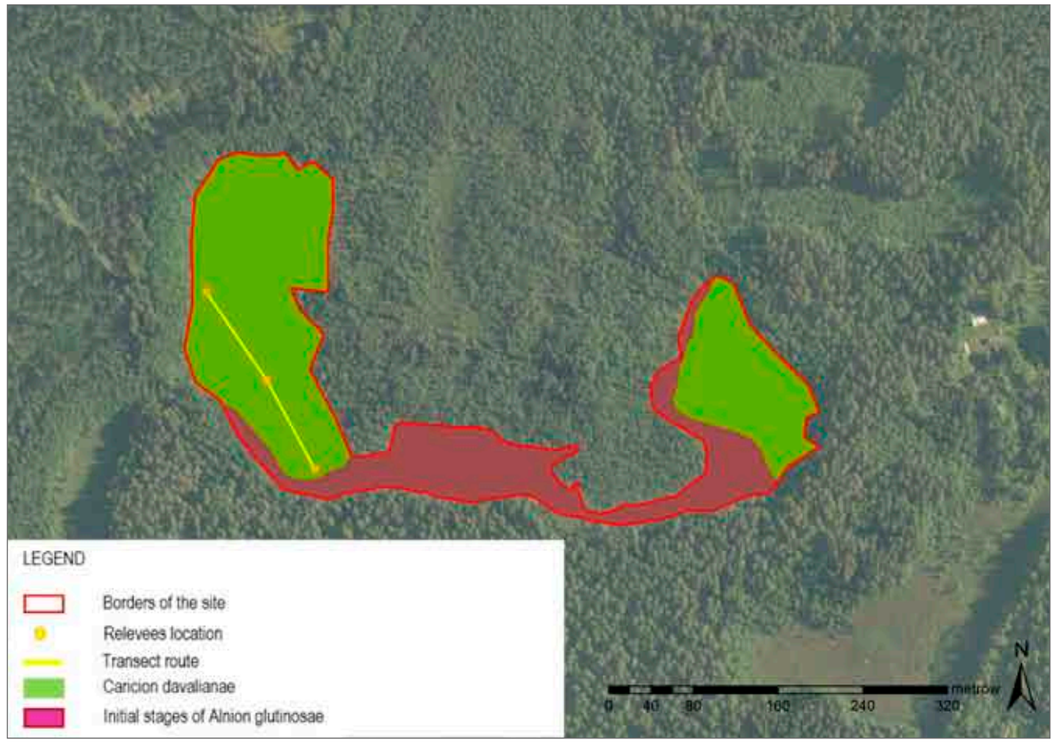


Fig. 131. Actual vegetation of the Borsuki fen.

Fig. 132. Actual vegetation of the Jazy fen.

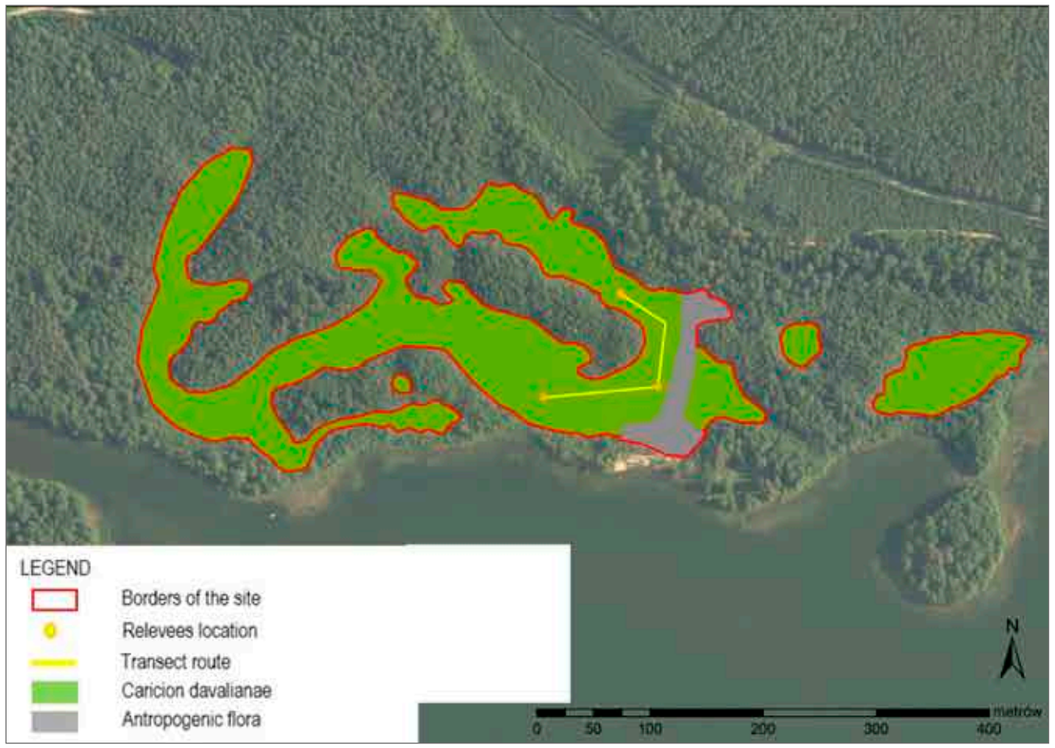


Fig. 133. Actual vegetation of the Kobyla Biel fen.

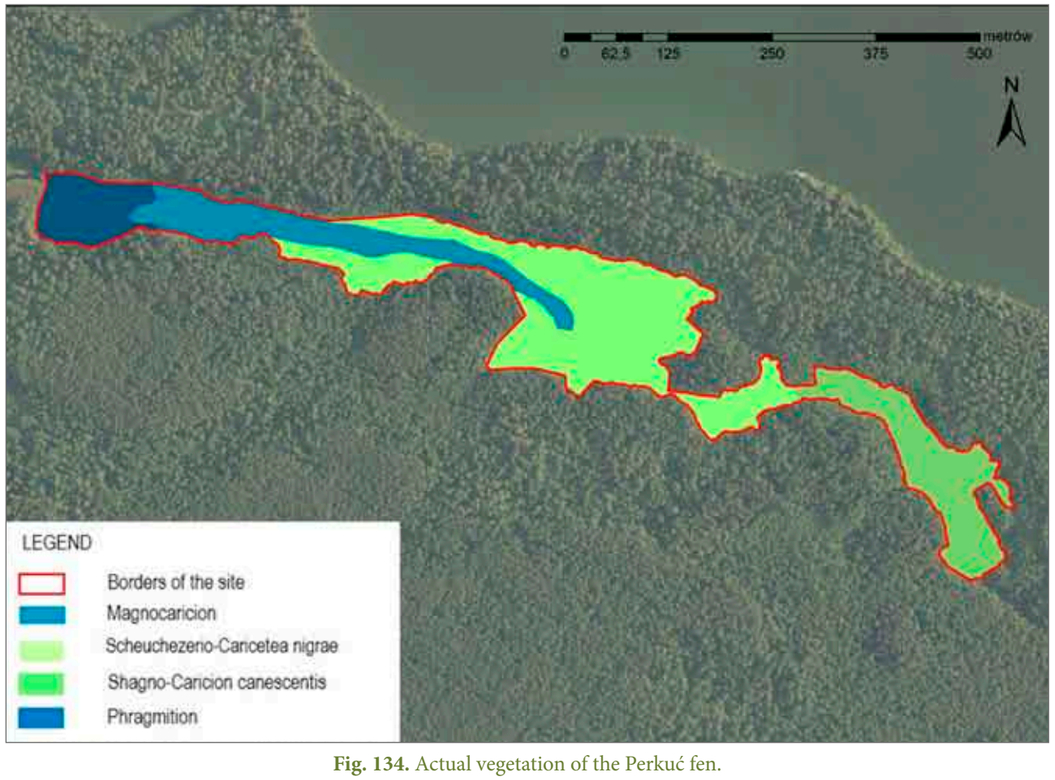


Fig. 134. Actual vegetation of the Perkuć fen.

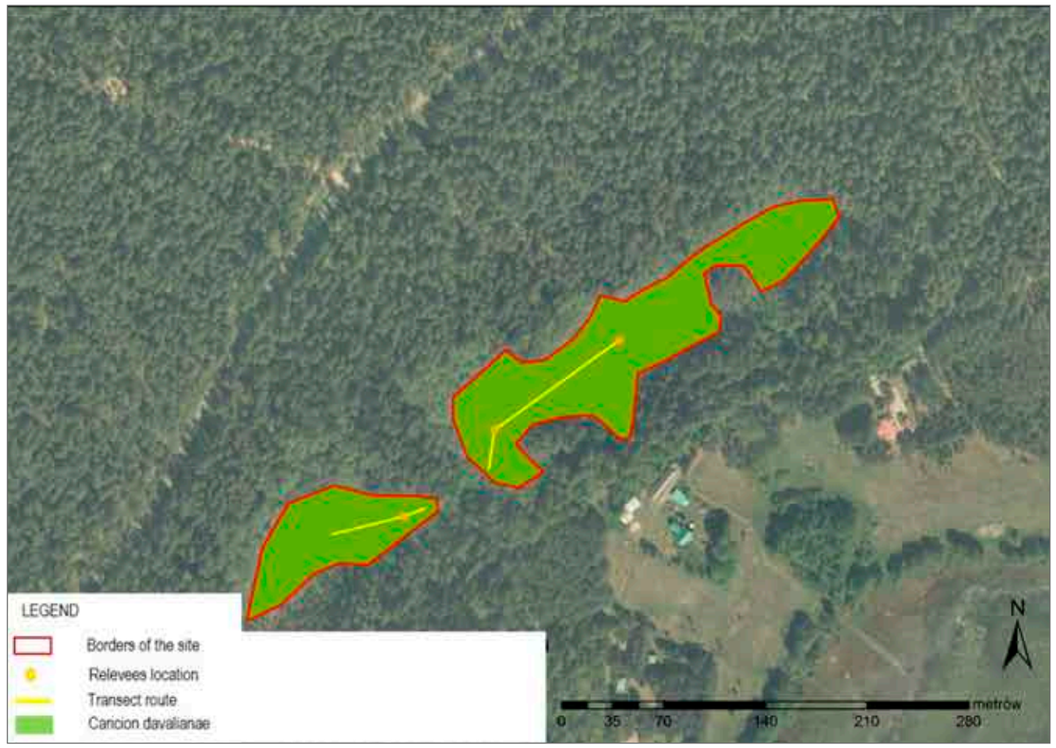


Fig. 135. Actual vegetation of the Płaska fen.

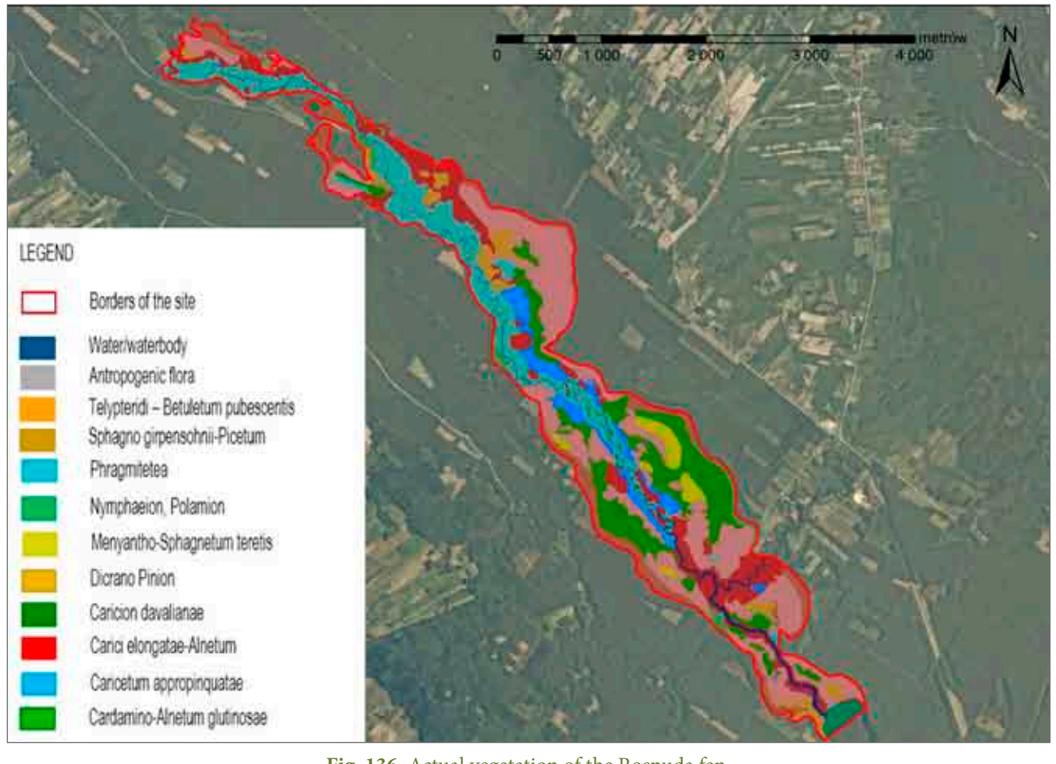


Fig. 136. Actual vegetation of the Rospuda fen.

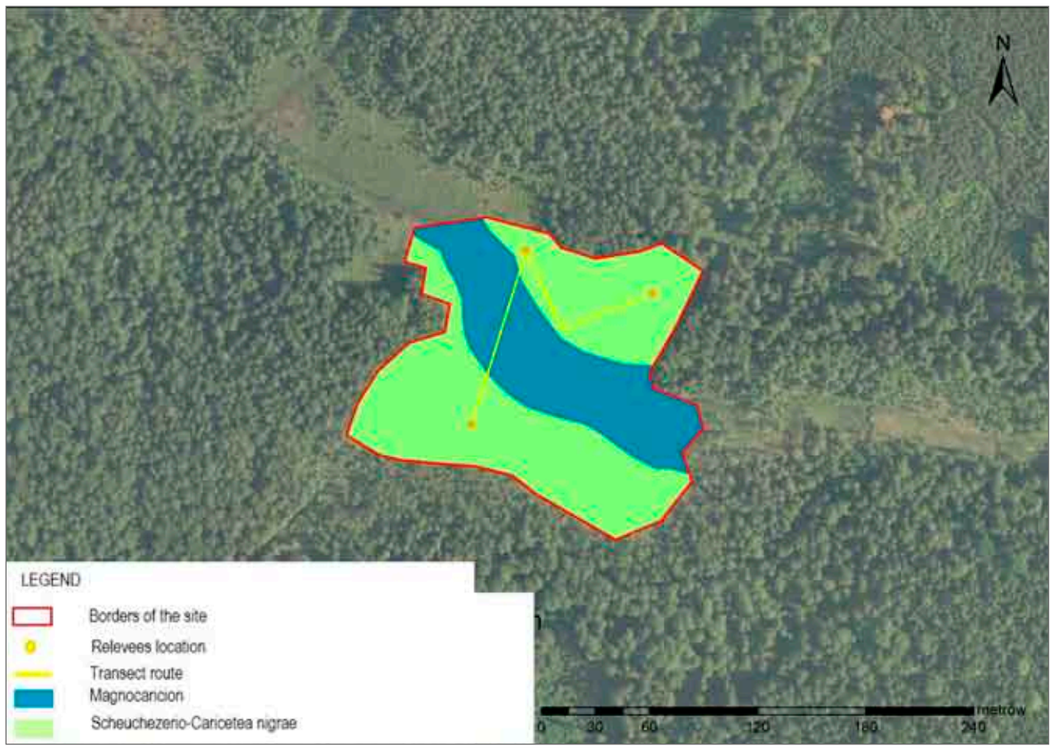


Fig. 137. Actual vegetation of the Sawonia-Mostek fen.

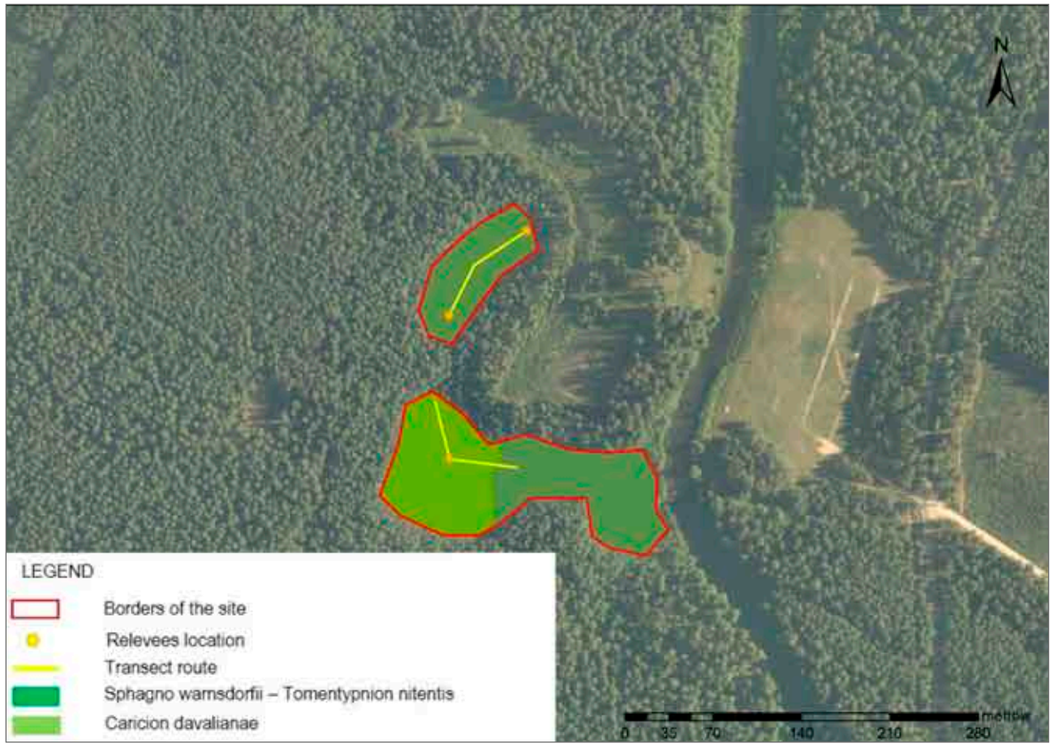


Fig. 138. Actual vegetation of the Żyliny fen.

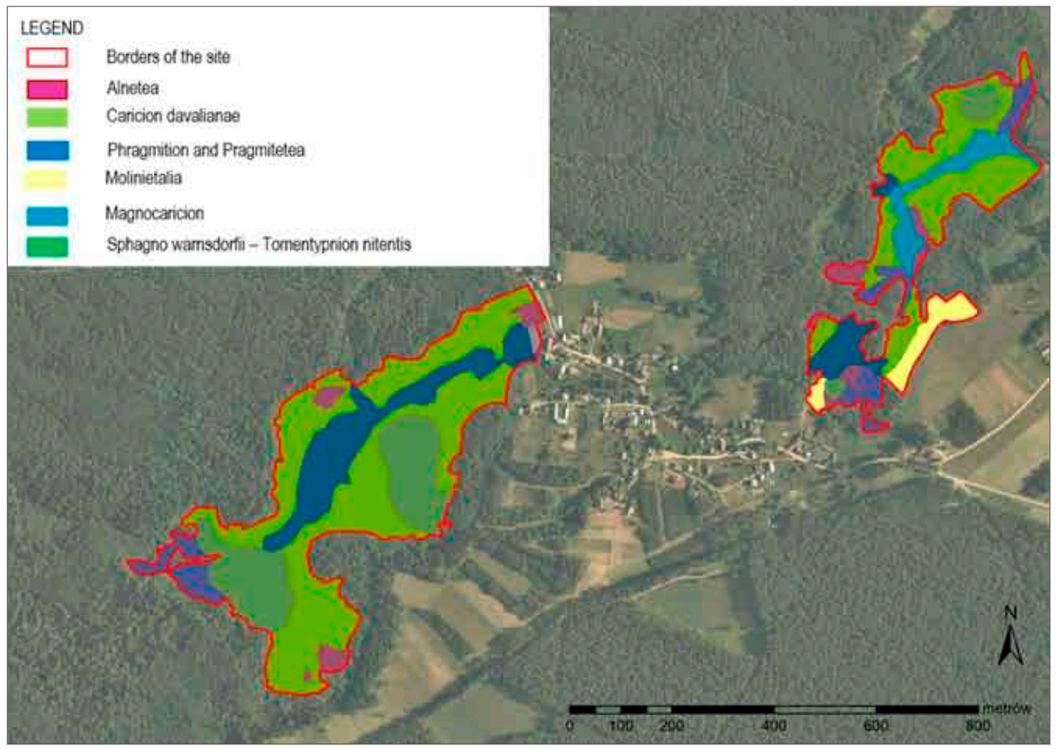


Fig. 139. Actual vegetation of the Sarnetki fen.

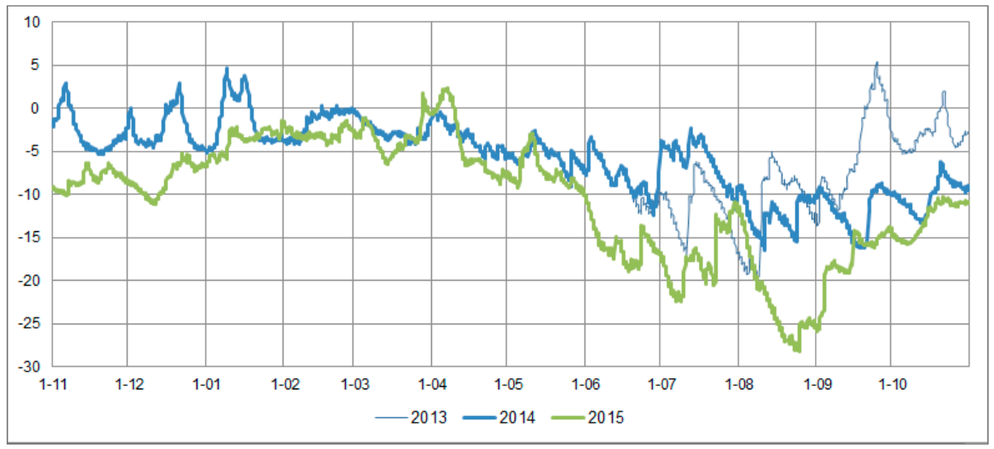


Fig. 140. Changes of the groundwater table on the Kobyla Biel fen in the hydrological years 2013 – 2015.

Photo 105. Augustów-Ogródki fen (photo F. Jarzombkowski).

Photo 106. Kobyla Biel fen (photo F. Jarzombkowski).

The water level ranged from 5 cm above the fen to 25 cm below the surface of the ground, indicating only slight summer drying of the top layers of peat. This is not a phenomenon disturbing the functioning of the fen; it is connected with increased evaporation (also evapotranspiration of plants) in the summer period. The relatively stable level of groundwater in the alkaline fens is probably due to the lack of drainage in most of them, and partly to the activity of beavers in the area in recent years that helps to maintain an appropriate level of hydration.

The stratigraphic studies confirmed the occurrence of well-preserved peat deposits composed of various types of moss and sedge-moss peats often underlined with calcareous gyttja. Their thickness is relatively high, reaching the values of over 15 m in the Rospuda Valley (ca. 3 m of peat and over 12 m of gyttja).

Photo 107. Torfowisko Borsuki – Borsuki fen (photo F. Jarzombkowski).

Photo 108. Torfowisko Płaska – Płaska fen (photo F. Jarzomkowski).

The observations indicate that the plant communities characteristic for alkaline fens in all patches, where protective measures were carried out, have improved as a result of the removal of trees and shrubs. However, succession processes (overgrowth by trees and shrubs – mainly birches, alders and willows) as well as acidification and oligotrophication are still observed on each of the sites, leading to a decrease in the extent of the habitat. This process is most pronounced at the edges of the moss -sedge vegetation, in the immediate vicinity of areas overgrown by trees. In addition, some of the sites are within the impact of beaver activity, due to which *Phragmites australis* reed sometimes enters the habitat

Photo 109. Torfowisko Sarnetki – Sarnetki fen (photo F. Jarzombkowski).

Photo 110. Torfowisko Sawonia Mostek – Sawonia-Mostek fen (photo F. Jarzombkowski).

Photo 111. Torfowisko Żyliny, Żyliny fen (photo F. Jarzombkowski).

Natura 2000 site „Mazurskie Bagna" PLH280054

Reserve „Jeziorko koło Drozdowa"

Torfowisko Jeziorko koło Drozdowa (fen Lake near Drozdowo) is an ancient lake fen with moss mire and moss -sedge vegetation. It is a mosaic of transitional plant communities between moss -sedge, mossy forms of quagmires, and minerotrophic moss mires.

The fen is located in a forest complex with predominantly pine stands on mineral soils and pine and birch stands on wetlands. Bog forests dominate the immediate vicinity of the fen. The site is quite clearly distinct from its surroundings (cf. Fig. 141).

The Torfowisko Jeziorko koło Drozdowa fen is situated in a former, relatively extensive, outflowless kettle bowl, adjacent to the depression of the Wężówka watercourse. It is located in the Vistula River basin, with water flowing through Wężówska, Śniardwy, Pisa, and Narew. The fen is surrounded by forests, but the area is dominated by land used for agriculture. In the 1930s there was still the Jeziorka Lake at the site of the fen (cf. Fig. 142). As a result of the drainless melioration of the boggy basin, carried out at the turn of the 1920s and 1930s, and drainage of water to Wężówka (village), the water level in the lake was lowered, accelerating its succession towards reeds and fens. Currently, a ditch, partially neutralized as a result of beaver activity, draining water to Wężówka, is located to the south-west.

Within the overgrown lake, temporary fens (7140) have developed, which surround the central vegetation of reeds, quagmires, and moss patches (7230). In the central and northern parts of the fen, the expansion of the *Phragmites australis* reed is noticeable. Secondary succession is also visible in some places, and the most numerous of the trees are the grey willow *Salix cinerea* and the downy birch *Betula pubescens*. The fen was not used for agricultural purposes in the past.

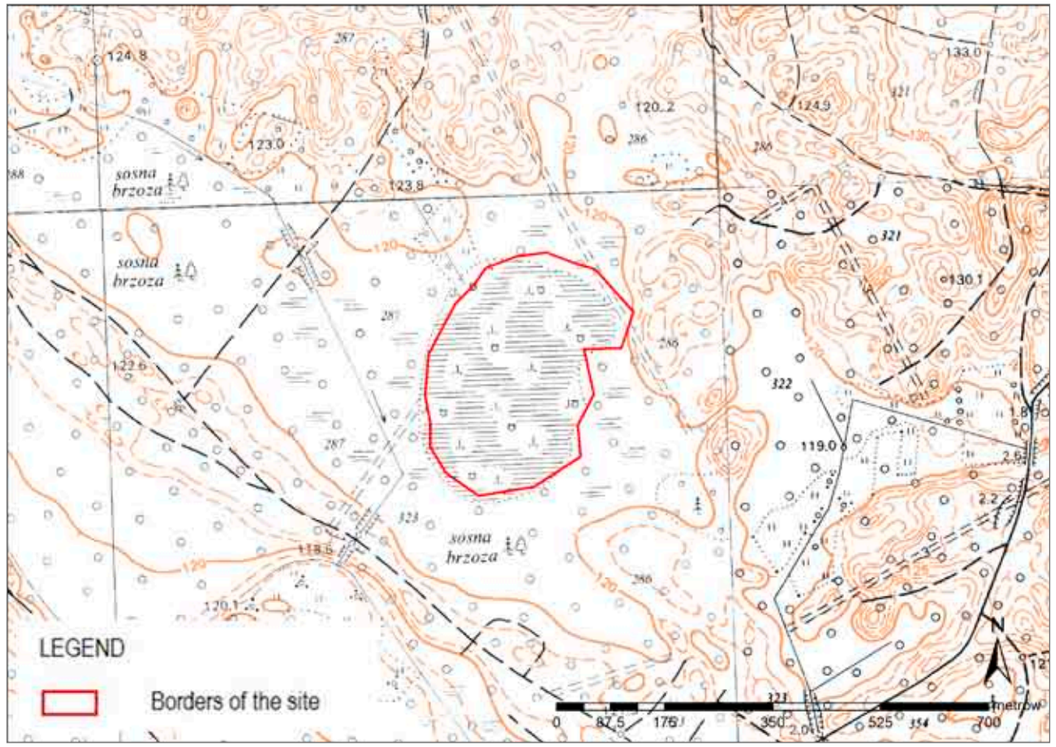


Fig. 141. Location of Torfowisko Jeziorko koło Drozdowa on the background of a topographic map.

Fig. 142. Fragments of historical topographic maps from 1921 (left) and 1932 (right) show the creation of a melioration system at the turn of the 1920s and 1930s in the area of the fen.

Fen Jeziorko koło Drozdowa is an extremely valuable habitat for many rare and protected species associated with fens. Its mosaic layout (patches of transitional fens, minerotrophic moss mires, moss -sedge, bryophytic forms of quagmires, and various transitional states between them) creates favorable conditions for the occurrence of specific plant species that are rare both in Poland and in Europe. Among the rare and endangered plant species are: *Liparis loeseli*, *Baeothryon alpinum*, *Betula humilis*, *Carex dioica*, *C. limosa*, *C. chordorrhiza*, *Eleocharis quinqueflora*, *Eriophorum gracile*, and many mosses typical for alkaline fens, including the rare *Cinclidium stygium*, and *Hammatocaulis vernicosus*.

The vegetation of the Torfowisko Jeziorko koło Drozdowa fen is formed by moss mire and moss - sedge communities. They constitute the spatial arrangement of plant communities connected with subsequent phases of lake overgrowth. Initial quagmire communities with shrubs of grey willow *Salix cinerea* and downy birch *Betula pubescens*, as well as the fern and reed floating mat of *Thelypteridi-Phragmitetum*, occur in the central and eastern part of the fen. These are ancient lake systems with moss patch vegetation, connected to the *Caricetum diandrae* association, with numerous reed elements and with moss mire and moss patch vegetation. Currently, brown moss patches have almost completely disappeared at the expense of the species-diverse mosses (with *Sphagnum teres* and *Sph. angustifolium*), which are partly similar to the *Menyantho-Sphagnetum teretis* association. The remaining part of the fen contains plant communities with *Carex lasiocarpa* and *C. limosa*, as well as transitional communities between the moss -sedge communities and mossy forms of *Thelypteridi-Phragmitetum*.

In the extreme parts of the fen, the development of vegetation settling on the slightly acidic and acidic soils is observed, using rainwater to a large extent. These areas are dominated by peat mosses typical for transitional and high fens such as *Sphagnum fuscum*, *Sphagnum fallax*, *Sph. Rubellum*; in the herbaceous layer, often found are *Oxycoccus palustris*, sometimes *Ledum palustre*, and locally *Carex limosa* and *Scheuchzeria palustris*. Trees are also entering the habitat (*Betula pubescens* and *Pinus sylvestris*).

The fen is home to the expansion of common reeds and the entry of trees – particularly *Salix cinerea* and *Betula pubescens*.

Due to the opposition of the person in charge of the area, despite the approved conservation plan, no active protection measures were carried out on the fen.

The natural values of the area were discussed, among others, in the studies by Olkowski and Olesiński (1963), Łachacz (1996, 2003), Łachacz & Olesiński (1999, 2000), Jabłońska (2014), and Wołejko et al. (2012).

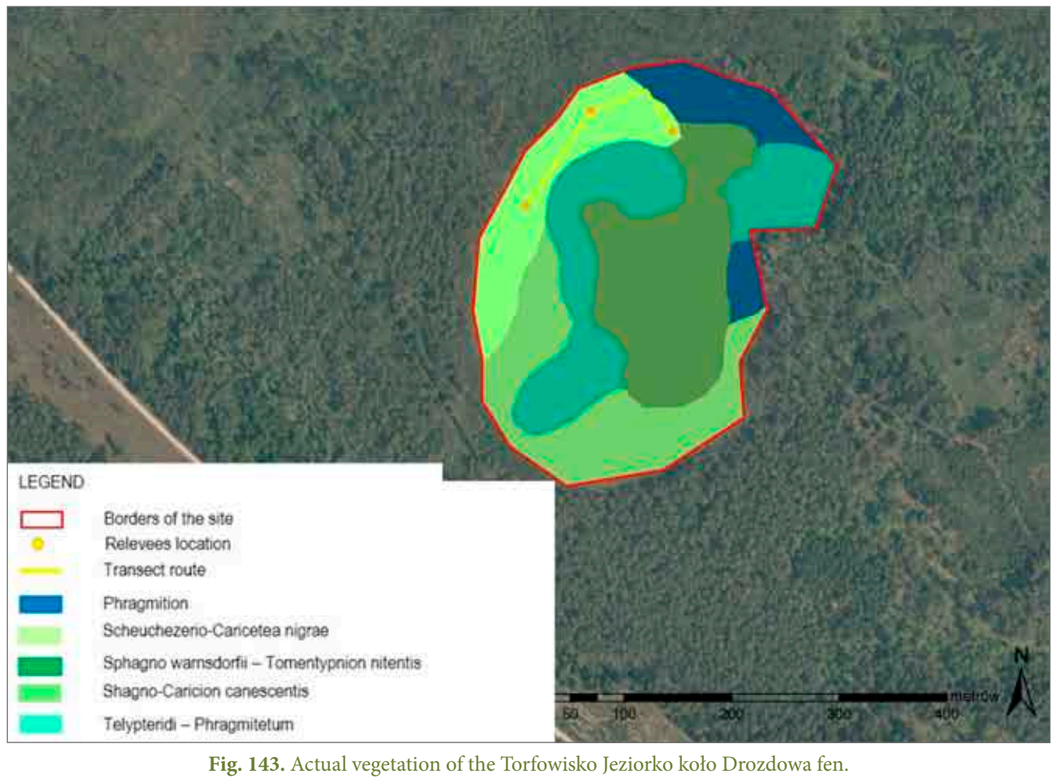


Fig. 143. Actual vegetation of the Torfowisko Jeziorko koło Drozdowa fen.

The surface of Jeziorko koło Drozdowa fen remained stable throughout the entire year during the period of several years of observations, as the fen mat floated up and down with the fluctuating water level. The amplitude of water table fluctuations was not large due to the fact that the outflow from the fen was blocked by beavers, which stabilized the so far changing hydrological conditions.

The stratigraphic studies showed that the fen vegetation did not take long to develop. Dominant are limnic sediments and the layers of typical fen sedimentation are not thick. There is still water or detritus guttja, and deeper – calcareous gyttja, under a relatively thin coat of moss and sedges, over a large area of the fen.

Photo 112. Jeziorko koło Drozdowa (photo F. Jarzombkowski).

Natura 2000 site „Puszcza Romincka" PLH280005

Reserve „Struga Żytkiejmska"

Żytkiejmska Struga is a soligenous fen with moss-sedge vegetation, with spring cupolas sometimes reaching the height of several meters.

The fen is located in the Romincka Forest, in the peat-rich valley of the Żytkiejmska Struga River, close to the border with the Kaliningrad Oblast (cf. Fig. 144). It is surrounded mainly by mixed forests, although spruce forests on peat are directly adjacent to it. The area is under reserve protection.

The Żytkiejmska Struga fen is located in the eastern part of the Romincka Forest complex and is situated in the Pregoła River basin. It is surrounded by forests on all sides, but there are also large sedge reeds growing by the river in its immediate vicinity.

In the 19th century, open fens occupied much larger areas, but after water conditions had been regulated (riverbed regulation, construction of drainage ditches) and the area had been drained, forest vegetation, especially spruces, developed. Treeless fens have been preserved only locally – in spots of strong and stable underground water supply (Jabłońska 2004, Pawlikowski, Jarzombkowski 2010, cf. Steffen 1922). At present, the open fen has only been preserved on the southern side of the river. Secondary succession is visible in some places, and the most numerous of the trees are *Betula pubescens* and *Picea abies*.

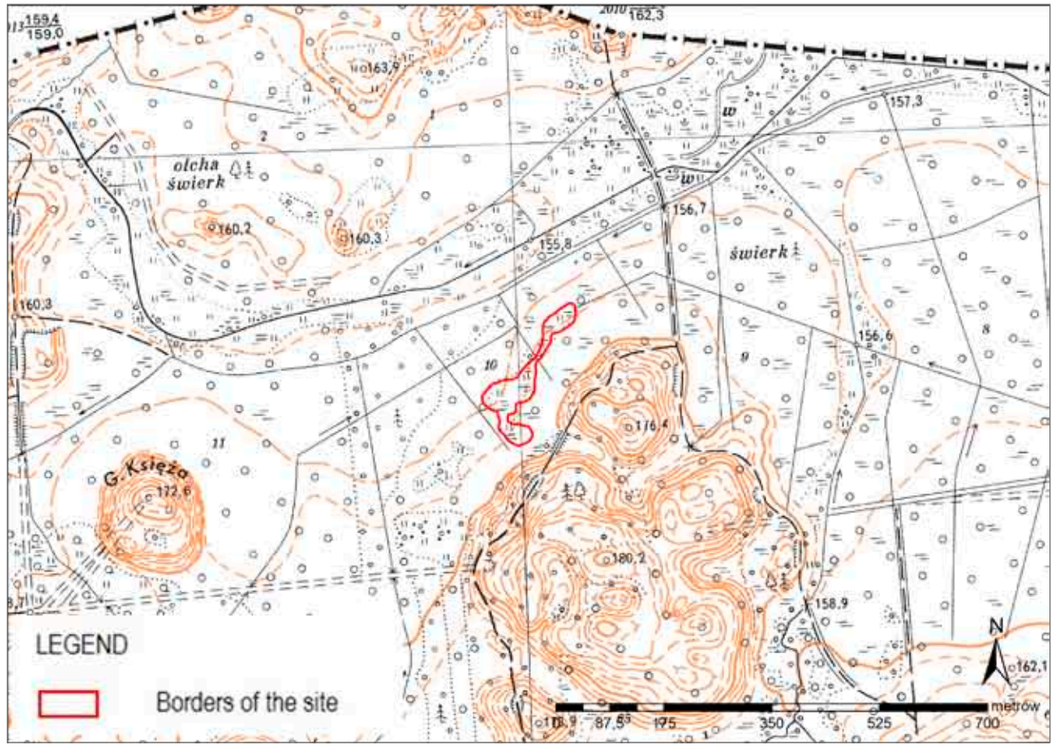


Fig. 144. Location of the Żytkiejmska Struga fen on the background of a topographic map.

Fig. 145. Fragment of a historical topographic map of 1938.

The Żytkiejmska Struga fen is located on the slope of the valley at the point of outflow of groundwater rich in mineral salts. Around the area where the water escapes to the surface, a soligenous alkaline fen has formed, the highest point of which is indicated by the area of the most intensive water upply.

These moss -sedge vegetation are an extremely valuable habitat for many rare and protected species associated with fens. It is the only known place in the Romincka Forest with *Liparis loeselii*, *Malaxis monophyllos*, *Saxifraga hirculus* and *Stellaria crassifolia*, *Betula humilis*, and *Helodium blandowii* mosses as well as *Paludella squarrosa* (Pawlikowski & Jarzombkowski 2010). In addition, there are sedges such as *Carex atherodes* (in the patches of riverside reeds adjacent to the fen), *Carex dioica* and *Carex loliacea*, *Corallorhiza trifida*, *Dactylorhiza fuchsii*, and *Dactylorhiza ruthei*.

The flora of the Żytkiejmska Struga fen is formed by moss -sedge communities developing on and around the spring cupolas. These are species-rich plant communities, located mainly in the southern part of the valley at the foot of a steep hill in the form of a kame. Their sedge-grassy nature is associated with an intensive outflow of mineral rich groundwater. The spring cupolas located north of Żytkiejmska Struga are currently of a forest and shrub nature with a poor moss layer. In some places there are reed or shrub patches with the dominance of shrubby birch and moss patch species of vascular plants and mosses.

On the best-preserved spring cupola located on the southern side of the river, in the place of the strongest outflow of groundwater with confined aquifer, the fen took the form of a quagmire. This area is dominated by *Carex rostrata*, *Agrostis stolonifera*, and *Plagiomnium ellipticum*, also found is the fleshy starwort. The surrounding moss patch contains mostly *Carex rostrata* and *C. lasiocarpa*, with a large presence of meadow species such as *Poa pratensis*, *Festuca rubra*, *Galium uliginosum*, and *Rumex acetosa*. Often found are the reed species *Equisetum palustre* and *Peucedanum palustre*, as well as the orchirds *Epipactis palustris*, *Listera ovata*, and, less commonly, *Liparis loeselii*. The moss layer is dominated by *Plagiomnium ellipticum* in highly hydrated areas and in the dryer ones – *Aulacomnium palustre*. Also common are *Tomentypnum nitens*, *Sphagnum teres*, *Calliergonella cuspidata*, *Marchantia polymorpha*, and *Hamatocaulis vernicosus*.

The vegetation is divided into zones – the central part of the fen is occupied by moss -sedge communities, and on its edges a not very wide area of shrubs has developed, built by the downy birch *Betula pubescens*, Norway spruce *Picea abies*, willows *Salix sp.* (usually the gray willow *Salix cinerea*) and the shrubby birch *Betula humilis*. The shrubs turn into a pine and birch bog forest with the participation of *Betula pubescens*, *Pinus sylvestris*, and *Picea abies*, and then into a spruce forest on peat. On the northern side, large sedge reeds and alder forests have developed in the vicinity of the river.

Active protection tasks focused mainly on removing the shrubs and mowing open parts of the moss -sedge vegetation (cf. chapter 1.5.1).

The natural values of the area were discussed, among others, in the studies by Abromeit et al. (1898 – 1940), Steffen (1922, 1931). Lettau (1901), Koppe & Koppe (1931), Polakowski (1962), Sokołowski (1971), Czerwiński (1967, 1986), Czerwiński & Pirożnikow (1986), Dembek (1991), Olesiński (1962), Pawlikowski (2000a,b, 2001, 2004, 2010), Łachacz (2002), Jabłońska (2004), Bernacki & Pawlikowski (2010), and Pawlikowski & Jarzombkowski (2010).

The surface of Torfowisko Żytkiejmska Struga remained stably hydrated throughout the year during the period of several years of observations (cf. Fig. 147). The water level ranged from +5 cm to about 15 – 20 cm below the surface of the fen, meaning that there are no significant hydrological disturbances of the remaining treeless fragments of the fen. There is only a slight natural decrease in the water table during the growing season due to evapotranspiration of plants and evaporation from the surface. However, as a result of capillary rising, the peat profile is fully saturated and the water is available to the plants all year round. This was largely due to the stable and significant hydrological supply in the area where the patches were formed, the activity of beavers on the Żytkiejmska Struga River, and the fact that at the beginning of the 21st century, thanks to the efforts of the Romincka Forest Landscape Park, several dozen water damming gates were built on some of the ditches.

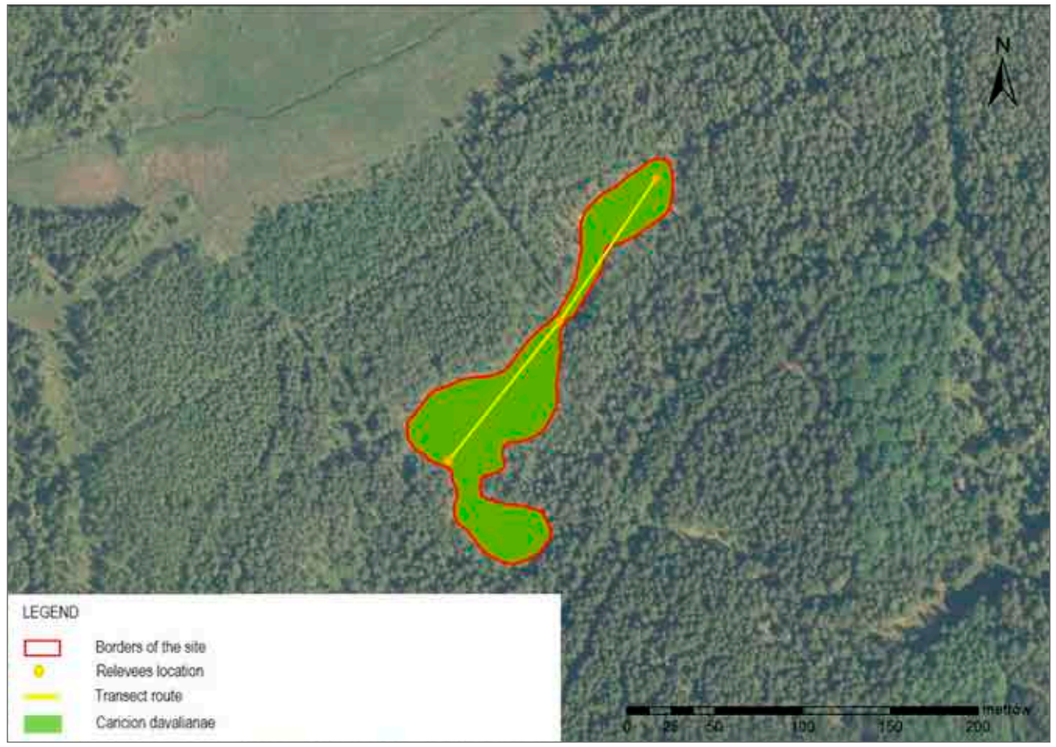


Fig. 146 Actual vegetation of the Żytkiejmska Struga fen.

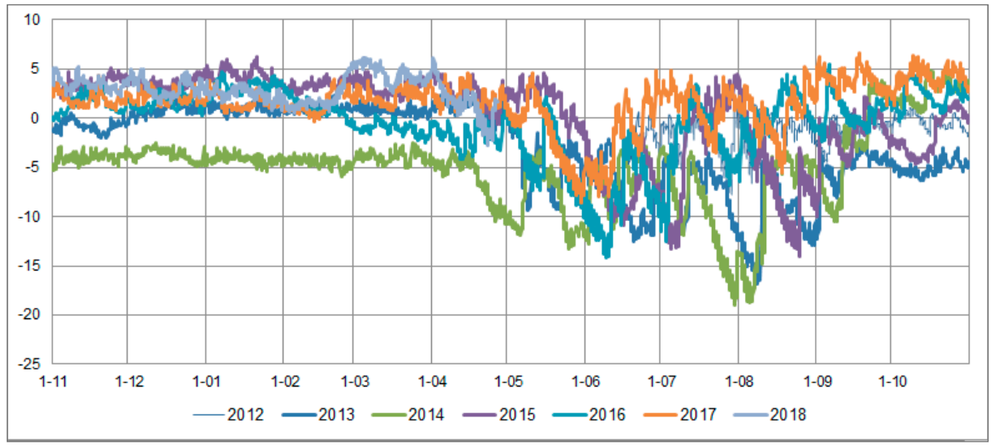


Fig. 147. Changes of the groundwater table on the Żytkiejmska Struga fen in the hydrological years 2012 – 2018.

The stratigraphic studies confirmed the occurrence of well-preserved – although locally shallow – peat deposits composed of various types of moss and sedge-moss peats underlined with thick layers of calcareous gyttja. The peat profile confirms the long-term development of the fen in the form of mossy sedge patches, reaching ca. 5 m from the valley end and much higher at the locations of the spring cupolas. There are numerous interlayers of calcareous sinter (Dembek 1991, Pawlikowski & Jarzombkowski 2010).

Photo 113. Żytkiejmska Struga (photo F. Jarzombkowski).

Table 9. List of selected, rare, protected and endangered plant species in the Natura 2000 sites where project were implemented.

Name of the species \ Name of the site	NORTH – WEST PART OF POLAND																NORTH – EAST PART OF POLAND											Conservation status			
	Dolina Pliszki	Dolina Ilanki	Dolina Rurzycy	Torfowisko Młodno	Uroczyska Kujańskie	Sandr Brdy	Mechowiska Sulęczyńskie	Ostoja Zapceńska	Jezioro Krąg	Orle	Rynna Dłużnicy	Dolina Słupi	Uroczyska Puszczy Drawskiej	Dolina Radwi, Chocieli i Chotli	Mechowisko Manowo	Dolina Płoni i Jezioro Miedwie	Ostoja Knyszyńska	Jeleniewo	Góry Sudawskie	Dolina Czarnej Hańczy	Ostoja Piska - Głógno	Ostoja Welska - Kopaniarze	Ostoja Napiwodzko-Ramucka - Trępel	Dolina Górnej Rospudy - Bagno Parchacz	Mazurskie Bagna - Jeziorko k. Drozdowa	Torfowisko Zocie	Ostoja Augustowska	Puszcza Romnicka - Żytkiejmska Struga	Polish Red Book of Plants (Kaźmierczakowa, Zarzycki i Mirek, 2014)	Red List of plants and fungi of Poland (Mirek in. 2006) Red List of briophytes of Poland (Żarnowiec i in. 2004)	Plant Species protection according to Ministry of Environment Order of 9.10.2014	
																														Strict	partial
Aldrovanda vesiculosa																						●					●		CR		▪	
Baeotryon alpinum																			●	●	●			●	●	●	●		VU	V		
Betula humilis																			●	●					●	●	●	●	EN	V	▪	
Bryum neodamense																										●	●			E	▪	
Campylium stellatum	●		●		●	●	●	●	●	●			●	●			●	●	●	●	●	●	●	●	●	●	●					
Carex chordorrhiza						●													●	●	●				●	●	●		VU	V	▪	
Carex davalliana																											●			V	▪	
Carex diandra	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●				
Carex dioica						●	●	●									●	●	●	●	●	●	●	●	●	●	●	●		V		▪
Carex demissa													●																			
Carex flava													●				●	●	●	●	●	●	●	●	●	●	●					
Carex lasiocarpa	●	●	●	●	●	●	●	●	●	●			●	●	●		●	●	●	●	●	●	●	●	●	●	●	●				
Carex limosa	●		●			●	●	●		●		●					●	●	●	●	●	●	●	●	●	●	●	●				
Carex lepidocarpa	●		●		●	●	●	●	●	●	●	●	●	●			●	●	●	●	●				●	●	●					

	Name of the site	Name of the species	*Carex panicea*	*Carex pulicaris*	*Corallorhiza trifida*	*Cinclidium stygium*	*Cladium mariscus*	*Dactylorhiza baltica*	*Dactylorhiza fuchsii*	*Dactylorhiza incarnata*	*Dactylorhiza incarnata ssp. ochroleuca*	*Dactylorhiza maculata*	*Dactylorhiza majalis*	*Dactylorhiza russowii*	*Dactylorhiza ruthei*	*Dactylorhiza traunsteineri*	*Dicranum bonjeani*
NORTH – WEST PART OF POLAND		Dolina Pliszki	•						•	•		•	•				
		Dolina Ilanki	•							•			•				
		Dolina Rurzycy	•				•			•							
		Torfowisko Młodno	•							•			•				
		Uroczyska Kujańskie	•														
		Sandr Brdy	•		•	•			•	•			•				
		Mechowiska Sulęczyńskie	•			•				•			•	•		•	
		Ostoja Zapceńska	•			•			•	•		•	•				
		Jezioro Krąg	•			•											
		Orle	•							•			•				
		Rynna Dłużnicy	•										•				
		Dolina Słupi	•							•			•				
		Uroczyska Puszczy Drawskiej	•														
		Dolina Radwi, Chocieli i Chotli	•	•													•
		Mechowisko Manowo	•														
		Dolina Płoni i Jezioro Miedwie	•							•			•				
NORTH – EAST PART OF POLAND		Ostoja Knyszyńska	•			•			•	•							
		Jeleniewo	•					•		•							
		Góry Sudawskie	•					•	•	•	•				•		
		Dolina Czarnej Hańczy	•			•	•	•	•	•					•		
		Ostoja Piska - Głógno	•						•	•							
		Ostoja Welska - Kopaniarze	•		•				•	•							
		Ostoja Napiwodzko-Ramucka - Trępel	•						•	•							
		Dolina Górnej Rospudy - Bagno Parchacz	•				•		•	•							
		Mazurskie Bagna - Jeziorko k. Drozdowa	•							•						•	
		Torfowisko Zocie	•							•							
		Ostoja Augustowska	•			•	•	•	•	•	•						•
		Puszcza Romnicka - Żytkiejmska Struga	•							•							•
Conservation status		Polish Red Book of Plants (Kaźmierczakowa, Zarzycki i Mirek, 2014)	•								EN				EN		
		Red List of plants and fungi of Poland (Mirek in. 2006) Red List of briophytes of Poland (Żarnowiec i in. 2004)	•				E					V	V	V			
	Plant Species protection according to Ministry of Environment Order of 9.10.2014	Strict	•				■		■	■				■	■	■	
		partial	•							■			■				

	Name of the site	Name of the species	*Drosera anglica*	*Drosera rotundifolia*	*Drosera x obovata*	*Dryopteris cristata*	*Eleocharis quinquaeflora*	*Epipactis palustris*	*Equisetum variegatum*	*Eriophorum gracile*	*Eriophorum latifolium*	*Fissidens adianthoides*	*Hamatocaulis vernicosus*	*Hammarbya paludosa*	*Helodium blandowii*	*Gymnadenia conopsea*	*Herminium monorchis*
NORTH – WEST PART OF POLAND		Dolina Pliszki		•		•	•	•					•		•		
		Dolina Ilanki				•		•							•		
		Dolina Rurzycy		•			•	•					•		•		
		Torfowisko Młodno				•		•							•		
		Uroczyska Kujańskie					•								•		
		Sandr Brdy	•	•		•	•	•					•	•	•		
		Mechowiska Sulęczyńskie	•	•	•	•	•	•					•		•		
		Ostoja Zapceńska	•	•	•	•	•	•					•		•		
		Jezioro Krąg		•			•	•					•		•		
		Orle				•	•	•					•				
		Rynna Dłużnicy				•		•							•		
		Dolina Słupi		•		•		•							•		
		Uroczyska Puszczy Drawskiej					•					•					
		Dolina Radwi, Chocieli i Chotli					•				•	•					
		Mechowisko Manowo															
		Dolina Płoni i Jezioro Miedwie				•		•									
NORTH – EAST PART OF POLAND		Ostoja Knyszyńska		•		•		•				•	•		•	•	
		Jeleniewo		•				•				•					
		Góry Sudawskie		•		•		•				•			•		
		Dolina Czarnej Hańczy	•	•		•		•				•			•		
		Ostoja Piska - Głógno		•		•		•				•					
		Ostoja Welska - Kopaniarze		•		•		•				•			•		
		Ostoja Napiwodzko-Ramucka - Trępel		•		•		•				•			•		
		Dolina Górnej Rospudy - Bagno Parchacz	•	•		•		•				•					
		Mazurskie Bagna - Jeziorko k. Drozdowa		•		•		•			•	•			•		
		Torfowisko Zocie	•	•	•	•		•				•	•		•		
		Ostoja Augustowska		•		•		•	•		•	•	•		•		•
		Puszcza Romnicka - Żytkiejmska Struga		•		•		•				•			•		
Conservation status		Polish Red Book of Plants (Kaźmierczakowa, Zarzycki i Mirek, 2014)												EN			CR
		Red List of plants and fungi of Poland (Mirek in. 2006) Red List of briophytes of Poland (Żarnowiec i in. 2004)			E	V		V					EN	EN	E		E
	Plant Species protection according to Ministry of Environment Order of 9.10.2014	Strict	■	■	■			■		■		■	■	■	■		
		partial															

Name of the site	Name of the species	*Juncus alpinus*	*Juncus subnodulosus*	*Lathyrus palustris*	*Limprichtia cossonii*	*Limprichtia revolvens*	*Liparis loeselii*	*Listera ovata*	*Malaxis monophyllos*	*Meesia triquetra*	*Ophioglossum vulgatum*	*Paludella squarrosa*	*Palustriella commutata*	*Pedicularis palustris*	*Pedicularis sceptrum-carolinum*
NORTH – WEST PART OF POLAND	Dolina Pliszki		●		●		●	●			●	●	●		
	Dolina Ilanki		●					●			●		●		
	Dolina Rurzycy				●		●					●			
	Torfowisko Młodno							●			●				
	Uroczyska Kujańskie				●										
	Sandr Brdy				●		●	●			●	●		●	
	Mechowiska Sulęczyńskie				●		●	●				●		●	
	Ostoja Zapceńska				●		●	●				●			
	Jezioro Krąg				●		●	●				●			
	Orle		●		●		●	●				●			
	Rynna Dłużnicy				●		●	●			●	●			
	Dolina Słupi				●			●			●	●	●		
	Uroczyska Puszczy Drawskiej	●			●								●		
	Dolina Radwi, Chocieli i Chotli	●			●	●									
	Mechowisko Manowo	●			●										
	Dolina Płoni i Jezioro Miedwie	●	●					●			●				
NORTH – EAST PART OF POLAND	Ostoja Knyszyńska				●	●	●	●				●			
	Jeleniewo				●		●								
	Góry Sudawskie				●		●	●				●			
	Dolina Czarnej Hańczy				●		●	●							
	Ostoja Piska - Głógno				●		●								
	Ostoja Welska - Kopaniarze				●			●							
	Ostoja Napiwodzko-Ramucka - Trępel				●			●							
	Dolina Górnej Rospudy - Bagno Parchacz				●		●								
	Mazurskie Bagna - Jeziorko k. Drozdowa				●		●								●
	Torfowisko Zocie				●		●	●			●				
	Ostoja Augustowska			●	●		●	●			●				
	Puszcza Romnicka - Żytkiejmska Struga				●			●			●				
Conservation status	Polish Red Book of Plants (Kaźmierczakowa, Zarzycki i Mirek, 2014)						VU			NT					EN
	Red List of plants and fungi of Poland (Mirek in. 2006) Red List of briophytes of Poland (Żarnowiec i in. 2004)	V	V	V			E			V	V	E		V	E
	Plant Species protection according to Ministry of Environment Order of 9.10.2014 – Strict						■			■	■				■
	Plant Species protection according to Ministry of Environment Order of 9.10.2014 – partial		■	■				■						■	

Name of the site	Name of the species	*Philonotis tomentella*	*Polemonium coeruleum*	*Pseudobryum cinclidioides*	*Pseudocalliergon trifarium*	*Saxifraga hirculus*	*Scorpidium scorpioides*	*Sphagnum contortum*	*Sphagnum fuscum*	*Sphagnum subnitens*	*Sphagnum teres*	*Sphagnum warnstorfii*	*Splachnum ampullaceum*	*Swertia perennis*	*Stellaria crassifolia*	*Tofieldia calyculata*
NORTH – WEST PART OF POLAND	Dolina Pliszki									●	●	●				
	Dolina Ilanki															
	Dolina Rurzycy							●			●					
	Torfowisko Młodno										●					
	Uroczyska Kujańskie															
	Sandr Brdy				●	●	●		●	●	●	●			●	
	Mechowiska Sulęczyńskie						●		●	●	●	●			●	
	Ostoja Zapceńska				●	●	●		●	●	●	●			●	
	Jezioro Krąg					●					●					
	Orle										●					
	Rynna Dłużnicy					●					●					
	Dolina Słupi										●	●				
	Uroczyska Puszczy Drawskiej															
	Dolina Radwi, Chocieli i Chotli	●														
	Mechowisko Manowo															
	Dolina Płoni i Jezioro Miedwie															
NORTH – EAST PART OF POLAND	Ostoja Knyszyńska										●			●		
	Jeleniewo										●					
	Góry Sudawskie						●				●			●	●	
	Dolina Czarnej Hańczy						●				●					
	Ostoja Piska - Głógno										●					
	Ostoja Welska - Kopaniarze						●				●					
	Ostoja Napiwodzko-Ramucka - Trępel										●					
	Dolina Górnej Rospudy - Bagno Parchacz						●				●					
	Mazurskie Bagna - Jeziorko k. Drozdowa						●		●		●					
	Torfowisko Zocie					●	●		●		●					
	Ostoja Augustowska					●	●		●		●				●	
	Puszcza Romnicka - Żytkiejmska Struga					●					●				●	
Conservation status	Polish Red Book of Plants (Kaźmierczakowa, Zarzycki i Mirek, 2014)					EN									EN	[V]
	Red List of plants and fungi of Poland (Mirek in. 2006) Red List of briophytes of Poland (Żarnowiec i in. 2004)					E	E		V		E	E			E	E
	Plant Species protection according to Ministry of Environment Order of 9.10.2014 – Strict					■	■				■	■		■	■	■
	Plant Species protection according to Ministry of Environment Order of 9.10.2014 – partial								■	■			■			

Name of the site / Name of the species	NORTH – WEST PART OF POLAND															NORTH – EAST PART OF POLAND											Conservation status		
	Dolina Pliszki	Dolina Ilanki	Dolina Rurzycy	Torfowisko Młodno	Uroczyska Kujańskie	Sandr Brdy	Mechowiska Sulęczyńskie	Ostoja Zapceńska	Jezioro Krąg	Orle	Rynna Dłużnicy	Dolina Słupi	Uroczyska Puszczy Drawskiej	Dolina Radwi, Chocieli i Chotli	Mechowisko Manowo	Dolina Płoni i Jezioro Miedwie	Ostoja Knyszyńska	Jeleniewo	Góry Sudawskie	Dolina Czarnej Hańczy	Ostoja Piska - Głógno	Ostoja Welska - Kopaniarze	Ostoja Napiwodzko-Ramucka - Trępel	Dolina Górnej Rospudy - Bagno Parchacz	Mazurskie Bagna - Jeziorko k. Drozdowa	Torfowisko Zocie	Ostoja Augustowska	Puszcza Romnicka - Żytkiejmska Struga	Polish Red Book of Plants (Kaźmierczakowa, Zarzycki i Mirek, 2014)	Red List of plants and fungi of Poland (Mirek in. 2006) Red List of briophytes of Poland (Żarnowiec i in. 2004)	Plant Species protection according to Ministry of Environment Order of 9.10.2014	
																															Strict	partial
Tomentypnum nitens	●		●	●	●	●		●	●	●	●	●					●	●	●	●	●	●	●	●	●	●	●	●		V		■
Trisetum sibiricum																			●								●	●				
Utricularia intermedia	●						●	●									●	●	●	●		●	●	●	●	●	●	●		V	■	
Utricularia minor			●			●	●	●										●	●	●	●		●	●	●	●	●			V	■	
Utricularia ochroleuca								●																						E	■	
Viola epipsila																						●					●	●	CR	E	■	

Table 10. List of selected, charateristic plant syntaxa present in Natura 2000 site where project had been implemented.

Syntaxa	Dolina Radwi, Chocieli i Chotli	Dolina Płoni i Jezioro Miedwie	Mechowisko Manowo	Dolina Rurzycy	Uroczyska Puszczy Drawskiej	Dolina Ilanki	Dolina Pliszki	Torfowisko Młodno	Uroczyska Kujańskie	Sandr Brdy	Ostoja Zapceńska	Mechowiska Sulęczyńskie	Jezioro Krąg	Orle	Rynna Dłużnicy	Dolina Słupi	Głógno	Bagno Parchacz	Trępel	Zocie	Puszcza Augustowska	Puszcza Knyszyńska	Kopaniarze	Jeleniewo	Góry Sudawskie	Dolina Czarnej Hańczy
Cl. Utricularietea intermedio-minoris Den Hartog et Segal 1964 em. Pietsch 1965																										
Utricularietalia intermedio-minoris Pietsch 1965																										
Sphagno-Utricularion Müll. et Görs 1960																										
Scorpidio-Utricularietum minoris Müll. et Görs 1960											x	x								x	x				x	x
Cl. *Phragmitetea australis* (Klika in Klika et Novak 1941) R.Tx. et Preising 1942																										
O. *Phragmitetalia australis* W. Koch 1926																					x				x	
All. *Phragmition communis* Koch 1926																								x		
Cladietum marisci Allorge 1922 ex Zobrist 1935				x		x						x									x					
All. *Magnocaricion elatae* W. Koch 1926				x															x						x	
Caricetum rostratae Rübel 1912 ex Osvald 1923				x	x	x	x	x	x	x								x	x		x			x	x	x
Caricetum paradoxae R.Tx. 1937		x		x	x	x	x	x				x						x			x					
Cl. *Scheuchzerio-Caricetea fuscae* (Nordh. 1936) R.Tx. 1937																										
O. *Caricetalia fuscae* W.Koch 1926 em Nordh. 1936																		x								

All. *Caricion lasiocarpae* Vanden Bergen in Lebrun et al.. 1949																									
Caricietum lasiocarpae Osvald 1923	x			x			x	x		x	x	x		x		x									
Caricietum lasiocarpae Osvald 1923 campyllietosum stellati*	x																								
Scorpidio-Caricetum diandrae Osvald 1923 em. Jonas 1932 = *Caricetum diandrae* Jonas 1932	x			x	x		x		x	x	x	x		x		x									
Scorpidio-Caricetum diandrae Osvald 1923 em. Jonas 1932 *paludelletosum*	x			x	x																				
Comm. *Carex diandra*					x		x		x																
Menyantho-Sphagnetum teretis Waren 1926	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x		x		x	
Sphagno-Caricetum rostratae Steff. 1931 em. Dierss. 1978	x		x	x	x		x			x	x	x			x	x			x	x	x				x	
Sedge-moss fen Phragmites australis;			x				x					x														
Sedge-moss fen Typha latifolia												x														
Sedge-moss fen Typha angustifolia												x														
Sedge-moss fen Carex acutiformis												x														
O: *Caricetalia fuscae* W. Koch 1926 em. Nordhagen 1936																										
All: *Caricion davallianae* Klika 1934																										
Eleocharitetum pauciflorae Lüdi 1921	x						x			x	x	x								x	x					
Valeriano-Caricetum flavae Pawłowski 1949 ex 1960																										
Caricetum davallianae Dutoit 1924																										
Caricetum paniceo-lepidocarpae (Steffen 1931) W. Braun 1968 (Syn. i Pseud: *Parvocaricetum* Steffen 1931 *nom. illeg.; Parnassio-Caricetum fuscae* Oberd. 1957 *sensu auct. p.p. Campylio-Caricetum dioicae* Osvald 1923 *em.* Dierßen 1982 *sensu* Wołejko 2000 *p.p.)*	x			x						x	x			x	x						x	x			x	x

Comm. with Carex lepidocarpa												x													
Juncetum subnodulosi (Allorge1922) W.Koch 1926 (=? *Crepido-Juncetum subnodulosi* (Libb.1932) Pass. 1964)	x	x				x	x							x											
Residual comm. of all. *Caricion davallianae*	x		x		x																				
sedge-moss fen alder			x	x																	x				x
comm. *Helodium blandowii-Carex acutiformis**						x	x			x									x						
Thelypteridi-Phragmitetum																			x		x				
Sphagno warnstorfii-Tomentypnion nitentis																x		x	x	x	x	x	x	x	x
Campylio stellati-Trichophoretum alpini																x			x	x				x	x
Caricetum paniculatae																		x		x				x	x
brzezina mechowiskowa																x									x
Sphagno warnstorfii-Eriophoretum latifolii																x			x	x	x	x	x	x	x
Campylio stellati-Caricetum lasiocarpae																		x	x	x	x		x	x	x
Valeriano dioicae-Caricetum davallianae																x		x	x	x	x	x	x	x	x
Caricion canescenti-nigrae																	x			x	x		x		

"Bagno Stawek" reserve. One of the last *Saxifraga hirculus* refuge in western Poland (photo R. Stańko).

3. Strenghtening of the population of a disappearing fen species - the yellow marsh saxifrage *Saxifraga hirculus*

Joanna Bloch-Orłowska, Elżbieta Cieślak, Katarzyna Żółkoś, Magdalena Kędra, Magdalena Makowska

The activity was carried out in 2013 – 2017 and was entirely entrusted to the W. Szafer Foundation of Polish Botany in Krakow. The purpose of the task was to test the in vitro breeding as a method of strengthening the existing populations and reintroducing the saxifrage in Poland.

3.1. Species characteristics

Saxifraga hirculus L is linked to the mossy non-forest low fens of the soligenic type. It is encountered in sites with strong and stable water supply but never flooded. As a very low-competitive heliotropic plant, it grows in places with a low density of other vascular plants on moss patches made up of brown mosses (Łachacz 1995, Kosiński 2000, Bloch and Załuski 2001). It inhabits definitely minerotrophic habitats where surface waters are usually neutral to alkaline and rich in electrolytic ions, particularly of calcium, magnesium and typically iron. The substrate is usually medium decomposed sedge and moss peats, often with calcareous sinter deposits, covered with limnic sediments in the form of calcareous or calcareous-detritus gyttja. The concentrations of *Saxifraga hirculus* L develop in places with little coverage of other vascular plants, on lush moss patches most often composed of the following moss species: *Tomentypnum nitens, Aulacomnium palustre, Hamatocaulis vernicosus* and *Marchantia polymorpha*, and occasionally *Paludella squarrosa, Sphagnum teres*, and *Plagiomnum ellipticum*.

It is a species associated with undisturbed fens and an important threat is hydrological changes. Anthropogenic drying of mire habitats causes or accelerates habitat changes – peat decay, eutrophication of fens, acidification, and secondary succession towards thickets and forest communities (Bloch and Załuski 2001, Załuski and Bloch-Orłowska 2004).

The yellow marsh saxifrage is a polymorphous species in terms of morphology and cytology, with different numbers of chromosomes recorded in individual populations (2n = 16 or 32, rarely 24 – Hedberg 1992). A species not similar to other national representatives of the saxifrage genus. The flowering specimens are easy to find and identify. However, overlooking the species in its barren state is highly probable. The yellow marsh saxifrage blossoms from July to September. It is a perennial plant (hemicryptophyte) with buds hidden in the moss patches in winter. It exhibits protandry (maturation of the stamina before the carpels), which greatly reduces self-pollination. The flowers are visited by a wide range of pollinating insects, however the most important role is played by hoverflies *Syrphide*. The seeds fall out of the capsules due to wind or rain activity, and fall in close proximity (approximately 13 – 15 cm on average) to the mother plant.

The number of shoots on the stands is subject to considerable fluctuations, while in stable habitat conditions they mainly concern the number of generative shoots, with a similar number of vegetative shoots. Shoots dominate numerically and even in the years of abundant flowering constitute at least ¾ of the total number of shoots. Under unfavorable conditions, the population may consist only of vegative shoots that are easy to miss.

3.2. Methodology and applied measures

3.2.1. Preliminary inventory and collecting of samples

All the undertaken activities required obtaining relevant decisions of the nature conservation administration, authorizing the following:

- scientific research related to the species under strict protection in Poland – from individual, locally competent Regional Directorates of Environmental Protection;
- collection and keeping of generative and vegetative parts of the protected species – from the locally competent Regional Directorates for Environmental Protection, and additionally, in the case of activities undertaken on the premises of the reserves, also from the General Directorate for Environmental Protection;

- reintroduction to the natural environment – similarly as in the case of collection and storage – approval of the locally competent Regional Directorates of Environmental Protection, and additionally of the General Directorate for Environmental Protection in the areas of the reserves.

Initially, 12 sites (fens) located in Northern Poland were selected for the activities

Out of the above fens, Mechowiska Sulęczyńskie, Dolina Kulawy, Bagno Parchacz, and Orle were designated as yellow marsh saxifrage reintroduction sites, while the remaining ones were designated as sites to be reinforced with individuals bred as part of the project. Ultimately, in the case of the last 2 sites, no specimens were reintroduced due to unfavorable habitat conditions as well as the small amount of available material to be reintroduced. Additionally, in the Orle site, which is entirely privately owned, the Club did not obtain permission to carry out any conservation activities, including those related to strengthening the population of the yellow marsh saxifrage in Poland. For this reason the Bagno Parchacz and Orle fens are omitted in the description below.

Due to its nature – the small size, relatively short flowering period, production of generative shoots only in favorable weather and habitat conditions (which means that flowering does not have to take place annually), the first two years (2013 – 2014) were devoted to visits of pre-selected sites in order to confirm the presence of the population of the yellow marsh saxifrage. In the case of confirmation of species occurrence at the site, the conservation status and condition of the population were determined and, if possible, material was collected for genetic testing.

The results of observations carried out in 2013 – 2016 indicate large fluctuations in the saxifrage population (expressed in the number of flowering shoots) in subsequent years (Fig. 148). The starting point were the data from the national inventory of habitat 7230 carried out by the Naturalists' Club in the years 2008 – 2010 under the project financed from the funds of Axis V of the Operational Programme Infrastructure and Environment 2007 – 2013 entitled „Conservation programmes for: alkaline fens (7230) and endangered species related to them – yellow marsh saxifrage, fen orchid, musk orchid and fleshy starwort".

Table 11. List of sites preliminarily selected for the implementation of the activities.

Voivodeship	Natura 2000 site	Name of the reserve	Name of the fen (site)	Code
Pomeranian	Sandr Brdy	Bagno Stawek	Bagno Stawek	BS
Pomeranian	Sandr Brdy	Dolina Kulawy	Dolina Kulawy	DK
Pomeranian	Ostoja Zapceńska	Mechowisko Radość	Torfowisko Radość	MR
Pomeranian	Rynna Dłużnicy	-	Jezioro Małe Długie	MD
Pomeranian	Sulęczyno	Mechowiska Sulęczyńskie	Sulęczyno	MS
Pomeranian	Jezioro Krąg	Mechowisko Krąg	Jezioro Krąg	JK
Podlaskie	Ostoja Augustowska	-	Sawonia Mostek	SM
Podlaskie	Dolina Szeszupy	-	Poszeszupie	PO
Podlaskie	Puszcza Romincka	Struga Żytkiejmska	Żytkiejmska Struga	ZS
Podlaskie	Dolina Górnej Rospudy	Bagno Parchacz	Bagno Parchacz	BP
Warmian-Masurian	Ostoja Welska	-	Torfowisko Kopaniarze	TK
Pomeranian	Orle	-	Orle	OR

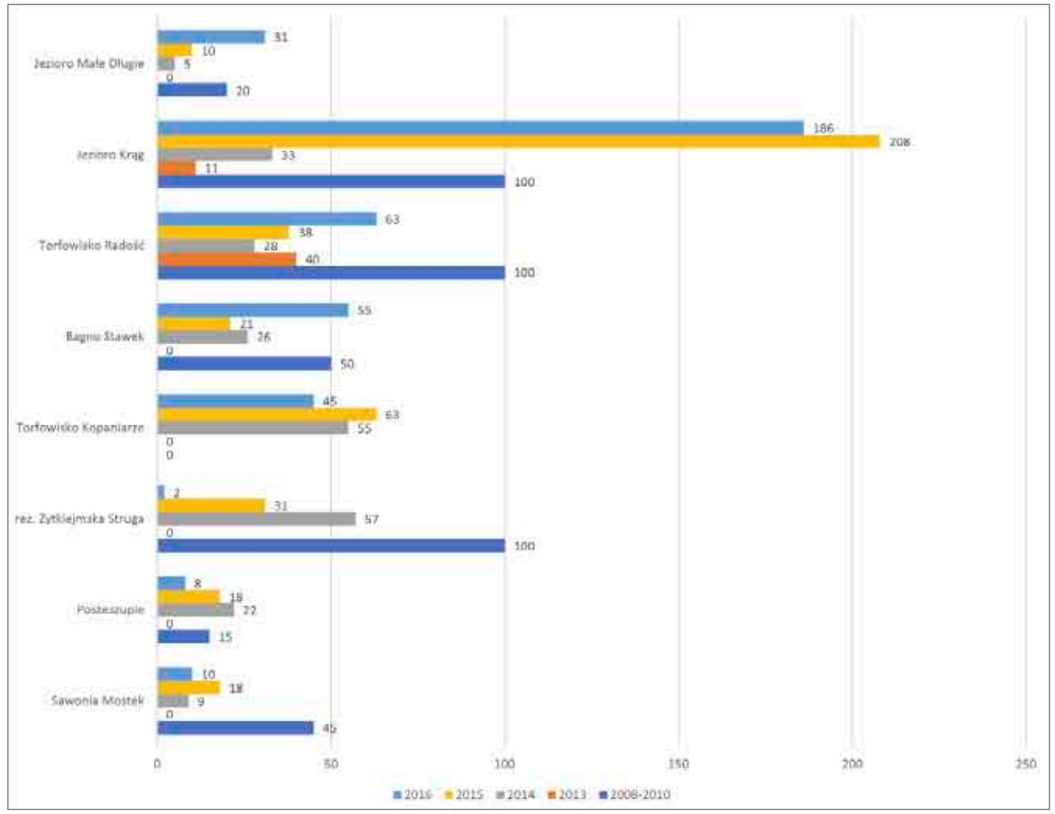


Fig. 148. Population of *Saxifraga hirculus* subject to field visits in 2013 – 2016, supplemented by data from 2008 – 2010.

Due to the entire scope of activities, the size of the population in 2014 was very important. Site visits in this year were carried out several times during the growing season. First of all, they were aimed at determining the current location and resources of the yellow marsh saxifrage population in the fens covered by the project. In order to do this, it was necessary to capture the moment when the populations at each site were in optimum blossom. This enabled reliable determination of the size of the individual populations and collection of representative samples for genetic testing. In total, all the sites included in the project to reinforce the population (Mechowisko Radość, Bagno Stawek, Jezioro Małe Długie, Jezioro Krąg, Torfowisko Kopaniarze, Żytkiejmska Struga, Sawonia-Mostek, and Poszeszupie) were visited, as well as one of the fens intended for reintroduction – the fen in Dolina Kulawy (Kulawa River valley). At eight sites where the yellow marsh saxifrage was found, all the population patches present were localised using GPS and their location in the field was permanently marked with numbered bamboo poles. At the same time, population size was determined. During the last field visits at the end of the 2014 growing season, capsules with seeds were collected for multiplication.

Bagno Stawek Reserve

In 2014, the presence of 6 small patches of the yellow marsh saxifrage concentrated in the north-western part of the fen was found. The distance between the patches was 1.5 – 4 m. A total of 26 flowering shoots were recorded (Table 12).

Table 12. Data on population size and number of samples for individual locations in 2014.

Site name	number of patches	number of flowering shoots	number of collected samples (leaves)*	number of collected samples (capsules)**
Mechowisko Radość	10	28	25	26
Jezioro Małe Długie	2	5	5	4
Bagno Stawek	6	26	25	20
Jezioro Krąg	6	33	25	13
Żytkiejmska Struga	4	57	25	12
Sawonia-Mostek	4	9	9	10
Poszeszupie	2	22	22	8
Kopaniarze	6	55	25	24

Explanations: *total number of samples (with duplicates) for genetic testing; ** total number of samples for multiplication; collection of more capsules was possible due to the formation of several flowers (usually 2, less frequently 3 or even 4) on one shoot for most of the generative shoots of the yellow marsh saxifrage.

Jezioro Krąg (reserve "Mechowisko Krąg")

The population of the yellow marsh saxifrage at the Krąg Lake was formed by 6 patches located in the western part of the fen. A total of 33 flowering shoots were recorded (see Table 12). Importantly, the patches observed in 2014 did not coincide with the locations where the species was recorded in 2013.

Jezioro Małe Długie

The population within this fen was small – a total of 5 flowering shoots were recorded, forming 2 small patches occurring at a distance of 3 m from each other (see Table 12). One of them had already been recorded in 2013.

Sulęczyno (reserve „Mechowiska Sulęczyńskie")

There were no specimen recorded in 2013.

Torfowisko Radość (reserve „Mechowisko Radość")

In 2014, the population was smaller – only 28 flowering shoots were found, compared to more than 40 in 2013 (cf. Table 12). They were concentrated in 10 small patches, separated from each other by several to several dozen meters. In addition, only some of them overlapped with the species locations of the previous year. All the patches were not numerous – from 1 to 5 flowering shoots.

Poszeszupie

The population found in 2014 in the Szeszupa Valley consisted of 2 patches, approximately 23 m apart. A total of 22 flowering shoots were recorded here (see Table 2). Most of these shoots had damaged tips, which translated into a small number of produced capsules. This is likely to have been influenced by the summer felling of trees and shrubs within, and in the immediate vicinity of, the yellow marsh saxifrage population (the cut shoots were still lying on the fen in October).

Sawonia-Mostek

The yellow marsh saxifrage population in the Marycha Valley near the Sawonia-Mostek forest range consisted of 4 patches, several meters from each other. Individual flowering shoots were recorded In all the patches; in total, 9 generative shoots were found at the location in 2014 (see Table 12).

Torfowisko Kopaniarze

The population of the yellow marsh saxifrage on the Kopaniarze fen was formed by 6 patches located 1 – 4 m apart in the north-eastern part of the fen, on the outskirts of its non-forest part (Fig. 9). A total of 55 flowering shoots were recorded (see Table 12). It was one of the two largest *Saxifraga hirculus* populations visited in 2014.

Żytkiejmska Struga (reserve „Struga Żytkiejmska")

The population of the yellow marsh saxifrage in the valley of Żytkiejmska Struga was composed of 4 patches, 2 – 4 m apart. It was the largest population out of 8 project visits in 2014. In total, 57 flowering shoots were recorded at this location.

Changes in the number of observed shoots at particular locations in subsequent years may be the result of various phenomena. One of the reasons for this may be the unfavorable tendency observed in recent years for the population of the yellow marsh saxifrage to dwindle. This is also indicated by observations at other sites, such as in the north-eastern part of Poland, east of the village of Sarnetki or on the Marycha River near Giby (P. Pawlikowski 2003 – 2011, unpubl.) and on Lake Księże in Pomerania (P. Pawlikowski 2011, unpubl.). On the other hand, Saxifraga hirculus is a specific species that sometimes does not produce generative shoots, which in the case of small leaf rosettes makes it practically impossible to find the species at the location. Such a phenomenon was also observed in the case of the Pomeranian population on Lake Wyrówno (J. Bloch-Orłowska, unpubl.), as well as in Bagno Stawek bog, where the species was found in 2009 after many years of lack of confirmation (Stańko et al. 2009). Such results may also have been accompanied by a rapid rate of dying out of the fruiting shoots in the 2013, which made it much more difficult to find the species at the sites. At the same time, data collected during 4 years and supplemented by earlier observations indicate the persistence of the studied populations of this species within the studied sites.

The variable number of flowering and fruiting shoots in each year is likely to depend on the climate and habitat conditions in that year. In addition, flowering shoots may occur in different places within the location, indicating the potential for population development under favorable conditions but making it difficult to find. It also indicates the need to visit the locations (even several times) during the flowering period of the species in order to capture it at its optimum. It should be noted that the flowering time of the yellow marsh saxifrage may vary slightly from region to region.

3.2.2. Performance of genetic tests to determine the genetic affinity of selected populations

The purpose of the tests was:

- analysis of the genetic variability within and between populations of Saxifraga hirculus based on material from the territory of Poland (material collected for the purpose of research),
- determination of the genetic relations between populations of *S. hirculus* from different areas of Poland (Pomerania, South Pomeranian Lake District, and Suwałki Lake District).

The material came from eight natural populations in Poland. In total, 159 individuals were collected (Table 13).

A single sample in molecular analyses was the stem leaf of a given individual. Total DNA from all the samples taken was isolated with DNAazy Mini kit 96 (plate type; Qiagen) according to the procedure specified by the manufacturer. The quality and quantity of DNA in the individual samples were checked on the agarose gel.

Table 13. Data on population size and number of samples for individual locations of *Saxifraga hirculus.*

location	population code	Number of patches	Number of flowering shoots	Number of samples for genetic testing
Bagno Stawek	BS	6	26	25
Jezioro Krąg	JK	6	33	25
Jezioro Małe Długie	MD	2	5	5
Mechowisko Radość	MR	10	28	25
Poszeszupie	PO	2	22	22
Sawonia-Mostek	SM	4	9	9
Żytkiejmska Struga	ZS	4	57	25
Torfowisko Kopaniarze	TK	6	55	25

Analysis of AFLP data

The AFLP analysis covered all 161 individuals of Saxifraga hirculus from eight natural populations from Poland on the basis of the modified Vos et al. (1995) procedure. The populations ranged from 5 to 25 individuals. The AFLP analysis was carried out in two stages:

1. Preliminary stage: a pilot study was carried out on the stages of the method, i.e., restriction, ligation, pre-PCR and selective PCR (control on the agarose gel and last step on the genetic analyzer), method reproducibility test, as well as test and selection of the primer pairs, which were then taken into account in the analysis of the entire test material; 16 samples were included in this stage.
2. Fundamental stage: 159 individuals were analyzed using three pairs of primers: EcoAAG-MseCTG, EcoACT-MseCAG, and EcoAGG-MseCAA. The individual stages of this analysis were carried out on an Applied Biosytems thermal cycler and the PCR selective reaction product was separated using the ROX-500 mass standard (Applied Biosystems) on the ABI Prism 3130 genetic analyser (Applied Biosystems).

Replicates of genotyping (ca. 10 – 15% of the tested samples) were taken into account in the analyses, allowing to control the reproducibility of the obtained profiles and to eliminate unique markers. The replicated samples were taken from a single DNA isolate.

The final effect of the AFLP analysis was the DNA fragment profiles obtained in the range of 50 – 500 bp, which were analyzed with GENOGRAFHER software (Applied Biosystems). The data was stored in the form of a binary data matrix (no fragment/fragment present), which became the basis for statistical analyses.

The analysis of genetic variability of the taxon was carried out at the intra-population and inter-population levels. The level of polymorphism in populations was determined on the basis of the share of polymorphous fragments (P, P%), characteristic fragments (Pch – fragment present in at least 1 individual from a given population/taxon, absent in other populations/taxes), private fragments (Pp – fragment present in all individuals from a population/taxon, absent in other populations/taxons), and the value of Nei's genetic variation factor (Hj) (NEI 1978), calculated by means of the programs: AFLPdat (Ehrich 2006) and POPGENE V1.32 (Yen et al. 1997).

Interrelationships between the studied individuals and populations were investigated by the Nei & Li genetic distance dendrogram (1979) using the UPGMA method, obtained by the application of TREECON 1.3b (van de Peer & De Wachter 1994) and by Principal Coordinate Analysis (PCoA), which included the Nei & Li genetic distance matrix (1979), made using the MVSP program (Schlüter & Harris 2006). The level of genetic similarity for the population pairs was calculated according to Nei (1978).

The level of intra-population and inter-population genetic variability of Saxifraga hirculus was estimated by molecular variance analysis (AMOVA). AMOVA was also used to test the results of grouping of individuals obtained as a result of Bayesian analysis. The analyses were performed using ARLEQUIN 3.5.1.2 (Excoffier & Lischer 2010), and the significance was estimated on the basis of 1,000 repetitions.

The genetic structure was analyzed using STRUCTURE 2.2.4 (Falush et al. 2007), which used the analysis of Bayesian grouping of individuals using the Monte Carlo algorithm and Markov chains (Markov Chain Monte Carlo; MCMC). The *admixture* model and independent frequency of the alleles were applied. AFLP markers are dominant markers, and therefore the *recessive allele model* was used. The number of groups (K) from 1 to 6 was tested. 100 repetitions were performed for each K in order to check the repeatability of the grouping results. The STRUCTURE-SUM-2009 program (part of the AFLPdat software; Ehrich 2006) summarized the results obtained from STRUCTURE. A high coefficient of similarity between repetitions for each K, values of ΔK, and K probability (Evanno et al. 2005) allowed for determining the optimal number of groups (K) for particular analyses.

The repeatability of AFLP profiles was high and amounted to 95%. Using three pairs of selective primers – EcoAAG-MseCTG, EcoACT-MseCAG, and EcoAGG-MseCAA – a total of 269 repeatable and informative AFLP markers were obtained, of which 188 (69.89%) were polymorphic (Table 4), and the mean value for the population was 106.5 (+/- 32.28). Nei's coefficient was 0.2474 (+/- 0.19), and the mean value for the population was 0.201 (+/- 0.16). The value of gene flow between the studied populations was relatively low: Nm = 0.6082.

The highest values of genetic similarity were recorded between the pairs of populations from the Suwałki region – populations in the Żytkiejmska Struga and Sawonia Mostek fens, as well as Poszeszupie and Sawonia Mostek. These populations were also very similar to the population of Torfowisko Kopaniarze (Chełmińsko-Dobrzyńskie Lake District). The lowest level of similarity was observed in the pairs of population of Bagno Stawek and Jezioro Małe Długie, as well as Mechowisko Radość (Pomerania).

Table 14. Genetic variability parameters obtained from AFLP analysis for the population of *Saxifraga hirculus*. N – number of individuals tested; P – number of polymorphous bands (percentage of bands); Hj – Nei's coefficient of genetic variation. Abbreviated names of populations – Table 11.

Population code	N	P (P%)	Hj
BS	23	84 (31.22 %)	0.1025 +/-0.17
JK	25	117 (43.49%)	0.1354 +/- 0.18
MD	5	38 (14.12%)	0.589 +/- 0.15
MR	25	106 (39.41%)	0.1356 +/- 0.18
PO	22	129 (47.95%)	0.1692 +/- 0.19
SM	9	118 (43.86%)	0.1625 +/- 0.21
TK	25	119 (44.23%	0.1391 +/- 0.18
ZS	25	141 (52.42%)	0.1747 +/- 0.19
Total	159	188 (69.89%)	0.2474 +/- 0.19

Principal Coordinate Analysis (PCoA), based on AFLP markers and Nei & Li's genetic distances (1979) between individuals of Saxifraga hirculus, showed differences between the studied populations. The populations of Bagno Stawek, Jezioro Krąg, and Mechowisko Radość (Pomerania) showed clear distinction from the other populations. The remaining populations form a relatively compact group, in which there is little overlap between the individuals from the populations (Figure 149).

The analysis of UPGMA clusters based on AFLP markers and Nei & Li's genetic distances (1979) between Saxifraga hirculus individuals showed a differentiation between the populations of Saxifraga hirculus. However, the fundamental division into main groups is supported by very low bootstrap values (below 50%), which indicates a generally high mutual similarity between the studied populations. On the other hand, the genetic distinctiveness of the population is very strong and is supported by high bootstrap values at this level. This indicates that individual populations form compact groups with a characteristic genetic pool (Figure 150).

The AFLP 8 method analysis of the population showed, on the one hand, a relatively high level of variability in populations from Poland. At the same time, the analyses have shown that individuals in a given population are more similar to each other than to individuals in other populations. In particular, the results of the Bayesian analysis showed that the majority of the population (6) is characterized by a separate genetic pool.

Analysis of data obtained by DNA sequencing

The analysis covered 36 individuals, including: BS pop. 5 individuals; JK pop. 5 individuals; MD pop. 3 individuals; MR pop. 4 individuals; PO pop. 5 individuals; SM pop. 5 individuals; TK pop. 5 individuals; and ZS pop. 4 individuals. The results of the work on the species Saxifraga hirculus (Oliver et al. 2006) were taken into account when selecting the primers.

The analysis was carried out in two stages:

1. first stage: on the samples selected for the pilot study, tests of fragments of chloroplastic (cpDNA) and nuclear (ITS) DNA were performed – the quality of PCR products for particular fragments was verified,
2. fundamental stage: sequencing analysis was performed for three cpDNA fragments – atpB-rbcL, trnD-trnT, trnL-trnF – for which nucleotide polymorphism was observed in the surveyed material.

DNA amplification was performed with the AmpliTaq polymerase (Applied Biosystems). Sequencing was performed with BigDay Terminator ver. 3.1 (Applied Biosystems) according to the manufacturer's protocol. The amplicons were sequenced in two directions to confirm the observed differences in nucleotide alignment in the sequences.

After suspending the sample in formamide, the separation was carried out using the ABI Prism 3130 capillary genetic analyser (Applied Biosystems), on the polymer POP-7. The obtained sequences were developed using BioEdit 7.1.3. The results were analyzed using the following TCS 1.21 programs

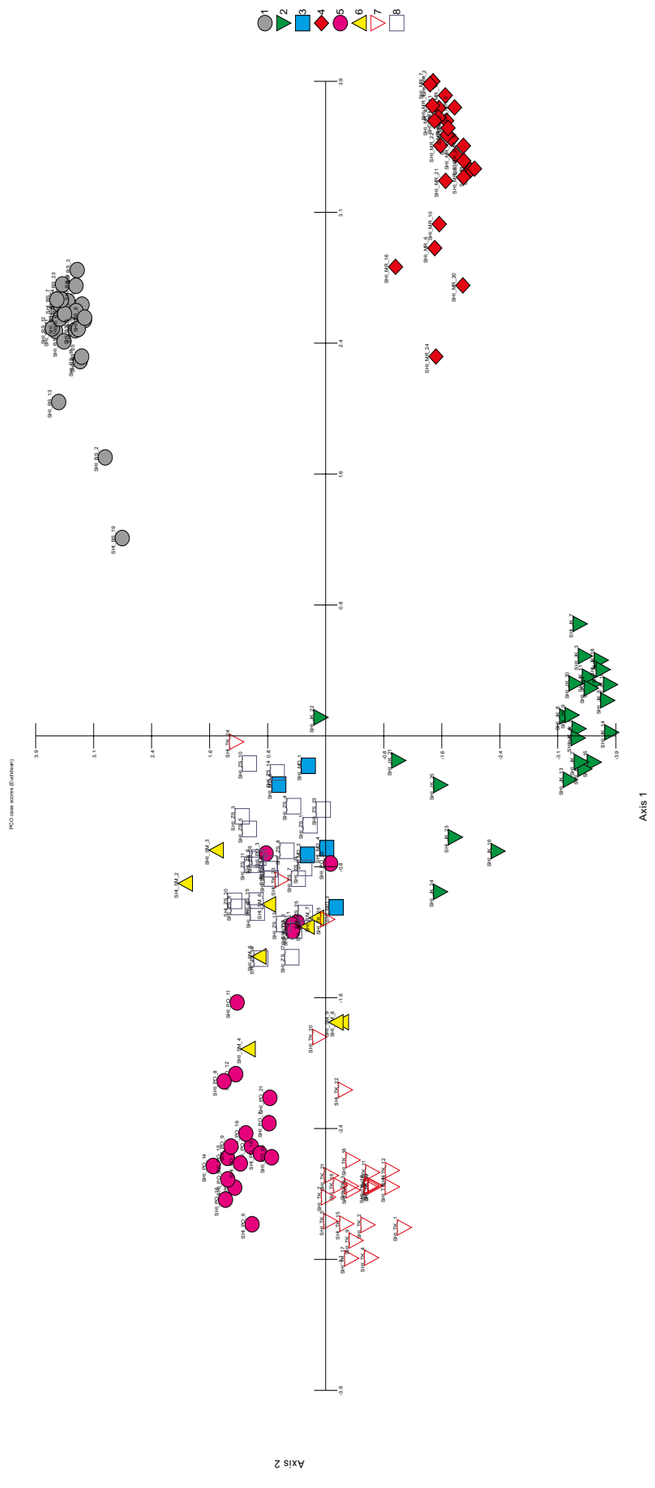


Fig. 149. Principal Coordinate Analysis (PCoA) based on the genetic distance matrix (Nei & Li's ratio) – scatter diagram of 159 Saxifraga hirculus individuals relative to axes 1 and 2. 1-BS, 2-JK, 3-MD, 4-MR, 5-Po, 6-SM, 7-TK, 8-ZS.

(Clement et al. 2005; TCS. 2005; TCS: Phylogenetic network estimation using statistical parsimony) 7.1.3. and Mega 5.1 (Tamura et al. 2007).

Genetic variability was analyzed on the basis of results of three fragments of cp DNA: atpB-rbcL, trnL-trnF, and trnD-trnT; the sequence length of these fragments was 2496 pairs of bases including atpB-rbcL–781 pz, trnL-trnF–799 pz, and trnD-trnT–916 pz. Seven mutations representing single-nucleotide substitutions (1-transfer and three transitions) and deletion/insertion-type mutations (one single-nucleotide and two fragments of several nucleotides) have been identified.

In the analysis of genetic variability of 36 individuals, two dominant haplotypes h2 and h4 were found, which occurred in more than one population. Additionally, 6 individual haplotypes (occurring in only one population) were found. Haplotype h2 was present in three populations and always in connection with other haplotypes (h3, h4 and h7). In three populations, only one haplotype was recorded, including PO and SM (Suwałki Lake District) – h4 and BS (Pomerania) – h1. This haplotype, h4, was also present in subsequent populations of TK and ZS, but in connection with other haplotypes (h2 and h7) (Table 5). The network of haplotypes definitely indicates the lack of differentiation of groups of haplotypes. Most haplotypes have a direct connection to the h2 haplotype (except for h6, h8, and h9). In the analysis of genetic variability by NJ method, individuals were assigned to two groups; however, this division is not statistically significant as it is supported by low bootstrap values (39) (Fig. 13). The first group was represented by 18 individuals, including 11 from the Suwałki Lake District – PO, SM, ZS, 4 individuals from the South Pomeranian Lake District – MR, and 3 individuals from the Chełmińsko-Dobrzyńskie Lake District – TK. In this group, the MR population forms a separate cluster. In the second group, 13 individuals from the population of the South Pomeranian Lake District were recorded – BS, JK and MD, and 2 from the Chełmińsko-Dobrzyńskie Lake District – TK, and 3 from Suwalskie Lake District – ZS. In the second group, individuals from the BS population form a separate cluster.

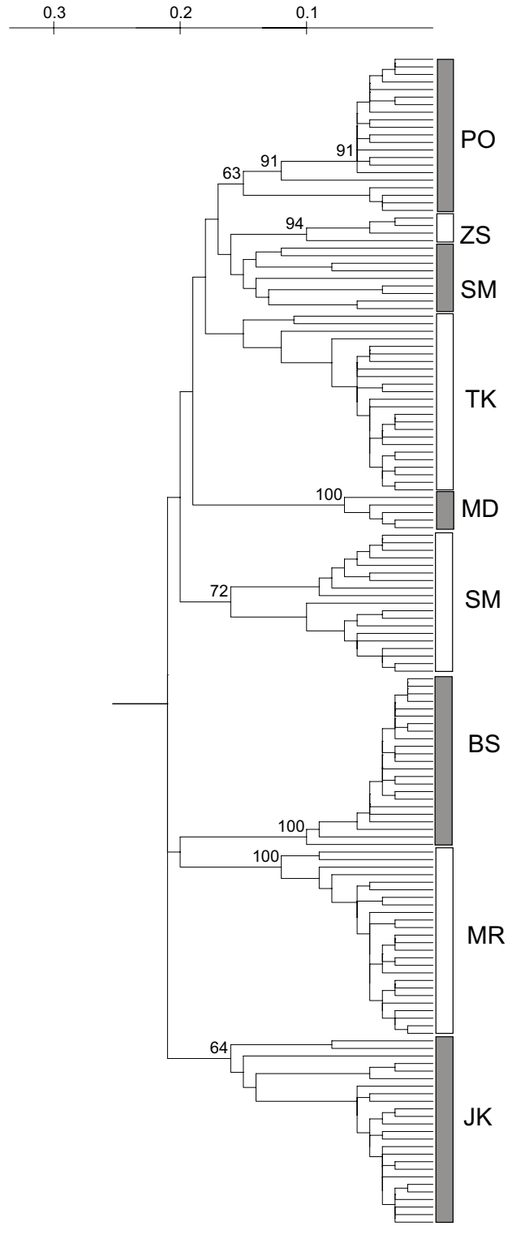


Fig. 150. Cluster analysis of 159 Saxifraga hirculus individuals based on AFLP analysis and genetic distances (Nei & Li's ratio) using the UPGMA method.

Table 15. Distribution of cpDNA haplotypes of three fragments – atpB-rbcL; trnL-trnF; trnD-trnT – in populations of *Saxifraga hirculus*. h – haplotypes present in only one population; h, h – haplotypes present in more than one population. Codes of the populations - see table 11.

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Population code	haplotype
TK	h2(2), h4(2), h7(1)
ZS	h2(3), h4(1)
PO	h4(5)
SM	h4(5)
BS	h1(5)
JK	h2(4), h3(1)
MD	h6(2), h5(1)
MR	h8(3), h9(1)

Molecular analyses showed that the studied populations of Saxifraga hirculus in Poland are characterized by a relatively high level of genetic variability. Lower values obtained for the population Jez. Małe Długie (MD) results from a very low number of individuals (5) compared to other populations (23 – 25). In the case of AFLP analysis, there were no statistically significant differences in the level of genetic variability in populations, whereas in the case of sequencing analysis, populations from the Southern Pomeranian Lake District were characterized by a much higher level of haplotype variability (including haplotype(s) characteristic for only one population) than from the Suwałki Lake District.

Neither of the methods have shown a strong correlation between genetic diversity and geographical location. However, the results of PCO and cluster analyses clearly indicate a very even level of variability within the population and a high mutual similarity of individuals within the population. In the case of Saxifraga hirculus, it appears that the biology of the species – in particular the presence of vegetative and generative reproduction – is the main influence on the level and pattern of genetic diversity. Field observations show that most probably, in this species in Poland, there is a predominance of vegetative reproduction. Additionally, a very low level of gene flow (Nm = 0.6) indicates that genetic processes may occur in populations, i.e., genetic drift, inbreeding, which increases the level of genetic diversity between them.

In order to preserve the genetic structure of Saxifraga hirculus, although there is no close correlation between genetic and geographical distance, due to the observed differentiation between populations it was considered that individuals from a given population should first replenish the pools of the population from which they originate.

3.2.3. In vitro multiplication and growing from seeds

Disinfection of shoots

The explants were the tip parts of the shoots ca. 3 cm long that were taken from plants growing on natural sites. Several disinfection procedures have been applied due to the high level of infestation with exogenous and endogenous pathogens of plant tissues. The shoots were disinfected with PPM biocides (Plant Preservative Mixture, the isothiozolonebiocide, PPM™, Plant Cell Technology, Inc., USA) at concentrations of 0.2% or 2% or IEO (Respiratory Enzyme Inhibitor, preservative, contains a mixture of 5-chloro-2-methyl-2H-isothiazol-3-one and 2-methyl-2H-isothiazol-3-one, FloraLab, Poland) at a concentration of 0.05 – 0.1%, which was added to the medium before autoclaving. The shoots were laid out without additional disinfection, or with disinfection using the above-mentioned PPM biocide at a concentration of 2% or IEO at a concentration of 1%.

Pathogens (bacteria, fungi, cyanobacteria) were also controlled by sterilizing the shoots first in 70% ethanol for 1 min. and then in 10% Domestos solution (commercial preparation) for 5 or 10 or 15 min. They were then rinsed three times in sterile distilled water for 10 min. for each rinse. Disinfection of the implant was carried out in "baby jars" (20 ml of medium/jar) or on Petri dishes (2 or 3.5 cm in diameter) with Murashige and Skoog's medium (MS, 1962) with 3% sucrose or half ingredients of the medium and 2% sucrose, pH 5.8 and with the addition of 0.2% PPM or 0.1% IEO, which have been solidified with agar (0.6% Agar-agar, Merck, Germany). The cultures were placed in a phytotron in the temperature of 20 °C (68 °F) 16-h photoperiod and light intensity of 60 μM m^{-2} s^{-1}.

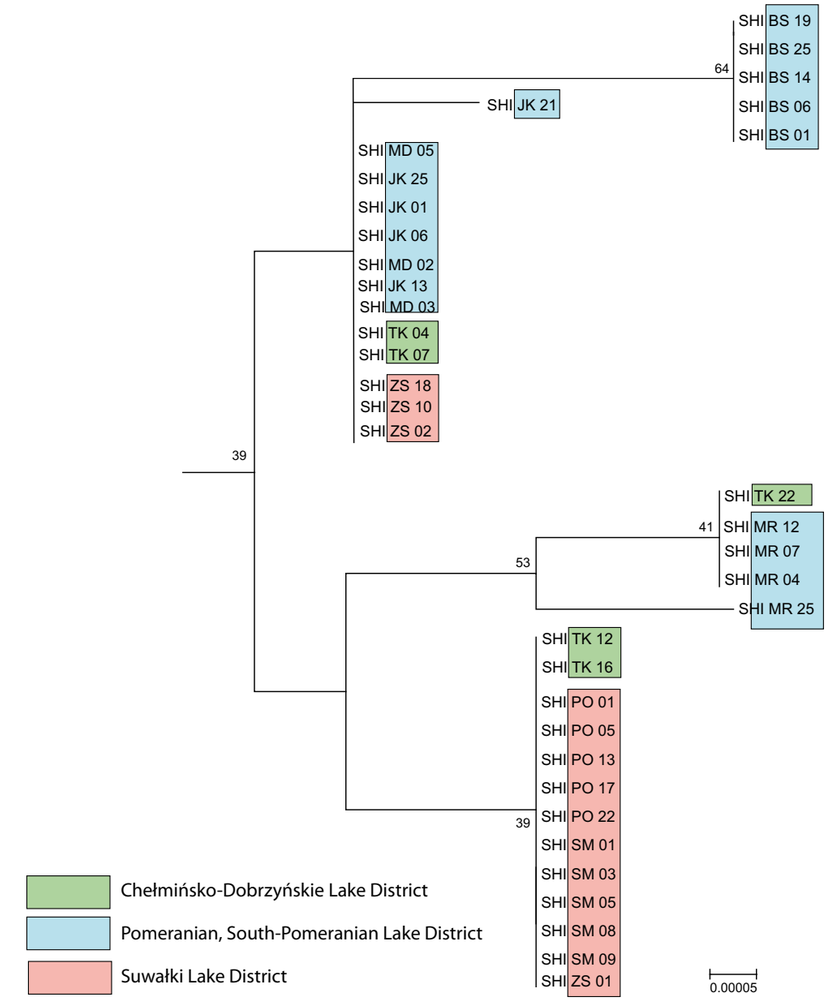

Fig. 151. Dendrogram obtained with the NJ method from cpDNA fragments for *Saxifraga hirculus*.

Due to the high presence of pathogens, the yellow marsh saxifrage explants were repeatedly sterilized with the alternating use of the biocide (soaking in 2% PPM with 1 addition of MS medium for 4 h) and traditional methods of disinfection (protocol with Domestos) and placed on media supplemented with biocide (MS media with 0.2% PPM or 0.1% IEO). In the end, the effect were individuals from three sites – Bagno Stawek, Jezioro Krąg i Żytkiejmska Struga – well adjusted to growth in in vitro cultures. 1 – 2 shoots from each location were disinfected and the longer shoots were cut into two parts. The obtained sterile specimens of Saxifraga hirculus were multiplied for the period of 5

Photo 114. Multiplication of *Saxifraga hirculus* shoots (photo M. Kędra).

– 6 months in order to obtain the seedlings needed for the subsequent reintroduction of the multiplied specimens to the natural environment conditions. In order to maintain the balance of the gene pool, no plant hormones have been introduced into the multiplication process. The number of plants multiplied in vitro in 2015 from the locations of Bagno Stawek (BS) is 15 cuttings, Jezioro Krąg (JK) – 18 cuttings and Żytkiejmska Struga (ZS) – 22 cuttings; each cutting had 2 – 3 shoots.

Disinfection of seeds

Various procedures were applied to disinfect the seeds of Saxifraga hirculus (average seed size 1 mm long x 0.5 mm wide). Disinfection with PPM at the concentration of 0.1% or 0.2%, which was added before autoclaving to 1/2 MS medium (MS containing 1.5% sucrose) with a pH of 5.8. The seeds were incubated directly without additional disinfection. Since pathogens appeared within 3 days of sowing, the method of their decontamination and introduction into sterile tissue cultures was modified. The seeds were soaked for 4 h or 24 h in 0.2% PPM and placed on a 1/2MS medium supplemented with 0.1% or 0.2% PPM. Large and small seeds were sown.

Standard disinfection with 70% ethanol for 1 min. was also used, followed by 10% Domestos solution (commercial preparation) for 5 min. Next, the seeds were washed five times in sterile distilled water (5 min. each) and placed on Murashige and Skoog's medium (1962) with 3% sucrose and pH 5.8, or on medium with half of all ingredients (1/2 MS), pH 5.8. All media were solidified with agar (0.6%, Agar-agar, Merck, Germany), sterilized in the autoclave, at 121 °C, under the pressure of 1 bar, for 20 min. The seeds were incubated on Petri dishes (diameter 2 cm or 5.5 cm) and placed in a phytotron at a temperature of 20 °C, a 16-h photoperiod, and light intensity of 60 μmol m^{-2} s^{-1}.

Growing *Saxifraga hirculus* from seeds

As a follow-up to in vitro breeding, part of the seeds collected at the end of the 2014 growing season were used for breeding using the classic method. All seeds intended for this purpose were stratified in the temperature of ca. 5°C for a period of 5 mos. Subsequently, seeds from each population (divided into patches in which the seed capsules were collected) were broken down into 2 groups – fully formed and others. All were placed on filter paper on Petri dishes in a breeding room at a temperature of about 17 °C, and under lighting conditions of 18/6 h and watered with deionised water every 3 – 4 d. Germination started on 28.02.2015, while the first germinating seeds were found on 13.03.2015 (Fig. 150). The germinating specimens of the yellow marsh saxifrage were then transferred to 27 mm diameter

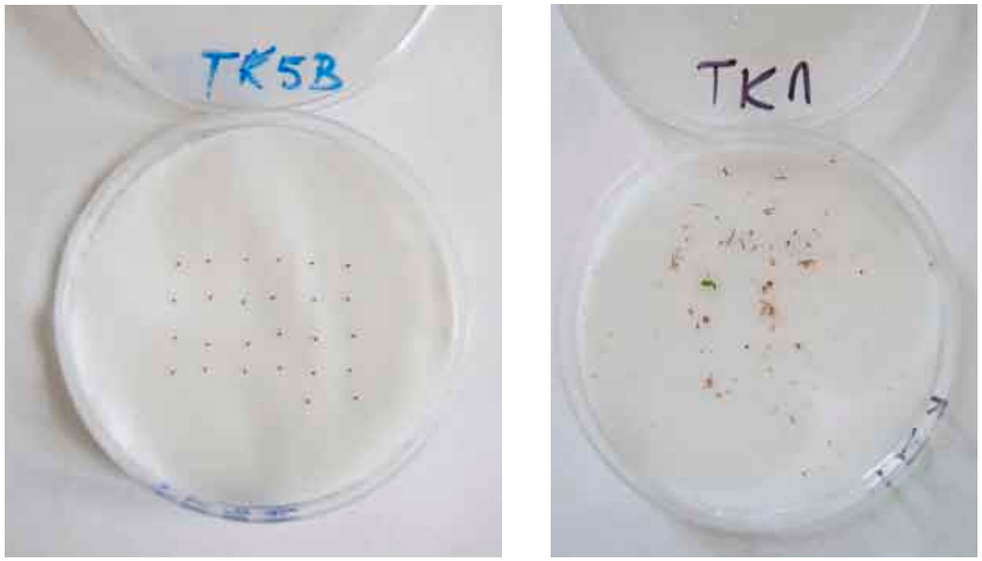

Photo 115. Seeds selected for germination and germinated on Petri dishes (photo J. Bloch – Orłowska).

Photo 116. Germinated specimens transplanted into peat discs (photo J. Bloch – Orłowska).

Photo 117. Young plants transplanted into pots filled with peat substrate (photo J. Bloch-Orłowska).

Table 16. Number of seeds and young grown specimens of *Saxifraga hirculus* from individual populations.

Population	Number of large seeds on Petri dishes	Number of specimens on peat discs	Number of young plants in pots
Bagno Stawek (BS)	52	5	1
Jez. Krąg (JK)	1	1	1
Jez. Małe Długie (MD)	0	-	-
Mechowisko Radość (MR)	11	5	3
Poszeszupie (PO)	2	2	0
Sawonia-Mostek (SM)	70	13	6
Torfowisko Kopaniarze (TK)	188	34	8
Żytkiejmska Struga (ZS)	80	13	5
Total	**404**	**73 (18%)**	**24 (6%)**

Presspoto-type peat discs and kept under the same breeding conditions. The peat discs were placed in labeled boxes covered with "breathing" food foil (Fig. 151). After the plants produced young shoots, they were transplanted individually (together with the peat disc) into small pots filled with de-acidified peat (pH 7.2 – 7.5). Each pot with a young plant was marked (specimen number, population) and then placed in a breeding tray covered from above with foil. The lighting and irrigation conditions remained unchanged (Fig. 152).

The percentage of germinating seeds was small, in total it amounted to 18% (Table 6). With the exception of two cases, germination was observed only on the dishes with large seeds. Additional difficulties included fungal hyphae appearing mainly at the stage of germination and early growth on peat discs.

The obtained young specimens of the yellow marsh saxifrage originated from 6 populations, including 3 from Pomerania (Bagno Stawek, Jezioro Krąg, and Mechowisko Radość) and 3 from south-eastern Poland (Sawonia-Mostek, Żytkiejmska Struga, and Torfowisko Kopaniarze). In the case of the Pomeranian site Jezioro Małe Długie, there were no large, fully-formed seeds, while in the case of the Poszeszupie population – the material consisted of 2 large seeds that withered at an early stage of development on the peat discs. The small number of specimens obtained in the breeding process confirm the previous literature data on difficulties in breeding and multiplying the yellow marsh saxifrage.

Due to the small number of specimens of *Saxifraga hirculus* obtained from both seed growing and in vitro multiplication, as well as the fact that the obtained specimens originate from only a part of the population, it was considered appropriate to include only those populations from which progeny were derived, while disregarding the populations indicated in the project for reintroduction. The aim of this measure was to increase the chances of survival of the cultivated plants.

3.3. Reintroduction of cultivated specimens into natural populations

Adaptation of grown seedlings for planting into the natural environment

All young specimens of the yellow marsh saxifrage were cold hardened in order to prepare them for planting in the natural environment. In the case of specimens from in vitro multiplication, preliminary cold hardening was carried out in Krakow. At the end of June 2015, these specimens were sent to Gdańsk for further adaptation and for planting on fens. At the end, as a result of in vitro multiplication, 54 specimens were obtained from the material collected from 3 populations.

At the same time, breeding of yellow marsh saxifrage specimens from seeds continued in the Biological Station of the Faculty of Biology of the University of Gdańsk. In the initial stage of hardening, the top cover foil of the potted plants was removed from the cultivation tray. After a few days, the young plants, with a relatively well-developed above-ground shoot, were moved from the laboratory to the garden, to a location partially shielded by trees. A total of 45 specimens, representing 6 populations, were grown from seeds and moved to garden conditions. The plants remained in the garden until the end of September 2015. During this time, all specimens (both from in vitro and seeds) were watered every few days; their vitality and condition were also monitored (cf. Fig. 18). Unfortunately, some of the plants could not be kept, mainly due to fungal pathogens and pests (aphids).

Reintroduction of grown plants into the natural subpopulations

Due to the small number of specimens finally obtained as a result of in vitro multiplication and seed breeding, it was decided to reintroduce them only to the sites from which the material for multiplication originated, without reintroduction to additional sites. The reintroduction was carried out on 30.08.2015 (for the Kopaniarze site) and 26 – 30.09.2015 (other sites).

New plants were introduced in small clusters (usually 3 – 4 specimens) not far from the existing populations of the yellow marsh saxifrage, in places with similar habitat conditions favorable for this species. Each of the formed patches was located

Photo 118 a, b. Marking of the patch to be reintroduced (photo J. Bloch-Orłowska).

with the use of GPS, numbered (as a continuation of the numbering of patches found at the locations in previous years), and permanently marked with bamboo poles. Additionally, each of the reintroduced specimens was marked with a small bamboo stick, with a number corresponding to the number of the specimen from the laboratory breeding stage (photo 118 a, b). The specimens were planted by hand. In addition, in the immediate vicinity (within a radius of approximately 20 cm) of their reintroduction, the above-ground shoots of neighbouring vascular plants were cut and removed in order to restrict competition and improve access to light.

Complementary multiplication and reintroduction of cultivated yellow marsh saxifrage specimens

At the end of 2016, after obtaining the consent of the General Director for Environmental Protection, material was collected from two Pomeranian yellow marsh saxifrage populations in the Bagno Stawek and Mechowisko Krąg Reserves for in vitro multiplication and reintroduction. The methodology was in line with the one previously adopted and described above. The obtained specimens were planted in 2 sites, where Saxifraga hirculus did not occur – the Dolina Kulawy and Mechowiska Sulęczyńskie Reserves, and also as additional reinforcement of the population at Jezioro Krąg and Bagno Stawek – as distinct subpopulations. Due to the very rainy summer and, above all, the effects of the storm of 11 August 2017, and the fact that some of the fens covered by the project were located in areas where access to the forest was prohibited, additional reintroductions were made at the end of the growing season, i.e., in October 2017.

Table 17 presents the list of patches formed at particular locations. Plants planted at the locations of Dolina Kulawy and Dolina Kulawy2 came from the multiplication of material from the Bagno Stawek Reserve, while the plants planted in the locations of Mechowiska Sulęczyńskie and Mechowiska Sulęczyńskie2 – from the Mechowisko Krąg Reserve.

Table 17. Number of yellow marsh saxifrage patches originating from reintroduction at individual sites covered by the project.

Location	Number of created patches	Total number of reintroduced specimens
Bagno Stawek 2	4	19
Dolina Kulawy	4	16
Dolina Kulawy 2	4	15
Jezioro Krąg	3	11
Jezioro Krąg 2	3	8
Mechowiska Sulęczyńskie	3	9
Mechowiska Sulęczyńskie 2	3	8
Total	24	86

Photo 119. *Saxifraga hirculus* in the reserve „Mechowisko Radość" (photo R. Stańko).

3.4. Methodology and monitoring results

Joanna Bloch-Orłowska, Magdalena Makowska

The presented results of the subsequent stages confirm that the yellow marsh saxifrage is a species difficult to multiply and maintain in breeding. The reasons for the small number of plants obtained for reintroduction should be attributed to the limited vitality and weak germination power of seeds, observed both during in vitro multiplication and in traditional breeding, as well as in the high mortality of seedlings and young specimens at different stages of their development. The withering of plants was additionally exacerbated by the presence of fungal pathogens that were difficult to remove, as well as occasional occurrence of pests (aphids) that weakened the condition of the cultivated plants.

As a result of in vitro multiplication and partially of the growing from seeds, a total of 143 specimens of yellow marsh saxifrage were finally obtained. As a result of their reintroduction, 13 species occurrence locations were created, i.e., 13 subpopulations located in 8 fens in northern Poland. In most cases it was a contribution to the existing yellow marsh saxifrage populations, whereas in the Dolina Kulawy and Mechowiska Sulęczyńskie Reserves it was the introduction of a species which did not occur there at the time (Table 18). The layout of the subpopulation's patches adopted at the time of planting was similar to the natural occurrence of the species.

One of the final measures within the described project was the monitoring of the yellow marsh saxifrage populations. It was carried out during the period of full flowering of the tested species between 22 July and 14 August 2016, and also for selected populations at the end of the 2017 growing season. The monitoring included field visits of all the existing Saxifraga hirculus populations covered by the project, and included determination of the number (number of flowering shoots) of both „natural" populations that developed spontaneously at the given sites, and of patches that were formed as a result of reintroducing plants from seed or in vitro multiplication. At the same time, the general habitat conditions at the sites were defined for the year. In general, yellow marsh saxifrage populations were visited at 8 sites, including 6 reinforced in 2015: Bagno Stawek, Jezioro Krąg, Mechowisko Radość, Torfowisko Ko-

Table 18. List of the *Saxifraga hirculus* populations reintroduced in 2015 – 2017.

Location	Number of patches	Total number of specimens	Initial population
Bagno Stawek	5	19	Bagno Stawek
Bagno Stawek 2	4	19	Bagno Stawek
Dolina Kulawy	4	16	Bagno Stawek
Dolina Kulawy 2	4	15	Bagno Stawek
Jezioro Krąg	6	20	Jezioro Krąg
Jezioro Krąg 2	3	8	Jezioro Krąg
Torfowisko Kopaniarze	2	7	Torfowisko Kopaniarze
Mechowiska Sulęczyńskie	3	9	Jezioro Krąg
Mechowiska Sulęczyńskie 2	3	8	Jezioro Krąg
Mechowisko Radość	1	3	Mechowisko Radość
Sawonia-Mostek	1	5	Sawonia – Mostek
Żytkiejmska Struga	1	14	Żytkiejmska Struga
Total	40	143	

Table 19. Number of yellow marsh saxifrage patches originating from reintroduction at individual sites covered by the project.

Location	Number of specimens reintroduced in 2015	Number of specimens in 2016	"success" in 2016 (%)
Bagno Stawek	19	8	42
Jezioro Krąg	9	5	55
Mechowisko Radość	3	3	100
Torfowisko Kopaniarze	7	2	28
Sawonia-Mostek	5	1	20
Struga Żytkiejmska	14	4	28

paniarze, Żytkiejmska Struga, and Sawonia-Mostek, as well as the 2 remaining sites in the project: Jezioro Małe Długie and Poszeszupie.

Populations of Saxifraga hirculus were found at all the sites included in the study. At the same time, the presence of specimens from cultivation or multiplication was confirmed at all sites of reintroduction, although their numbers varied (Table 19).

On average, the success rate for reintroducing Saxifraga hirculus specimens was 33%, while in individual patches it ranged from 0 to 100%. The number of flowering shoots observed in the last two years was variable. At most of the surveyed sites, especially the Struga Żytkiejmska, Sawonia-Mostek, Poszeszupie, and Kopaniarze Reserves, but also in the Jezioro Krąg Reserve, in 2016 a smaller number of flowering shoots was observed in relation to the previous year, which may indicate that that year was not a particularly good one for the species. At the same time, the number of reintroduced specimens that survived at these sites did not exceed 48%. In the remaining fens, where plants were reintroduced, the situation was varied – in the Bagno Stawek Reserve the number of flowering shoots was higher than in the previous year, while only 42% of the inhabited specimens survived, while in the Mechowisko Radość Reserve, despite the small number of planted specimens (N = 3), all grew roots, and at the same time the „natural" population produced more flowering shoots than in 2015 (cf. Fig. 152).

In the case of 2 sites – the fens of Kopaniarze and near Sawonia-Mostek – the low number of specimens that survived until 2016 was affected by the inability to find some of the patches, caused by the disappearance of the patches in the field (in the case of GPS accuracy of about 3 – 5 meters, it is not always possible to find small, several centimeter barren shoots among the layers of taller plants). Additional unfavorable factors were, in some cases, the high water level at the fen (especially near Sawonia-Mostek; some patches were practically flooded) as well as the persistent overgrowing process by taller herbaceous plants (especially in the case of the fens: Kopaniarze, near Poszeszupie, and by Lake Małe Długie). The size of the reintroduced specimens that survived until 2016 varied, as had been the case at the time of planting in 2015.

The results of observations of the specimens of yellow marsh saxifrage from the reintroduced patches at Bagno Stawek and Jezioro Krąg sites, which were also monitored in 2017 due to additional work in the project, indicate that the majority of plants that survived 1 year after their establishment continued in the following year (cf. Fig. 153).

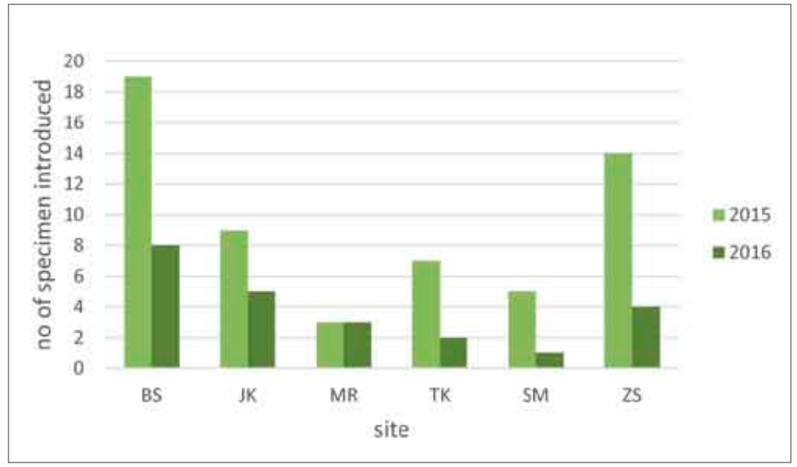

Fig. 152. Number of reintroduced yellow marsh saxifrage specimens at the sites surveyed at the time of planting (2015) and after one-year monitoring (2016).

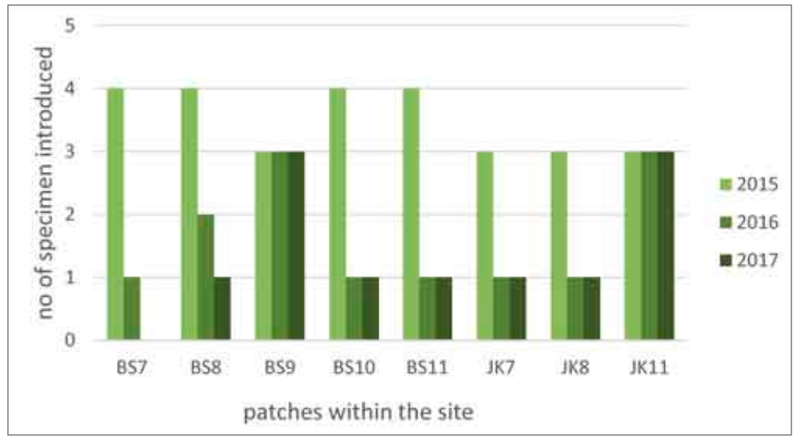

Fig. 153. Changes in the number of reintroduced specimens of yellow marsh saxifrage in subsequent years, in individual patches at the sites of Bagno Stawek (BS) and Jezioro Krąg (JK).

3.5. Conclusions

The natural populations of *Saxifraga hirculus* covered by the project were characterized by high population variability (measured by the number of flowering shoots). These differences were visible both between populations and in relation to individual populations in subsequent years.

Molecular analyses showed that the studied populations of Saxifraga hirculus in Poland are characterized by a relatively high level of genetic variability. In the case of AFLP analysis, there were no statistically significant differences in the level of genetic variability in populations, whereas in the case of sequencing analysis, populations from the Pomeranian region were characterized by a much higher level of haplotype variability (including haplotypes characteristic for only one population) than from the Suwałki Lake District. Moreover, neither of the methods have shown a strong correlation between genetic diversity and geographical location. However, the results of PCO and cluster analyses clearly indicate a very even level of variability within the population and a high mutual similarity of individuals within the population. In the case of Saxifraga hirculus, it appears that the biology of the species, in particular the presence of vegetative and generative reproduction, is the main influence on the level and pattern of genetic diversity. Field observations show that, most probably in this species in Poland, there is a predominance of vegetative reproduction. Additionally, a very low level of gene flow indicates that genetic processes may occur in populations, e.g., genetic drift, inbreeding, which increase the level of genetic diversity between them.

The yellow marsh saxifrage is a plant which is difficult to multiply in vitro and to cultivate from seeds, as well as to maintain later in breeding. This is due to the limited vitality and low germination power of the seeds, as well as to the high mortality of seedlings and young specimens at different stages of development, which are sensitive to the presence of fungal pathogens that are difficult to remove, and occasional pests that weaken the condition of the cultivated seeds.

The mixed success of yellow marsh saxifrage reintroduction at the investigated fens is a result of several factors – the condition of the habitat on each of the fens, the condition of the planted specimens, random factors (animal activity, loss of surface markers), as well as the chimericity of the species emergence in different years. It would be advisable to further control the degree of population conservation in particular locations – both the "natural" part and the one resulting from the reintroduction. At the same time, it is very important to monitor habitat conditions and, where necessary, renew active protection measures, in particular shrub removal and mowing.

The results of the implemented activities indicate that the reintroduction method can be used as an active safety measure but that, due to its difficult implementation and limited effectiveness, it should rather be used in exceptional cases. The main efforts to improve the conservation status of this species in northern Poland should include the improvement of habitat and phytocenosis conditions in the fens where the yellow marsh saxifrage was found. This applies in particular to maintaining a stable level of groundwater, periodic mowing and the removal of tree and bush deposits, i.e., activities included in other tasks of the project.

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Herminium monorchis, Saxifraga hirculus, Liparis Loeselii, Juncus subnodulosus, Carex chordorrhiza, Carex dioica **- these are rare species in Poland and threatened with extinction. Their common feature is the occurrence on alkaline fens - specific wetland ecosystems fed with clean, groundwater, waters rich in calcium and magnesium salts. They are characterized by an extraordinary richness of flora, especially bryophytes, and most of the plants found there are species described in the Red Books of species threatend with extinction. Unfortunately, alkaline fens are disapearing in an alarming pace. Over the last two centuries, we have destroyed over 90% of their original area. We can observe the best preserved and the largest fens only in the upper Biebrza valley and the Rospuda valley. Despite the outstanding natural values, distinguishing our country from the rest of the Europe, an extremely important role in shaping the country's water resources and marginal importance for the agriculture, alkaline fens are still exposed to degradation! This publication presents how, in the last few years we have tried to save these valuable ecosystems. We hope that the activities described here will not only be in the future continued, but also extended to other areas.**

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