A GUIDEBOOK on Good Practices

of alkaline fen conservation

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1. Introduction

Robert Stańko

Alkaline fens in many ways stand out from the wetland ecosystems of Poland. The abundance of species found here, including rare, protected, and endangered species, are a delight not only for beginning botanists but also experienced florists. The hydroecological composition of alkaline fens is a challenge for every inquisitive naturalist who undertakes to protect them. Unfortunately, what distinguishes these valuable ecosystems is the dramatic rate of their disappearance. In the past, they were drained on a large scale and then abandoned. Now, further drained - often with ditches that serve no purpose whatsoever - they degrade and become overgrown with forest. Once destroyed, they cannot be recreated.

Alkaline fens have long been of particular interest to us, not only as research sites but also as a subject of protection. In this publication, we attempt to pass on our experience and knowledge gained over the past twenty years. We hope that it will serve all those involved in protecting alkaline fens to act more effectively.

2. General characteristics of alkaline fens

Lesław Wołejko, Robert Stańko, Paweł Pawlaczyk

The subject of this publication concerns the issues of protection of mountain and low alkaline fens in the group of flush fens, sedge and moss fens, i.e., the so-called natural habitat designated in the European Union[1] with the code 7230.

In the intention of the authors of the Habitats Directive, alkaline fens are identified (Moss and Davies 2002, European Commission 2013) as unit 54.2 in the Palearctic Habitat Classification (Devilliers and Devilliers-Terschuren 1996), currently identical with unit D4.1 in the so-called EUNIS Classification (Davies et al. 2004, European Environmental Agency 2017), corresponding to the paludological[2] definition of „*rich fens*"[3].

This habitat is described as follows: „*Wetlands and spring-mires, seasonally or permanently waterlogged, with a soligenous or topogenous base-rich, often calcareous water supply. Peat formation, when it occurs, depends on a permanently high water table. Rich fens may be dominated by small or larger graminoids (Carex spp., Eleocharis spp., Juncus spp., Molinia caerulea, Phragmites australis, Schoenus spp., Sesleria spp.) or tall herbs (e.g. Eupatorium cannabinum). Where the water is base-rich but nutrient-poor, small sedges usually dominate the mire vegetation, together with a „brown moss" carpet. Hard-water spring mires often contain tufa cones and other tufa deposits. Excluded is the water body of hard-water springs; calcareous flushes of the alpine zone are a separate category.*" The main features identifying this type of ecosystem are therefore: fen-like character, groundwater supply (shallow or deep), and alkalinity of the water supply.

1 The term „natural habitat", used in the jargon and legal language of the European Union, currently widely accepted and introduced into Polish law, means "land or water area, natural, semi-natural or anthropogenic, distinguished by its geographical, abiotic and biotic features"; an ecosystem associated with a specific fragment of biogeographical space; biogeocenosis. Habitat type codes were introduced in the so-called EU Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora).

2 Paludology – the study of swamps (lat. *palus*, *paludis* = swamp and gr. *logos* = science), a branch of ecology concerned with wetlands.

3 The word *rich* can also mean *fertile* – in this context it refers to the abundance of the species of vegetation rather than to fertility. Typical „rich fens" are not „fertile" in the common sense, or at least biogenic nutrients are not available for plants.

The criterion distinguishing alkaline fens from other low fens supplied by surface water (EUNIS D.5, mostly[4] not included in the Annex to the Habitats Directive) is the groundwater supply. The criterion distinguishing alkaline fens from acidic fens (EUNIS D.2, partly not included in the Annex to the Habitats Directive and partly constituting a natural habitat with code 7140) is the reaction of supply waters.

The central, most typical form of alkaline fens, where its specific features are most visible, are the so-called moss fens, i.e., alkaline fens with vegetation dominated by brown mosses and low sedges. The condition for the development of this form of ecosystem is the alkalinity of supply water and its low fertility, i.e., the low availability of biogenic nutrients to plants (which may result from the reduction of this availability as a result of specific biogeochemical processes, see chapter 3). The description of habitat 7230 in the Interpretation Manual of European Union Habitats (European Commission 2013) refers to this most typical habitat form: „*Wetlands mostly or largely occupied by peat- or tufa-producing small sedge and brown moss communities developed on soils permanently waterlogged, with a soligenous or topogenous base rich, often calcareous water supply, and with the water table at, or slightly above or below, the substratum. Peat formation, when it occurs, is infra-aquatic. Calciphile small sedges and other Cyperaceae usually dominate the mire communities, which belong to the Caricion davallianae, characterized by a usually prominent „brown moss" carpet formed by Campylium stellatum, Drepanocladus intermedius, D. revolvens, Cratoneuron commutatum, Acrocladium cuspidatum, Ctenidium molluscum, Fissidens adianthoides, Bryum pseudotriquetrum and others, a grass-like growth of Schoenus nigricans, S. ferrugineus, Eriophorum latifolium, Carex davalliana, C. flava, C. lepidocarpa, C. hostiana, C. panicea, Juncus subnodulosus, Scirpus cespitosus, Eleocharis quinqueflora, and a very rich herbaceous flora including Tofieldia calyculata, Dactylorhiza incarnata, D. traunsteineri, D. traunsteinerioides, D. russowii, D. majalis ssp. brevifolia, D. cruenta, Liparis loeselii, Herminium monorchis, Epipactis palustris, Pinguicula vulgaris, Pedicularis sceptrum-carolinum, Primula farinosa, Swertia perennis*", however noting correctly that, "*Wet grasslands (Molinietalia caerulaea, e.g., Juncetum subnodulosi & Cirsietum rivularis), tall sedge beds (Magnocaricion), reed formations (Phragmition), fen sedge beds (Cladietum mariscae), may form part of the fen system, with communities related to transition mires or spring communities.*"

4 Excluding the calcareous fens included in Annex I – natural habitat 7210.

Also in the Polish literature, the description of the natural habitat „alkaline fens of spring fen, sedge fen and moss fen characteristics (7230)" according to the „Manual for recognizing habitats and species of Natura 2000" edited by J. Herbich (Herbichowa & Wołejko 2004) focuses on this typical form: *„meso- and meso-oligotrophic, poorly acidic, neutral and alkaline flush fens, low spring and flow-through fens, supplied by groundwaters, abundant or very abundant in alkalisa, covered by diverse, geographically diverse, peat producing moss and low sedge communities (moss fens), in part with an outstanding proportion of calcicole species, including those growing outside or near the edges of continuous geographical ranges."*

However, moss fens are not the only possible form of alkaline fens.

In the popular classification, though abandoned in professional paludology, which divides peatlands in Polish nomenclature into „low", „high" and „transition"[5], alkaline fens are a special type of the so-called "low" peatlands. For a layman, however, this is not obvious at all. On the one hand, some spring fens are not flat and low at all, but they can form clearly visible domes – which is a morphological feature common with "high" peatlands (raised bogs), although of course the vegetation is completely different and these types of mires cannot be confused. On the other hand, the vegetation of typical, moss forms of alkaline fens – with the dominance of low sedges with dense brown moss carpets, sometimes also peat mosses – resembles transition mires, which is the reason for the frequent mistakes in diagnoses (cf., Table 2). Also, moss and moss-sedge peats accumulated by alkaline fens due to the mixing of moss and sedge residues are sometimes misidentified as „transition peats".

Current fen classifications are based on their location and water supply characteristics. Alkaline fens are divided into soligenous, percolating and spring fens, which will be discussed further in this chapter.

Alkaline fens are found across almost all of Europe (Jiménez-Alfaro et al. 2014, European Environmental Agency 2018), although in the different biogeographical regions they can take on slightly different forms and flora compositions. The Alpine biogeographical region is considered to be the area where they take the most typical and „textbook" form, bringing together plant species from the *Caricion davallianae* alliance (Jiménez-Alfaro et al. 2014), which is not always the case in other regions.

In Poland, habitat 7230 is found in lower-mountain and upland locations and in the entire lowlands, although the most numerous locations are in its northern part (Koczur 2012, Wołejko et al. 2012, Stańko et al. 2015c). Numerous, though

5 The English names for those types of peatlands are not adequate to show how Polish jargon can be misleading. That is why authors decided to keep direct translation from Polish and not to use corresponding English nomenclature used worldwide – though it would be more appropriate.

small, alkaline fens can be found in the Polish part of the Carpathians, rich in limestone, e.g., in the Black Orava catchment area (Kiaszewicz & Stańko 2010), in the Pieniny and Gorce (Stańko & Horabik 2015), and in the Nida Basin area (Przemyski & Wołejko 2011), the Lublin region (Dobrowolski et al. 2016), and the Low Beskids.

Due to regional differences in topographic, geological, and hydrogeological conditions related to the age of the landscape and dominant geomorphological processes as well as the nature of human influence, it was proposed (Herbichowa & Wołejko 2004) to divide habitat 7230 in Poland into three subtypes:

- 7230-1 mountain flush fens,
- 7230-2 alkaline fens of southern Poland (excluding mountains) and central Poland,
- 7230-3 spring and percolating fens of northern Poland.

This is also partially reflected in the diversity of vegetation of these ecosystems (Stańko & Wołejko 2018).

Traditionally, the frequently used identifier of natural habitats is the phytosociological aspect of vegetation and indicator species of plants. The flora of alkaline fens as a habitat type is very rich, distinguishing them from other types of fens, e.g., "high" mires - raised bogs or most of the transition mires. Often, floral variety and the occurrence of floral peculiarities are features of individual patches, although not always. For alkaline fens, however, it is difficult to name appropriate phytosociological identifiers. The Matuszkiewicz syntaxonomic system (1984, 2018), commonly used in Poland and dating back several decades, treats fen vegetation very superficially (which the author himself admits), including a very poor grasp of alkaline fen vegetation. As a consequence, attempts (e.g. Koczur 2012) to indicate good phytosociological identifiers of natural habitat 7230 within its boundaries are doomed to fail.

The phytosociological knowledge of flush fen and moss fen vegetation has developed significantly in recent years, both in Europe (Hájek & Hájková 2011, Peterka et al. 2017) and in Poland itself (Wołejko 2000a, 2000b, Wołejko et al. 2008, Wołejko & Stańko 2018); it is still the subject of lively discussions and proposals for new approaches. In the newer catalogue of plant syntaxa of Poland, prepared by Ratyńska et al. (2010), the possibilities of indicating plant communities related to habitat 7230 are greater (cf., Table 1).

However, this approach also focuses on the typical form of alkaline fens – sedge - moss fens. Other forms of alkaline fens – particularly flush fens, spring fens, but also degradation forms, e.g., alkaline fens with meadow vegetation – generally do not have good phytosociological identifiers.

Floristic and phytosociological indicators are to some extent suitable for the identification of sedge-moss fens. All species characteristic of the *Caricion davallianae* vegetation alliance should be considered as typical for them. They are, for example, sedges: *Carex buxbaumii*, *C. davalliana, C. flava, C. lepidocarpa, C. panicea,* and also *Gentianella uliginosa*, *Polygala amarella, Eriophorum latifolium*, *Valeriana simplicifolia*, *Juncus subnodulosus, Schoenus ferrugineus*, *Eleocharis quinqueflora*, *Equisetum variegatum*, and *Juncus alpino-articulatus* (= *J. alpinus*). The characteristic species of the alliance, occurring (at least theoretically) in a greater number of communities, are: *Bryum pseudotriquetrum, Campylium stellatum*, sedges: *Carex flacca*, *C. hostiana, C. pulicaris*, orchids: *Dactylorhiza incarnata*, *D. majalis*, *Epipactis palustris*, *Liparis loeselii* and other *Fissidens adianthoides*, *Limprichtia cossonii*, *Parnassia palustris*, *Pinguicula vulgaris*, *Primula farinosa, Scorpidium scorpioides*, *Sesleria caerulea* (=*S. uliginosa*), *Swertia perennis*, *Tofieldia calyculata*, and *Valeriana dioica.* The presence of these species usually indicates a good conservation status of the ecosystems of particular alkaline fens.

However, most of the above species are not found solely on sedge-moss fens or alkaline fens in general and may also be found in other habitat types. For example, the species characteristic of the *Caricion davallianae* association also form a base of calcareous fen vegetation (code 7210); they can be found in the flora of the petrifying springs (7220) and they can also be found in *Molinia* meadows (6410).

The species of *Caricion davallianae* are more numerous in the alkaline fens of southern Poland, whereas in northern Poland their occurrence in this type of habitat is usually less pronounced (Herbichowa & Wołejko 2004) – which is in line with the results of the research of Jiménez-Alfaro et al. (2014), according to which *Caricion davallianae* species are mostly found on Alpine alkaline fens but are not necessarily so typical in the case of fens in other biogeographical regions of Europe.

Typical, but of course not exclusive for alkaline fens, are also the species characteristic for some higher syntaxa of the *Scheuchzerio-Caricetea fuscae* class; *e.g.*, *Baeothryon alpinum, Calliergon giganteum, Carex dioica*, *C. chordorrhiza, C. diandra, C. lasiocarpa, C. limosa, Cinclidium stygium, Eriophorum gracile*, *Hamatocaulis vernicosus*, *Helodium blandowii*, *Limprichtia revolvens, Meesia triquetra*, *Menyanthes trifoliata, Paludella squarrosa*, *Pseudocalliergon trifarium*, *Saxifraga hirculus*, peat mosses: *Sphagnum teres*, *S. warnstorfii, S. contortum, Stellaria crassifolia*, *Tomentypnum nitens*, *Pedicularis palustris*, *P. sceptrum-carolinum*, *Triglochin palustre*, and *Warnstorfia exannulata.*

The flora of alkaline fens is supplemented and often dominated by species representing other synecological groups, in particular reeds (*Phragmitetea* class), meadow *(Molinio-Arrhenatheretea*) and spring (*Montio-Cardaminetea* class) vegetation, but also alder wood *(Alnetea glutinosae*) species, and species associated with shalow l water bodies *(Utriculariete intermedio-minoris*), and even some bog species *(Oxycoc*). Vegetation of the alkaline fen can often take the form of large sedge rushes – particularly *Caricetum appropinquatae, Caricetum acutiformis, Caricetum paniculatae, Caricetum rostratae*, *Cladietum marisci*, *Phragmitetum australis, Urtico-Phragmitetum*, wet meadow *Angelico cirsietum oleracei*, *Cirsietum rivularis*, and even *Deschampsietum caespitosae* (Wołejko 2000a, Wołejko & Piotrowska 2011).

Typical species of mountain flush fens include: *Carex flava*, *C. panicea*, *Eriophorum latifolium*, *Epipactis palustris*, *Tofieldia calyculata*, *Carex davalliana*, *C. dioica*, *Valeriana simplicifolia* and the appearance is also affected by horsetails, clumpy sedges, *Eriophorum latifolium*, and *Crepis paludosa*. In general, however, it is not possible to give good, specific floristic or phytosociological identifiers for alkaline spring fens, including flush fens. Their vegetation is usually composed of species with wider ecological scales, and the *Caricion davallianae* species do not have to be present at all: in these cases, the ecology of the ecosystem, and not its vegetation, must be the key to identifying the 7230 habitat.

Photo 1: *Carex davalliana and Dactylorhiza majalis* (in the background) (photo R. Stańko).

Photo 2: *Carex lepidocarpa*
(photo K. Kiaszewicz).

Photo 3: *Carex panicea*
(photo K. Kiaszewicz).

Photo 4: *Schoenus ferrugineus* (photo E. Gutowska).

Photo 5: Flowering *Liparis loeselii,* on a moss fen dominated by *Paludella squarrosa* (photo R. Stańko).

Photo 6: *Saxifraga hirculus* (photo R. Stańko).

Photo 7: *Eleocharis quinqueflora* (photo R. Stańko).

Photo 8: *Juncus subnodulosus* (photo R. Stańko).

In terms of physiognomy, sedge-moss fens often stand out among river valley vegetation due to the low height of the sedge sward and the abundance of mosses – either the so-called brown mosses or brown and dark red peat mosses *(Sphagnum teres, S. warnstorfii*). Often from a distance, the multiple white fruits of *Eriophorum latifolium* are visible. In the spring, flowering orchids *Dactylorhiza sp. div*. are usually very numerous within the sedge-moss fens. A specific summer aspect of some fens may be associated with the flowering of the *Epipactis palustris* in huge numbers at some sites. Sometimes the sedge-moss fens in a river valley are marked by individual dwarf pines, visible from a distance.

In the mountain landscape, flush fens are often noticeable as clusters of white *Eriophorum latifolium* fruit.

However, in the appearance and composition of vegetation, some forms of alkaline fens may resemble wet meadows, sedge rushes, reed patches, or hills in a valley overgrown with reeds, willows and herbs, without at first sight revealing their nature. One physiognomic signal of the possible presence of an alkaline fen, or at least its historical remains, is the often abundant water, constantly flowing down from such places, coming from the groundwater supply.

Photo 9: Alkaline fens cover a wide range of highly diversified plant communities: from moss-dominant with barely noticeable vascular plants (photo (A) – Chłopiny Reserve), to communities dominated by high sedges with a mixture of bryophytes, sometimes on the border of meadow communities (photo (B) – fens of the upper part of the Słupia River) (photo R. Stańko).

Photo 10: *Sphagnum teres* (photo R. Stańko).

Photo 11: *Cinclidium stygium* (oval leaves) with *Paludella squarrosa* (photo R. Stańko).

Photo 12: *Pseudocalliergon trifarium* – a species associated with the most hydrated fragments of fens and the reservoirs found within them (photo R. Stańko).

Photo 13: Flowering *Dactylorhiza majalis* and *Menyanthes trifoliata* (on the right) (photo R. Stańko).

Photo 14: Flowering *Pedicularis palustris* surrounded by *Limprichtia cossonii* (photo R. Stańko).

Photo 15: *Carex chordorrhiza* (photo R. Stańko).

Photo 16: *Parnasia palustris* (photo R. Stańko).

Photo 17: *Paludella squarrosa* with *Helodium blandowii* and *Aulacomnium palustre* (photo R. Stańko).

Photo 18: *Hamatocaulis vernicosus* (photo R. Stańko).

Photo 19: *Tomentypnum nitens* (photo R. Stańko).

Photo 20: *Helodium blandowii* with *Paludella squarrosa* (photo R. Stańko).

Photo 21: *Scorpidium scorpioides* (photo R. Stańko).

Table 1. Syntaxonomy list and characteristics of plant communities typical for alkaline fens, but not an exhaustive list of all possible vegetation of alkaline fens (Ratyńska et al. 2010)

Cl. *Scheuchzerio-Caricetea fuscae* (Nordhagen 1936) R. Tx. 1937 (Syn.: *Carici-Drepanocladetea* Pałczyński 1975)
Ch. Cl.: *Agrostis canina*, *Carex dioica*, *C. nigra* (=*C. fusca*), *C. serotina*, *Comarum palustre*, *Dactylorhiza ruthei*, *Drepanocladus aduncus* (opt.), *D. sendtneri*, *Eriophorum angustifolium*, *Hamatocaulis vernicosus*, *Helodium blandowii*, *Polytrichum commune*, *Pseudocalliergon lycopodioides*, *Limprichtia revolvens*, *Sphagnum contortum*, *S. subsecundum*, *Warnstorfia exannulata*, *W. sarmentosa*
O. *Scheuchzerietalia palustris* Nordhagen 1936 (Syn.: *Eriophoretalia angustifolii* R. Tx. et al. 1972)
Ch. O.: *Baeothryon alpinum*, *Drosera anglica*, *D. intermedia*, *D.* x *obovata*, *Sphagnum angustifolium*, *S. fallax* (opt.), *S. flexuosum*, *S. inundatum*, *S. lindbergii*, *S. subnitens*, *Straminergon stramineum*, *Warnstorfia fluitans* et al. Ch. All. *et* Ass.; D. O.: *Drosera rotundifolia*, *Oxycoccus palustris*

Ass. *Caricion lasiocarpae* Vanden Berghen *in* Lebrun *et al.* 1949 (Syn.: *Eriophorion gracilis* Preising *in* Oberd. 1957, *Sphagno warnstorfiani-Tomenthypnion* Dahl 1957 *p.p.*)
Ch. All.: *Calliergon giganteum* (opt.), *Carex diandra*, *C. lasiocarpa*, *Cinclidium stygium*, *Eriophorum gracile*, *Meesia triquetra*, *Menyanthes trifoliata* (opt.), *Paludella squarrosa*, *Pseudocalliergon trifarium*, *Saxifraga hirculus*, *Sphagnum contortum*, *S. obtusum*, *S. riparium*, *S. teres*, *S. warnstorfii*, *Stellaria crassifolia*, *Tomentypnum nitens*; D. All.: *Carex rostrata*, *Lysimachia thyrsiflora*, *Peucedanum palustre, Ranunculus lingua* et al.
Caricetum lasiocarpae Osvald 1923 (Syn.: *Caricetum lasiocarpae* W. Koch 1926 nom. illeg., *Sphagno-Caricetum lasiocarpae* Steffen 1931 et al.) Ch. Ass.: *Carex lasiocarpa* (dom.)
Scorpidio-Caricetum diandrae Osvald 1923 nom. invers. et nom. mut. (Syn.: *Caricetum diandrae* Jonas 1932) Ch. Ass.: *Carex diandra* (opt.); D. Ass.: *Calliergonella cuspidata, Hamatocaulis vernicosus*
Menyantho-Sphagnetum teretis Warén 1926 Ch. Ass. (lok.): *Sphagnum teres* (opt.), *S. warnstorfii* (opt.) (Centr. Ass.)
Drepanoclado revolventis-Caricetum chordorrhizae Osvald 1925 nom. invers. et nom. mut. (Syn.: *Caricetum chordorrhizae* Paul et Lutz 1941) Ch. Ass.: *Carex chordorrhiza*
Ass. *Caricion davallianae* Klika 1934 (Syn.: *Caricion fuscae* W. Koch 1926 p.p.)
Ch. All.: *Bryum pseudotriquetrum* (F), *Campylium polygamum* (=*Drepanocladus polygamus*), *C. stellatum*, *Carex davalliana*, *C. flacca* (F), *C. flava, C. hostiana, C. lepidocarpa, C. pulicaris, Dactylorhiza incarnata, D. majalis* (opt.), , *Epipactis palustris, Eriophorum latifolium, Fissidens adianthoides, Juncus alpinus* fo., *Liparis loeselii, Parnassia palustris*, *Pinguicula vulgaris* (F), *Polygala amarella, Preissia quadrata, Limprichtia cossonii, Swertia perennis ssp. perennis*, *Tofieldia calyculata, Valeriana dioica* (opt.), *V. simplicifolia* et al. Ch. Ass.; D. All.: *Abietinella abietina, Briza media, Ctenidium molluscum, Linum catharticum* et al.
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.) Ch. Ass. (lok.): *Carex lepidocarpa, C. panicea* (dom./kodom.), *Gentianella uliginosa, Polygala amarella* (Centr. Ass.)

Caricetum davallianae Dutoit 1924 Ch. Ass.: *Carex davalliana* (opt.), *Swertia perennis*
Valeriano-Caricetum flavae Pawłowski 1949 ex 1960 Ch. Ass.: *Carex flava* (opt.), *C. lepidocarpa* (reg.), *Eriophorum latifolium, Valeriana simplicifolia*; D. Ass. (geogr.): *Cirsium rivulare*
Caricetum buekii Kopecký et Hejný 1965 Ch. Ass.: *Carex buekii* (dom.)
Juncetum subnodulosi (Allorge 1922) W. Koch 1926 (Syn.: *Schoeno nigricantis-Juncetum obtusiflori* Allorge 1922 nom. illeg. p.p., *Crepido-Juncetum subnodulosi* (Libbert 1932) Pass. 1964) Ch. Ass.: *Juncus subnodulosus* (=*J. obtusiflorus*) (opt.)
Schoenetum ferruginei Du Rietz 1925 (Syn.: *Schoenetum nigricantis* (Allorge 1922) W. Koch 1926 p.p., *Primulo farinosae-Schoenetum ferruginei* (W. Koch 1926) Oberd. 1957, *Schoenetum ferruginei* (Fijałkowski 1960) Pałczyński 1966 nom. illeg., *Lipario-Schoenetum ferruginei* Głazek 1992 nom. inval.) Ch. Ass.: *Schoenus ferrugineus* (dom.)
Caricetum hartmannii Denisiuk 1967 Ch. Ass.: *Carex hartmannii* (opt.)
Caricetum buxbaumii Issler 1932 Ch. Ass.: *Carex buxbaumii* (opt.)
Eleocharitetum pauciflorae Lüdi 1921 (Syn. i Pseud.: *Eleocharitetum quinqueflorae* auct. nom. illeg., *Campylio-Caricetum dioicae* Osvald 1923 em. Dierßen 1982 sensu Wołejko 2000 p.p.) Ch. Ass.: *Eleocharis quinqueflora* (=*E. pauciflora*) (opt.), *Triglochin palustre* (lok., opt.)
Juncetum alpini Philippi 1960 (Syn.: *Equisetetum variegati* Fijałkowski 1990 nom. inval.) Ch. Ass.: *Equisetum variegatum, Juncus alpinus*
Ctenidio mollusci-Seslerietum uliginosae Klika 1943 em. Głazek 1984 Ch. Ass.: *Sesleria caerulea* (=*S. uliginosa*) (dom./kodom.); D. Ass.: *Ctenidium molluscum, Thuidium philibertii*

Photo 22: *Caricetum lasiocarpae* on an alkaline fen – Bagno Stawek Reserve (photo R. Stańko).

Photo 23: *Menyantho-Sphagnetum teretis* (photo R. Stańko).

Photo 24: *Caricetum paniceo-lepidocarpae* (photo R. Stańko).

Photo 25: *Caricetum davallianae* (photo R. Stańko).

Photo 26: *Valeriano-Caricetum flavae* (photo M. Bregin).

Photo 27: *Scorpidio-Caricetum diandrae* with numerous *Menyanthes trifoliata* (photo R. Stańko).

Photo 28: *Juncetum subnodulosi* (photo R. Stańko).

Alkaline fens in Poland often form part of larger peatland areas and are elements of spatial complexes that are not homogeneous in terms of water regime, trophy and vegetation. Usually, however, hydrological tests allow to identify the soligenous, i.e., underground supply to their most developed parts. Groundwater which has been in contact with the mineral base for a long time is to a large extent saturated with dissolved mineral compounds[6], which – as a result of specific biochemical processes – determines the nature of the ecosystem (cf., chapter 3).

Due to the intensity of the outflow, the position in the landscape, the type of accumulated sediments and other diagnostic features of soligenous wetlands – and, consequently, alkaline fens – they are classified into percolating fens and spring fens (domed and suspended). This division refers to the so-called ecological and landscape classification of wetlands (Succow & Jeschke 1986, Żurek & Tomaszewicz 1996, Pawlaczyk et al. 2002).

Flush fens are usually small wetlands of a transitory character between suspended fens and open springs. In the strict hydrological sense, a flush fen is a type of spring area characterized by a superficial, unconcentrated flow of groundwater. As they are usually located on slopes, there are no good conditions

6 An easily measurable indicator of such saturation in the field is conductivity, typically in the range of 300 – 800 µS/cm, sometimes even more.

Table 2. Most common mistakes in the identification of a natural habitat 7230

Mistaken for	Reasons for mistake	Explanation
Natural habitat 7140 – transition mires and quaking bogs	The physiognomy of herbaceous and moss vegetation, with carpets of brown mosses or peat mosses; with a mixture of moss and sedge remains in peats.	It is necessary to diagnose which moss species, including peat moss, are specifically concerned. The carpets of brown mosses and certain species of peat moss (*Sphagnum warnstorfii, Sphagnum teres*) are very typical of alkaline fens, as is the sedge and moss composition of the low peats typical for these habitats. Local occurrence of other species of peat mosses, up to the bog *Sphagnum fuscum* or *Sphagnum magellanicum*, on the surface of the alkaline fen is also possible as a result of the surface acidification process.
Natural habitat 7210 – calcareous fens	Dominance or abundance of *Cladium mariscus, Schoenus spp*.	The calcicole species typical for calcareous fens are of a wider ecological scale, among others they may occur and dominate also on alkaline fens. Phytosociological diagnosis is not sufficient to differentiate between these habitat types; it is necessary to identify the composition of the fen and its water supply.
Habitats outside Annex I of the Habitats Directive, "non-Natura 2000"	Physiognomy and composition of vegetation not corresponding to descriptions of typical forms of alkaline fens. Physiognomy of a rush or meadow. Lack of plant species and plant communities typical for alkaline fens.	The phytosociological and floristic diagnosis does not identify all alkaline fens. On some alkaline fens, or in some parts of them, the presence of typical species is masked by rushes (e.g., reeds, tall sedges), thickets (e.g., willows) or meadow vegetation. When mowed, meadow plant communities may develop in the alkaline fen, such as wet meadows or sedges (e.g., *Angelico-Cirsietum, Cirsietum rivularis, Caricetum acutiformis, Caricetum rostratae, Caricetum paniculatae, Caricetum appropinquatae*), although the nature of the alkaline fen can still (not always!) be indicated by the composition of the moss layer (e.g., *Tomentypnum nitens, Helodium blandowii*). In the case of some alkaline fens, especially spring fens (spring domes, flush fens), there are no characteristic plant communities or plant species, although the classification as alkaline fens is still determined by the peat-forming process conditioned by the supply of alkaline groundwater.

Photo 29: Mountain flush fen with *Eriophorum latifolium* in the Gorce National Park (photo R. Stańko),

Photo 30: Mountain flush fen with dominant brown mosses in the Gorce National Park (photo R. Stańko).

Photo 31: Spring flush fen in the Bielawa Valley in Pomerania
(photo P. Pawlaczyk).

for the formation of larger peat deposits – in the substrate often only shallow layers of peat-gley soils or rather shallow peats are formed. A flush fen is the most common type of fen in mountainous areas (cf., Photo 29), and in the case of alkalinity of the supply waters – a typical alkaline fen form found in the mountains. However, the occurrence of flush fens is not limited to the mountains; they also develop in the lowlands, especially in young glacial landscapes.

Spring fens can be found in various topographic situations ensuring a long-term, even supply of groundwater, often under hydrostatic pressure. It is a concentrated outflow, limited in terms of its spatial extent. Local outflow of a significant amount of mineralized groundwater is often related to tectonic faults (as in the Lublin region), or to the so-called hydrological windows – more permeable patches within the less permeable geological formations. These fens often take the form of domes or bars formed as a result of peat deposition, or as a result of alternating or simultaneous deposition of peat formations and tufas (various precipitations of calcium carbonate) built, in addition to calcium salts, of iron and magnesium compounds. The precipitation of mineral compounds from water is called petrification.

Photo 32: (A) Petrification with brown mosses, (B) on *Scorpidium scorpioides* (photo A. Szafnagel – Wołejko).

Photo 33: Vegetation on a tufa substrate, Black Orava (photo R. Stańko).

Cupola spring fens are relatively common, also in lowland Poland, but nowadays almost always in a more or less degraded form: Spurgle, the deepest known fen of its kind in north-eastern Poland, reaches the thickness of about 16 m of sediments, with the prevalence of tufa (Łachacz 2000). In north-western Poland, a series of spring sediments with a thickness of approx. 8 m was registered in the spring fen in the Chociel Valley (Wołejko 2001, Pidek et al. 2012). Often, the only traces of the earlier existence of accumulation of spring domes are eroded deposits (cf., Photo 34) or blocks of tufa. Similarly transformed are numerous spring fens of the Mazurian Lake District (Łachacz 2006). In many regions of Northern Poland, altered water conditions currently prevent active accumulation of tufa (Grootjans et al. 2015a).

Photo 34: Tufa deposits several meters deep in a closed spring dome in the Płonia Valley near Barlinek (photo R. Stańko).

Spring fens can also develop without the accumulation of tufa.

Photo 35: Spring fen in the Bielawa Valley in Pomerania
(photo P. Pawlaczyk).

Percolating fens are formed when the outflow of water from aquifers is of a non-concentrated nature. This can take place on the borders of river valleys or within lake basins. Percolating alkaline fens develop best in areas with varied terrain, especially in glacial landscapes. Unlike flush fens or small spring fens, flow-through fens are usually characterized by a large thickness of peat deposits, often lined with sediments deposited under water – gyttjas. On this type of fens, vegetation in the form of moss patches is most often formed.

In growing fens, water slowly seeps under the surface of the peat from the mineral border to the watercourse or lake. The surface of the fen is sloping, sometimes significantly. In wide river valleys in old glacial areas (e.g., the Biebrza Valley) the slope may be insignificant and difficult to detect without geodetic surveying. With a low slope and blocked drainage system, the share of rainwater in the hydrological balance of the fen is easily increased. This initiates the succession of peat-forming vegetation towards raised bog communities, and may cause difficulties in proper identification of the ecological character of the fen and the type of natural habitat.

Photo 36: Percolating fens in the lower reaches of the Rospuda River. On the left, near the slopes at the edge of the valley, you can see treeless, open moss patches. The fen is supplied mainly by groundwater flowing from under the slope, which then percolates through the peat bed towards the river bed (photo K. Brzezińska).

Photo 37: Percolatig fen with abundant *Menyanthes trifoliata*, *Carex limosa* and *Epipactis palustris*. The Borsuki fen, located in a lake basin with steep slopes in the Augustów Primeval Forest (photo P. Pawlikowski).

Photo 38: A young percolating fen on a thick layer of ancient lake gyttja, distorted by use as a meadow. Łunoczka in the Drawa National Park (photo P. Pawlaczyk).

Photo 39: Percolating fen in the side branch of the Zgnilec Valley in the Drawa Primeval Forest (photo P. Pawlaczyk)

Photo 40: Vegetation of a percolating fen. Zgnilec Valley in the Drawa Primeval Forest (photo P. Pawlaczyk).

Photo 41: Alkaline fen by a lake in the Torfowisko Radość Reserve in Pomerania (photo P. Pawlaczyk).

Photo 42: Dąbie percolating fen in the Łupawa Valley in Pomerania
(photo P. Pawlaczyk).

Photo 43: Vegetation on degraded fragments of alkaline fen can have the appearance of high rushes; remnants of species typical for the habitat are hidden in the lower layers of the plant community. Fen over Korytnica in the Drawa Primeval Forest (photo P. Pawlaczyk).

Photo 44: *Juncetum subnodulosi* rush overgrowing with pine – the vegetation of a percolating fen in the Drawa military training grounds in the Drawa Primeval Forest (photo P. Pawlaczyk).

Photo 45: A degraded percolating fen, with vegetation dominated by sedge rushes and wet meadows, with rare moss fen elements, in the Łupawa Valley in Pomerania (photo P. Pawlaczyk).

Paleoecological studies showing the stages of fen development currently representing habitat 7230 have illustrated their developmental relations with other habitats, mainly with petrifying springs (Mazurek et al. 2014), hard water lakes (Stańko et al. 2015b) and calcareous fens (Wołejko & Piotrowska 2011). In an extreme case, spreading of a moss patch to the surface of a raised bog with *Sphagnum fuscum* was documented (Grootjans et al. 2005), Hájkováet al. 2012, Madaras et al. 2012). Sometimes alkaline fens develop in wet hollows between dunes (Gałka et al. 2016, Laime 2017, Wołejko et al. 2018). As a result of succession, there are changes in the direction of transition mires and raised bogs, sedge rushes and bog forests within the sedge-moss fens. In many areas e.g., the Tuchola Forest, Drawa Forest, sedge-moss fens with brown mosses – most probably similar to today's alkaline fens – were a common stage in the development of most of today's raised bogs (Lamentowicz 2007, Kujawa-Pawlaczyk & Pawlaczyk 2014, 2015, 2017). In part, therefore, the current distribution of moss fens can only be a shadow of their spread a few thousand years ago, when the hydrological and climatic conditions were slightly different. Thicker spring fens can go through a moss fen phase in their history; they are also often located adjacent to moss fens. Flush fens, although quite stable due to high hydration, may experience slow succession to bog-type thicket and forest communities.

Many current alkaline fens with typically formed sedge-moss fen vegetation are relatively young, with thin peat layers accumulated over the last five hundred to two thousand years, on thick layers of ancient lake gyttja or lacustrine marl. On the other hand, at some sites (e.g., the Stążka Valley in the Tuchola Forest – Lamentowicz et al. 2013, Bagno Serebryjskie bog – Gałka et al. 2017) lasting alkaline fens and their characteristic vegetation were documented for one to three and a half thousand years.

The natural succession trends of alkaline fens are intertwined with an overwhelming anthropological impact, which expedite their transformations (cf., chapter 4). As a result, at present the dominant component of the fen complexes of the former alkaline fens are various types of meadow ecosystems used, and even more frequently – abandoned meadows – which are rapidly turning into herb communities, secondary rushes and forests. The complex can also include fragments of calcareous fens, communities related to the raised bogs and transition mires, rushes, water, spring and thicket vegetation, as well as transitional forms for these types of vegetation.

For these reasons, typical sedge-moss fen plant communities can be considered as important indicators for the occurrence of a habitat, but not as the entire habitat 7230 patch. The extent of a natural habitat patch should be interpreted more widely than the extent of a vegetation patch. Other factors such as stratigraphic structure, hydrological regime, hydrochemical parameters, and the position of the fen in the landscape should also be taken into account during its identification. Such an approach is important for the planning and implementation of protection, ensuring that the integrity of the ecosystem, especially its stages affected and transformed by human activity, is preserved.

In the years 2008 – 2011, the Naturalists' Club made an attempt to take an inventory and map alkaline fens in Poland, with particular emphasis on sedge-moss fens. Its product is a database published on http://alkfens.kp.org.pl/o-torfowiskach/ogolnopolska-baza-mechowisk/. It has also been updated in later years with new found sites. The database currently includes nearly 900 sites with a total area of approximately 14,500 ha. These data are based on the best available knowledge of Polish naturalists, however this does not mean that they are complete – it is still possible to find unknown, sometimes very valuable natural sites. Certainly, alkaline fens of a non-moss nature form are not exhaustively included in this database.

Alkaline fens, compared to other fen ecosystems (such as transition and high fens), are characterized by an extraordinary richness of species of high natural value, with a narrow ecological amplitude (Wołejko et al. 2012). At the same time, it is one of the habitats under the highest threat of extinction. In several regions of Poland it has practically disappeared, and in most areas it is extremely endangered (Stańko et al. 2015c). Despite the protection efforts, the condition of Polish resources of the natural habitat 7230 is rapidly deteriorating – in 2009, out of about 120 alkaline fens studied within the framework of the National Environmental Monitoring (cf., chapter 6.1 Institute of Nature Conservation 2018), 16.5% were in good condition (FV), 58.7% in unsatisfactory condition (U1) and only 14.8% in a bad condition (U2). However, repeating of the survey in 2017 showed that only 10.3% are in good condition (FV) and as much as 53.8% of the sites are in bad condition (U2). The same is true throughout the European Union – according to the reports for the years 2007 – 2012, in almost all EU countries the condition of 7230 habitat resources is bad or unsatisfactory, and the trends of deterioration outweigh the trends of improvement (European Environmental Agency 2018). Moreover, on the European Red List of Natural Habitats (Janssen et al. 2016), the EUNIS habitat groups „D4.1a *low sedge alkaline fens and calcareous spring fens*" and „D4.1b *high sedge alkaline fens*", which include the ecosystems under discussion here, are classified as near-extinct (EN) natural habitat types, i.e., among the most endangered types of fens.

3. Characteristics of alkaline fens from the point of view of their protection

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The existence of fens of all types depends on a relatively constant, high level of water content. Sufficiently high water level guarantees, among other things, the development of specific vegetation typical for fens (including many characteristic mosses) and deposition of dead organic matter in the form of peat.

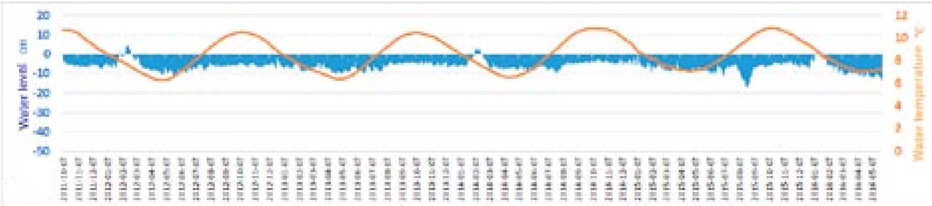
Alkaline fens differ from other fens by, among others, the origin of water supplying these ecosystems and its chemical composition, which influences the characteristic composition of vegetation developing in these systems (cf., chapter 2). Groundwater is the predominant source of supply, and rainfall plays a lesser role (Wołejko et al. 2012). Water can come from deeper aquifers, often under pressure (so-called soligenous fens), as well as from lakes with alkaline and calcium-rich waters. In the best preserved alkaline fens, hydration, measured as the location of the water table in the peat in relation to the surface of the fen, usually remains high (a water level not deeper than a few cm below the surface of the area) and at the same time very stable (changes during the year not more than 15 – 30 cm), partly due to the stability of the groundwater supply itself, and partly due to the adjustment of the surface of a healthy fen to the water conditions (Fig. 1; also Stańko et al. 2015a).

Due to the relatively wide scale of hydrochemical parameters in fens conventionally classified in Poland as habitat 7230 (Wołejko et al. 2012), it is necessary to review the specific characteristics of the main processes determining the possibility of their proper functioning. The reaction of water[7] "appropriate" for alkaline fens should be in the range from neutral to alkaline (pH > 7.0), however in practice we quite often find fragments of so-called sub-neutral fens with pH from 7.0 – 5.5. Depending on the diversity of these conditions, the main factors determining the availability of the most important biogenic nutrients for vegetation, in particular phosphorus and nitrogen, change.

Under conditions of undisturbed hydrological supply, alkaline fens (as well as petrifying springs) are usually saturated with carbonates, which often results in precipitation of tufa. Unfortunately, at present, especially in northern Poland, the concentrations of these ions are often below the saturation threshold, or the

7 This pertains to the water supplying the fen, i.e., the pH of the water in the deeper layers of peat. The pH of water in puddles on the surface of the fen, or of water in watercourses flowing out of the fen, may not be reliable, especially after heavy rainfall.

A:



B:

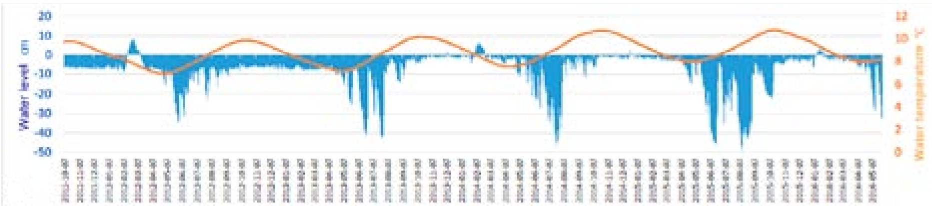


Fig. 1. Changes in the water level in relation to the fen surface in two fragments of the same alkaline fen complex (Północne Łąki in the Drawa National Park): A – in a fragment of a better preserved moss fen, B – in a fragment strongly transformed and transformed into wet meadows (Kujawa-Pawlaczyk & Pawlaczyk 2014, supplemented).

waters rich in them no longer reach the surface of the fen (Grootjans et al. 2015a). This is associated with anthropogenic changes in the conditions of hydrological supply both within the wetland itself and within the area of alimentation of its underground catchment. The chemical composition of fen waters can also be modified due to an increased share of rainwater, surface water, or chemical pollution of the environment.

In the fen with higher pH of supply water (> 7), the main element limiting phosphorus availability is calcium which, together with phosphorus, forms complexes unavailable to plants (e.g., Boyer & Wheeler 1989, Jabłońska et al. 2014). The supply of the ions of this element on low fens is mainly related to the inflow of mineralized groundwater (Wassen et al. 1996). Biochemical limitation of the availability of biogenic nutrients affects the characteristic physiognomy of a typical form of alkaline fens as a moss fen, where low, narrow-leaved sedges and low vascular plants often dominate, which allows, among other things, the access of sunlight to the ground and the development of a layer of typical mosses.

The seepage of water of appropriate mineral composition through the peat ensures, on the one hand, stable high hydration and, on the other hand, prevents the development of eutrophic vegetation, determining the specificity of the sedge-moss fen and the occurrence of specific endangered plant species typical of the sedge-moss fens (Wassen et al. 2005). Therefore, the protection of such a fen must depend on maintaining the appropriate state of these parameters.

On the other hand, iron compounds play an important role in fens with lower pH. Under conditions of constant high hydration, biogenic elements are excluded from the cycle creating compounds unavailable to plants. Iron concentrations in the water supply to the fens can vary greatly, but the concentrations in the soil pores of the upper layers of the fen are of the greatest biological importance. These concentrations can vary significantly from values measured in water samples from aquifers. More recent studies (e.g., Aggenbach et al. 2013, Emsens et al. 2016, Emsens et al. 2017, literature review in the work of Emsens 2017) show that iron can negatively affect the chances of restoring previously dehydrated alkaline fens. In the soils of such fens – which are supplied by waters rich in iron compounds – significant phosphorus loads (e.g., in the form of ferrous phosphate) were previously accumulated. The re-irrigation of this substrate releases phosphorus and initiates a process of internal eutrophication. This creates the conditions for the lush development of biomass, mainly formed by common species of fertile wetland habitats. It reduces the possibility of development for small sedges and bryophytes typical for alkaline fens. One of the important reasons for limitation in their development is the lost competition for light (Kotowski et al. 2006).

Flooding of a previously drained fen may result in a significant transformation of iron from a trivalent form to a bivalent form under anaerobic conditions. This form is toxic to many plant species (Snowden & Wheeler 1993), even in low concentrations. On many sub-neutral fens a mosaic structure of vegetation is observed in which rare mesotrophic fen plants can only be found at the tops of the clumps elevated above the range of water occupying the depressions between the clumps. These depressions are dominated by common species that prefer higher trophy and tolerate higher iron concentrations.

Bivalent iron also significantly accelerate the decomposition of organic matter. This may reduce or completely prevent the accumulation of peat on restored fens (Aggenbach et al. 2013).

The facts and hypotheses mentioned above should be taken into account both during the planning of protective measures and during the assessment of their results. This applies in particular to the potential of fens supplied by iron-rich waters. The identification of the hazards associated with the toxicity of iron ions to valuable fen species should be a reason for avoiding certain active protection methods, such as grazing or the use of heavy machinery, and changing the microtopography of fens (see below).

As a consequence of these specific conditions, alkaline fens are very difficult to protect (Nilsson 2015). It is particularly difficult, verging on impossible, to achieve a significant improvement in the condition of degraded ecosystems. This is due to the fact that the hydrological balance of an alkaline fen is very easy to disturb, and once it is disturbed it cannot be restored. Even small surface disturbances can easily alter the way calcareous water flows from „seeping through the fen" to „surface run-off by rills and ditches", and this change will switch the biochemical mechanisms that maintain the characteristic of the fen; it can initiate the development of eutrophic vegetation and the entire chain of changes it entails. Even slight decay of dry peat will prevent the fen from adjusting to the water level by its shape, resulting in fluctuations in the position of the water table in relation to the surface, and consequently allowing the expansion of trees and shrubs. While it is possible to try to maintain typical vegetation with repetitive active protection measures (e.g., mowing), the mechanisms of ecosystem self-maintenance can usually no longer be fully restored. Poorly thought-out, undiagnosed protective measures may (e.g., by activating the above-mentioned iron-related biochemical mechanisms) harm rather than help.

However, each fen is different. It should therefore be emphasized that conservation measures should be considered in the context of each individual patch of the habitat and should be based on a detailed inventory, including eco-hydrological, of the entire geoecosystem.

Knowledge in the following areas may be particularly useful:

Location in the landscape: Preliminary information on how the fen is located in relation to geomorphological structures and other fens is essential for understanding the wider context of its functioning and water supply. Is it located in a side branch of the valley? In the wing of the valley? Or in the middle? On a slope? By a watercourse or lake? Is it accompanied by mineral elevations which can potentially act as hydrological windows? Is the fen an element of a larger peat complex, e.g., in a valley? Is it part of a larger sequence of fens of different types, e.g., within a terrain channel or on a bend? This is important for protection: spring fens are more susceptible to spontaneous or anthropologically induced erosion, thus their effective restitution after drainage is more difficult, or even impossible. Lake - or river -side mires often maintain a high level of groundwater, supported by stable surface water levels within the valley bottom, which allows for minimizing erosion processes and stable peat accumulation within the permanently irrigated peat layer (Wołejko & Piotrowska 2011).

Geological structure of the fen: Thickness and stratigraphy of peat layers reveals the history of fen formation and development. It is examined by drilling with a special peat drill, which extracts the peat core in sections. On the basis of plant residues in the peat, an expert is able to reconstruct the botanical composition of the peat from various depths, interpreting on this basis the history of changes in the fen vegetation (Tobolski 2000). Assuming that the ecological requirements of individual plant communities remain unchanged, this makes it possible to interpret the sequence of changes in the conditions prevailing on the fen. Possible, although less frequently used, is the absolute dating of selected peat samples by sending them for C_{14} analysis. Most often, several boreholes are made, arranged in transects, which allows for making cross-sections showing the structure of the fen. Professionals are able to analyze many other features of the profile – old ecological conditions, in particular hydration, are shown well in e.g., remains of *Testacea*, and the history of changes in the vegetation in the area is shown by preserved plant pollens.

Peat drillings will tell you whether the fen has a spring origin (peat layers usually deposited on sand) or a lake origin (peat layers on gyttja), and whether it is a young formation (a thin layer of peat on gyttja) or old (thick layers of peat); whether in the past there was an accumulation of thicker tufa (cf., chapter 2, tufa lumps appear in the profile). Comparing the vegetation of the past with that of the present will enable the drawing of conclusions about the naturalness of the present form of the fen (the changes may result from natural succession, but the sharp discrepancy between the present vegetation and the sequence documented in the peat usually results from fresh anthropogenic transformations). The profile will show whether or not the fen was overgrown with trees and shrubs in the distant past and, therefore, whether the current occurrence of trees and shrubs is a natural state, an episode of repeated fluctuation or a new anthropogenic situation.

Recent history of the fen: The history of changes in the physiognomy of the fen (in particular, its overgrowth with trees and shrubs, forms of use, possible drainage) is a very important element of the knowledge required for its protection. Interviews with local residents and users of the fen may be a source of the findings. Old topographic maps are a good source, usually available for periods from the end of the 19th century (indexes and even map resources can be easily found on the Internet), although their good interpretation requires knowledge of the nuances of the history of cartographic art. Historical orthophotomaps and aerial photographs are very useful. The popular Google Earth program has a time slider that allows you to reach the historical orthophotomap, but the available time ranges differ. Historical orthophotomaps from the last several years are available in Geoportal (www.geoportal.gov.pl), although the extraction of material from a specific date requires quite advanced computer operations. A wider collection of archival aerial images, usually since the 1950s, has been made available for a fee by the Head Office of Geodesy and Cartography (http://www.gugik.gov.pl) and the purchase prices are not high. Sometimes you can even find older aerial photographs, as well as archival ground photographs, which can be very helpful.

These materials will show how and how quickly the fen vegetation has changed, or at least its physiognomy, over the last several decades – e.g., when and how quickly the fen overgrown with trees and shrubs (rapid growth in recent times will usually be a prerequisite for the need for active protection-removal of trees and shrubs, while the stability of the tree cover may mean that there is no need for it). Recent use, e.g., mowing, will often reveal itself (usually as an indication of the need to restore mowing). Sometimes it is possible to determine when the drainage ditches were dug (in the case of ditches made relatively recently and their proper blocking, prognoses for the fen are better).

Diversification of surface topography, ditches: The topography of the fen surface (e.g., flat or sloping, possible occurrence of dome structures, protruding mineral hills) is an important premise for further research on the origins, water supply, and functioning of the fen. The identification of ditches is the basic source of information for planning protection measures. Identification in this respect can be carried out by precise penetration of the fen, and in an advanced form by geodetic measurement of surface ordinates. Nowadays, however, a very helpful and easily accessible material is the so-called numerical model of terrain based on data from laser scanning (LIDAR). Such data can be purchased, also online and for a small fee, from the Head Office of Geodesy and Cartography (http://www.gugik.gov.pl) and explore, for example, with free GIS software (e.g., QGIS). We can then display a „hypsometric map" of the fen surface, which usually reveals ditches and rills, as well as height differences of even several centimeters.

Ecohydrological conditions: The starting point should be the exact penetration of the fen and observation of the water – where it flows from, where it appears, where it goes and how quickly it flows out. However, it is not enough to do it all just once. This observation should be repeated in different seasons of the year, as well as, for example, in rainy or dry periods. In this way, the groundwater supply can often be seen (as evidenced by visible sources, water constantly seeping from peat slopes, a strong, suddenly occurring outflow, as well as the stability of these phenomena during the year and in various weather conditions), and it can be determined which ditches pose the greatest threat to the fen.

Monitoring of the water level in peat can and should be a source of supplementary information for the diagnosis. It is made in observation wells made for this purpose – usually in the form of a PVC pipe penetrated into the peat, sealed at the bottom and perforated at the appropriate depth. Once the water level in the pipe has stabilized, its depth in relation to the fen surface is measured. Manual measurement is certainly possible, but nowadays it is rather common to use sensors/recorders embedded in the pipe, so-called divers, which automatically record changes in pressure of the water column[8] during a given interval (e.g., once a day), and it is sufficient to read the collected data e.g., once a year (cf., also chapter 6.2). Usually, observations are made from a few to a dozen or so obser-

8 Usually, the sum of water column pressure and air pressure is recorded, which means that in order to interpret the results it is necessary to have data from the so-called baro-diver, i.e., a sensor and recorder of air pressure, located a few to a dozen kilometers from the fen. According to the experience of the Naturalists' Club, the cost of a single sensor, including an observation well and proper installation, is currently about PLN 2,500 – 3,500.

vation holes per fen[9], and the observations are made for at least one hydrological year (from the beginning of November to the end of October). Sometimes there are two boreholes made in one place with filtering at different depths: the water level established in them will not usually be the same, which can say a lot about possible underground supply; sometimes even artesian or sub-artesian aquifers may be discovered by such wells. Daily data is very valuable as it shows the stability of hydration – a very important feature for the assessment of the „health status" of a fen. A long-term series of measurements can provide interesting information on the reaction of hydration to changing rainfall and temperature conditions. Meteorological data on temperature and rainfall are useful for interpretation of the results. In order to obtain them, one can set up an own meteorological station[10], or use data from the nearest station of the national meteorological observation network, now available at https://dane.imgw.pl/data/dane_pomiarowo_obserwacyjne/. The boreholes and installed devices can then be used for the fen monitoring (chapter 6.2).

Measurements of the physicochemical properties of water will provide valuable information. The basic parameters that can be measured quickly in the field with a suitable meter are temperature, reaction (pH), and electrical conductivity (indicating the number of ions). Low temperature of the water, stable throughout the year, may indicate its underground origin. An acidic reaction may indicate acidification processes, a light acidic reaction indicates rainfall water, and an alkaline reaction may suggest water richer in calcium. Conductivity of several dozen μS/cm is typical for soft rainwater, while levels above 400 – 500 μS/cm suggest strong mineralization. The relations of these parameters in different places on the fen are important: in the outflow water, water in ditches, water on the surface, in puddles and floodplains, in water in observation wells filtered at different depths; correct interpretation of such relations contributes to the understanding of the water supply to the fen. It should be remembered that stagnant water on the surface of the fen may be of precipitation origin and (e.g., rainfall) may not be reliable for the ecological characteristics of the fen; therefore, measurements in observation wells filtered in the peat are more useful.

More sophisticated water analyses may provide further information but usually require sampling and laboratory analysis. In alkaline fens, a particularly important property is the amount of calcium and magnesium ions, as well as the content of potential nutrients: nitrogen, phosphorus, and potassium, and the

9 In practice, the Naturalists' Club uses masked holes in the field to prevent vandalism and destruction. The holes are measured to the features of the terrain (e.g., trees) and additionally identified by a cover with a metal element, found with a metal detector. The divers are embedded on the bottom of the pipe in appropriate housings and taken out for reading by means of a simple device using a garden connector.

10 A battery-powered recording station with rainfall and temperature sensors that can be installed anywhere in the area (after considering the risk of vandalism or theft), requiring data reading and battery replacement about twice a year; currently costs 2,500 – 3,500 PLN.

content of iron and aluminum. Sometimes these parameters may be necessary to select the appropriate protection method (see above).

Ecohydrological identification can be extended in many ways, each providing valuable information to help plan the protection as accurately as possible. Ideally, the identification should go beyond the fen itself and include its landscape context, which requires groundwater measurements also in the broad surrounding area of the fen. Groundwater temperature profiles at various depths around the fen can say a lot about the intensity of the groundwater supply (Grootjans et al. 2006). Similar information can be provided by profiles of content of calcium sulfate ions in the groundwater (Wołejko & Grootjans 2004, Grootjans et al. 2015b). The potential for tufa deposition can be checked by installing microscopic slides in the flowing water for a period of about one month and then analyzing the deposits (Grootjans et al. 2015a).

Very important information for the fens supplied with the groundwater would be an identification of the so-called alimentation area, i.e., the area from which the underground aquifer is supplied and from which the fen is then supplied in turn. This information is very important for protection because it identifies the area where, for example, disturbances in the flow of groundwater or its abstraction can have a significant impact on the fen. However, there are no realistic methods for identifying such an area accurately, and one can only try to guess on the basis of a precise geological diagnosis of the terrain (including the sequence of permeable and impermeable formations) and its topography.

Flora: It is often one of the most important natural values of alkaline fens, therefore its identification is particularly advisable. It requires a sufficiently detailed penetration of the fen by an appropriate expert. It is optimal to repeat such research at least several times a year, as well as to repeat it in different years. Some vascular plant species – such as *Saxifraga hirculus* – are surprisingly difficult to notice when they are not flowering. Many orchid species, including *Liparis loeselii*, appear in very different numbers in subsequent years.

In alkaline fens, the best indicator species, as well as the greatest flora peculiarities, are often moss species and not vascular plants. It is therefore important that the botanical expert carrying out the diagnosis has the appropriate skills and experience. Searching for mosses requires concentration and time, bending over and looking through herbaceous vegetation, and noticing them requires experience.

Sometimes the flora of individual sites can remain surprisingly stable, as evidenced by cases where some flora peculiarities have been found in the same places as they were reported in the 19th century. However, there are also cases of rapid changes, such as the disappearance or appearance of species. First of all, practice shows that even on sites theoretically well researched and repeatedly penetrated by botanists, one can still find previously unseen floristic peculiarities.

The ecological needs of valuable plant species will usually coincide with those of the habitat as a whole, i.e., the protection of these species will consist in the protection of the entire fen. Sometimes it may be advisable to make small modifications for certain plant species, such as postponing the time of mowing.

Vegetation: Describing a fen with its plant communities and a map of vegetation is a basic way of scientific communication and organizing information. It is important to express the diversity of the vegetation in a way that is more in line with contemporary rather than archaic classifications (cf., chapter 2). Drawing a vegetation map requires detailed field mapping by the relevant expert: only in this way can plant communities be identified, described, and documented with relevées. To determine their range, it may be helpful to use the current ortho photo map. It should be remembered, however, that the diversity of vegetation in phytosociological terms may be masked by the presence of, for example, reeds or sedges – mapping vegetation requires taking into account the entire flora composition, and not only the dominant ones.

The vegetation of the fen can be stable, but there are cases of significant changes even within 3 – 5 years, e.g., strong territorial expansion of some types of rushes, resulting in the disappearance of once existing communities.

Fauna: For vertebrates, alkaline fens are not a habitat particularly different from other wetlands, although they may be significant for some birds (e.g., *Grus grus*, *Scolopacidae*) or amphibians. However, the fauna of invertebrates may be very valuable at some sites. The peculiarities of fauna should be sought for mainly in the group of beetles, especially *Staphylinidae*. Since the invertebrate fauna of Polish fens is generally poorly recognized, it is often the mere entry of a suitable expert into a better preserved alkaline fen that results in the discovery of new localities of rare and valuable species.

Very valuable invertebrates can also be associated with groundwater outflows, often accompanying and occurring within or in the vicinity of alkaline fens. Particular attention should be paid to *Trichoptera*, *Hydracarina*, and *Coleoptera*.

It is possible that valuable, rare, and protected butterfly species may be found in alkaline fens. For this habitat, these may include: *Coenonympha oedippus, Lycaena dispar, Lycaena helle, Euphydryas aurinia, Phengaris nausithous,* and *Phengaris teleius.* The very rare *Coenonympha oedippus* (in Poland, there are three known sites – only alkaline fens) is found on sedges. Other species tend to have a wider ecological scale, including wet meadows, and are dependent on their respective host plants rather than on the type of the fen itself. *Lycaena dispar*, which is found on sorrels, is still relatively common in Poland and the chances of finding it on an average alkaline fen are quite high.

The peculiarities may also be found in the fauna of the *Odonata*, particularly often found in ditches and by small watercourses at the fens. Quite often one can find *Leucorrhinia pectoralis*, although it is not a species specifically related to the considered type of fens. The landscape of an alkaline fen in southern Poland may include *Coenagrion chasuble*, currently known only from two sites in the Lublin region.

The occurrence of rare and endangered whorl snail species is relatively often associated with alkaline fens, including those listed in Annex II of the Habitats Directive (Directive 1992) – *Vertigo angustior* and *Vertigo moulinsiana* (Książkiewicz 2010).

Protection of the valuable fauna of fens is usually the same as protection of the fen itself. However, for example, the occurrence of protected bird species may require modification of the dates of protective measures (especially mowing and trees removal). The occurrence of valuable butterfly species may require modification of mowing dates according to the life cycle of the butterflies; it also requires paying attention not to reduce the occurrence of host plants as a result of mowing (cf., Michalska-Hejduk & Kopeć 2012). The occurrence of whorl snails may require some modifications to the mowing practices (height and timing of mowing, leaving unmowed refuges).

Cultural elements: Some fens, or their vicinity, contain old technology heritage sites, e.g., old water abstraction facilities. From some sources water was taken in and pumped with the use of the so-called hydraulic ram – such a machine has been preserved in Kajny near the Łyna River in Warmia, and the remains of similar devices have been found in several other fens in northern Poland. Some small damming facilities on the ditches may also have the status of technical heritage. Some fens, flush fens, and springs may be associated with the values of non-material culture in the form of traditional field names (in northern and western Poland it is also worth looking for old German names), local history, and folklore tales (cf., e.g., Szmuc 2017).

Detailed problems of planning the protection of alkaline fens have been developed in subsequent chapters of this publication, as well as in a number of other manuals and handbooks devoted to the protection of alkaline fens (Šefferová Stanová et al. 2008, McBride et al. 2011, Nielsson 2015, Priede 2017).

4. Most common threats and symptoms of degeneration

Filip Jarzombkowski, Ewa Gutowska, Katarzyna Kotowska

For several hundred years man tried to transform fens into productive land by turning them into grasslands. On the territory of Poland, large-scale drainage networks were built by the Germans in Warmia and Mazury and in western Poland since the end of the 19th century. In the rest of the country, individual valleys of rivers with fens were drained on a larger scale already in the first half of the 20th century, but the largest works in this direction were carried out during the times of the People's Republic of Poland.

The purpose of the vast majority of ditches in fens is water drainage. In some complex drainage and irrigation systems there are also ditches for water supply, but in practice these have been relatively rare. Sometimes, but rarely, systems of gates were created on ditches to control the outflow. However, even where ditches are equipped with infrastructure for water supply or periodic drainage limitation, it is usually currently damaged or not maintained. Almost 100% of ditches in Polish fens function as linear, gravitational water drainage systems.

The water flowing in the drainage ditch is usually below the water level maintained on the fen, which in principle favors lowering of the water table and accelerated water circulation in the whole ecosystem. The impact of ditches on the fen, depends, among others, on their design, the degree of development of the drainage network in the vicinity, the degree of regulation of the watercourse to which they direct the water, or the supply of the fen can range from several to even several dozen meters.

The change of water supply to alkaline fens, and the change of water flow, are one of the most important factors which influence the degree of degeneration of natural habitat 7230. Draining an alkaline fen kills it, even if the outflow of water in the ditches may be stopped periodically, or if water may be supplied.

In the case of a moss fen, even small channels affecting its surface significantly change the way water flows. Instead of percolating through the peat, it starts to run down these channels to a greater extent. As a result, the biochemical mechanism of blocking the availability of biogenic nutrients for plants by calcium ions dissolved in water feeding the fen (cf., above) is inactive on the fragments between the channels, which initiates the development of tall sedges and herbs typical for wet meadows. They compete locally with the original moss vegetation, which is being displaced to the edge of the channels and in their immediate vicinity. This mechanism, although beneficial for farmers interested in

Photo 46: Drainage systems are the most important cause of fen degradation. A proposed nature reserve in the Kulawa river valley (photo A. Szafnagel-Wołejko).

the productivity of the mown meadow, irretrievably destroys the moss fen, even if the entire area of the fen remains strongly hydrated.

In the case of spring fens, even small channels, and alternating the way the water flows to linear paths, interrupt the peat accumulation and initiate the erosion of the fen.

A further stage of degeneration may include local drying of the top layers of peat, which undergoes - at first slight, and then deeper - mineralization. Repeated drops in the water level in peat, as a result of which it is not fully saturated with water, especially in dry periods, cause a change in the structure of peat from fibrous to lumpy and turn it into muck (Ilnicki 2002), making it impossible to maintain proper hydration of the fen in the future and causes that the bogginess ceases to limit the development of herbaceous plants of meadow plants, as well as shrubs and trees.

Mineralization of peat surface layers which prevents proper saturation of the entire peat bed with water results in an additional increased supply of a number of nutrients to the environment as a result of the decomposition of dry peat (Ilnicki 2002). Most often they are forms of nitrogen, potassium, or phosphorus available to plants.

As a result of these processes, i.e., eutrophication and at the same time unblocking the availability of nutrients for plants, the vegetation is growing higher and more abundant – instead of narrow-leaved sedges and relatively low herbaceous plants, there is an introduction of large sedges and high perennials, causing a gradual shading of the bottom of the fen and a decrease in the moss layer cover typical for alkaline fens. As a result of insufficient water content, lack of light, and unlimited access to nutrients, the species characteristic of the moss fen begin to disappear and the vegetation transforms into rushes and herbs.

Even if the drainage system is provided with facilities for water damming in ditches, periodically blocking the outflow and maintaining high hydration, and water management and meadow management are carried out in a sustainable way, this will not save the fens within such a system. Even sustainable meadow management requires at least a periodic reduction of the water level to about 30 cm below the surface of the fen, and this is lethal for alkaline fens, not least because the ditches necessary for this will inevitably change the way water flows through the fen in the way described above. Periodic water supply systems will also inevitably destroy the alkaline fen, as it depends on waters of a certain chemical composition, usually determined by their groundwater origin.

Nowadays, an important problem related to the protection of alkaline fens, much more common than new drainage systems, is the **maintenance of the old ditches**, often carried out without any prior assessments or permits (cf., chapter 9). Sometimes it takes the form of the reconstruction of heavily or completely overgrown ditches, in which case the effect becomes similar to that of newly constructed ditches. In addition, the maintenance of small watercourses, which are the hydrological base for the outflow of water from the alkaline fen, accelerating the flow of water in the course, may result in the drainage and degeneration of the neighboring fens (Prus et al. 2017, Biedroń et al. 2018).

As a result of the processes described above, most of the alkaline fen complexes in Poland have been destroyed. Only in a few cases has the moss vegetation survived to the present day, and still the area of the patches of habitat 7230 is significantly reduced and fragmented. They have often survived only in the most distant side branches valleys, or in places that cannot be drained (e.g., near lakes). Where the moss elements are still present among the meadow vegetation, their life can be extended by carefully planned mowing (see chapter 5.2), but the fen functioning mechanisms cannot be revived.

The ditches described above are particularly dangerous for fens developing in slightly elevated areas, e.g., suspended on the slopes of river valleys. Fens in the bottoms of valleys – near lakes or rivers – can sometimes maintain stable hydration even when ditches are present, when the water level in the peat is supported by stable water supply into the valley (cf., Wołejko & Piotrowska 2011); however, only on the condition that the hydration of the entire valley is not impaired, e.g., as a result of maintenance works carried out on the drainage watercourse (cf., Biedroń et al. 2018).

Often, after the drainage system was constructed for the alkaline fens, **meadow use was abandoned** after several years, which resulted in the overgrowth of these habitats not only by high perennials and sedges, but also by trees and bushes. The most common expansive species occurring in such situations include: *Phragmites australis*, *Molinia caerulea*, *Carex gracilis*, *C. acutiformis*, *C. appropinquata*, *Alnus glutinosa*, *Frangula alnus*, *Salix cinerea*, and *Salix aurita*.

On some fens with meadow vegetation (e.g., Bagno Wizna) **very intensive meadow use** was introduced, with several courses of mowing each year. Frequent mowing with heavy equipment required continuous and intensive drainage of the habitat which, combined with the pressure on the peat bed, led to the complete disappearance of the habitat.

Photo 47: One of the most drastic forms of degradation of alkaline fens is the almost complete drainage and conversion to various crops. In this photo can be seen the preparation of the land for fruit bushes cultivation in one of the fens of the Lublin region (photo R. Stańko).

In some moss fens, **acidification and oligotrophication** of the fens are observed. As a result of the increased share of rainwater in the fen's water balance (e.g., through lowering of groundwater table and deterioration of groundwater supply), among the species typical for alkaline fens, species common for more acidic habitats, but with tolerance for waters with slightly alkaline reaction, develop. The first to appear most often in higher positions (e.g., on clumps) are mosses such as *Sphagnum teres*. Over time peat moss carpets spread and moss peat cuts off the surface of the fen from the supply of calcareous groundwater, accelerating the process. Herbal species adapted to a lower pH, such as *Oxycoccus palustris* or *Ledum palustre*, are beginning to enter and the vegetation, if the succession processes are not directed towards forest and thicket communities, is turning into a form typical for transition mires. Perhaps this process is partly natural, but it can also be initiated and accelerated by anthropogenic changes in water conditions. This is the case even if there is no drainage system directly on the fen. The prevalence of such processes may be the result of a decrease in water levels affecting the entire area adjacent to the fen, or even the entire region. Some studies suggest that the process can be accelerated by interweaving periods of high rainfall and drying out of clumps (Vicherova et al. 2016), which would mean that it could also be affected by climate change.

It is clear from the above considerations that **any disruption of groundwater supply** would be a threat to alkaline fens. This means that investment projects and undertakings may be a threat, even located far from the fen itself, but affecting the aquifer from which it is supplied. These may include more extensive sealing of the ground surface (and thus limiting the supply to the aquifer), regulation of watercourses, all excavations, embankments and boreholes, extensive afforestation and, above all, groundwater abstraction (cf., photo 48). The sum of small water abstractions, even those carried out without administrative permits, under the so-called 'normal water use', may also be significant (cf. chapter 10). The sum of these various external factors influencing the water supply may completely change and destroy the water conditions necessary for the functioning of the fen, making its protection impossible, and resulting in the maintenance of – at most – humid meadows with an abundance of species (cf., e.g., Klimkowska et al. 2010b, d).

Groundwater supply is potentially affected by climate change, e.g., changes in rainfall characteristics, changing the supply of the aquifers.

It should be remembered that groundwater supply is often characterized by high inertia: the period from rainfall supplying the aquifer to the flow of this water to the surface may reach even several dozen years. The reaction of the groundwater supply to disturbances may therefore be significantly delayed.

Photo 48: Alkaline fens are sometimes a source of good quality drinking water. The water intake on the fen in the vicinity of the Bembeński brook in the Orava – Nowy Targ Basin is a potential threat to its hydrological conditions (photo R. Stańko).

Such threats, which are very serious in the case of alkaline fens, are very difficult to identify and assess as there are no easy ways to identify where the waters supplying the fen come from and, therefore, in what area projects that could have an impact on groundwater should be given special attention. Hence, the problem is often omitted from the environmental impact assessment procedures (cf., Pawlaczyk 2015 and chapter 9 herein).

Alkaline fens do not belong to ecosystems strongly exposed to the **expansion of alien plant species**, however they may be threatened by several species of specialized neophytes (cf., Dajdok & Pawlaczyk 2009). In some fens of Pomerania, *Mimulus guttatus* is observed (cf., photo 49). On alkaline fens in the Drawa Primeval Forest, *Spiraea tomentosa* was noted (cf., photo 50), although the main scope of its expansion concerns other types of fens. Heavily drained moss fens are also home to invasive alien species such as *Solidago canadensis* and *Solidago gigantea*. All of the neophytes listed here are of North American origin.

Photo 49: *Mimulus guttatus* on a degraded alkaline fen in the valley of Łupawa in Pomerania (photo P. Pawlaczyk).

Photo 50: *Spiraea tomentosa* on the alkaline fen Osowiec in the Drawa Forest (photo P. Pawlaczyk).

Direct physical destruction of alkaline fens, either for investment purposes or to use as landfill sites, is a somewhat less common threat, but extremely important in the context of environmental awareness. Cases of filling fens with domestic waste or flooding of living alkaline fens in order to create, for example, a water reservoir have been documented on numerous occasions. In the spring section of the Narew River, in place of the former alkaline fens, there is now the Siemianówka Reservoir, which was established in the second half of the 1980s. At the beginning of the 21st century, the attempt to build an expressway through the Rospuda Valley in the place of the occurrence of extensive sedge-moss fens became a very public issue. These activities are associated with low environmental awareness and ignorance, but also with a lack of willingness to protect the natural heritage. The reluctance of those responsible for maintaining good habitat conditions (e.g., landowners, land managers and even public administrations) to cooperate, particularly in some regions, is often the cause of degradation and loss of habitat 7230.

A physical threat to some alkaline fens may be the **intention to exploit peat and dig fish ponds in the fen**. In some parts of Poland these are popular and attractive ways of „developing non-productive areas". An additional motivation is that the ponds dug in a soligenous fen can often be automatically fed with spring water.

Photo 51: Seen as wastelands, fens can be „developed" in different ways. One of the most valuable alkaline fens of the Black Orava River with an underground sewage network and sewage treatment plant built on its border (photo R. Stańko).

Legal mechanisms enabling the prevention of contemporary threats to fens are discussed in chapter 9. In practice, however, they do not always turn out to be effective (cf. photos 51, 52). The primary and common problem with the protection of alkaline fens involves the negative effects of damage and threats from the past, which continue to exist to this day and which are impossible to fully remedy.

Photo 52: The backfilling of fens is quite common practice. Kobyla Biel – an example of a habitat 7230 in a Natura 2000 area degraded in 2016, where the perpetrator (as in most similar situations in Poland) has not suffered any legal consequences (as of 2018) (photo F. Jarzombkowski).

5. Methods of protection of alkaline fens

Robert Stańko, Dorota Horabik, Paweł Pawlaczyk

5.1. Protection against external threats

Alkaline fens are ecosystems that are easy to damage and destroy, but very difficult to repair and restore (cf. chapter 3). Once the hydrological and biogeochemical mechanisms of the ecosystem have been disturbed, it is never possible to fully remove the effects of such a disturbance. Therefore, the protection of ecosystems of this type must be based, above all, on avoiding anthropogenic degradation, including particularly careful protection of all those fen that are still in a near natural state. External threats and impacts may also define the framework within which the degraded fen may be restored.

The legal tools that can be used to address such threats, but also the underlying problems that undermine their effectiveness, are presented in chapter 9.

5.2. Optimization of water conditions

The most important factor determining the development and durability of alkaline fens is having appropriate water conditions. By this, we mean that only undisturbed flow rate, the appropriate level, and constant inflow of groundwater with specific physical and chemical parameters guarantee the development and proper long-term conservation status of alkaline fens (cf. chapters 3 and 4). At present in Poland, with a probable exception of single sites, there are no fens remaining beyond the negative impact of anthropogenic hydrological conditions (Stańko & Wołejko 2018). Therefore, all projects related to the protection of fens focus primarily on inhibiting excessive outflow or raising the level of groundwater in fens.

The main problem on alkaline fens, however, is the proper design of such an optimization of water supply. This is very difficult due to the specific ecosystem functioning mechanisms and typical alkaline fen degradation mechanisms already described in the previous chapters. In order to save the fen, it would usually be necessary not only to stop the water outflow, but also to restore the process of water seeping through the peat, which is usually not possible. As a result of fen degradation, often the remains of the most valuable fen vegetation are concentrated in ditches, the only places where it is technically possible to block drainage, but the edges of ditches and their immediate vicinity are often exposed to destruction by flooding. The general design rules for drain blockages will normally be: „to inhibit the outflow as close as possible to the sources", „to force continuous soaking of the peat in water up to the surface of the ground", and „many small, distributed drain blockages instead of a few larger dams". However, the practical implementation of these principles on a particular fen is usually not easy and, even when implemented, does not always guarantee positive effects.

Especially in the case of degraded fens, their re-watering by blocking the outflow may cause the biogenic nutrients to release and eutrophicate the fen again, which is very unfavorable from the point of view of its protection (cf., chapter 3). Therefore, before manipulating water conditions, it is necessary to well recognize the specific ecohydrological features of a particular fen.

The practical experience of the Naturalist's Club also shows that raising the water level in sites with significant surface peat mineralization contributes to the expansion of the rush vegetation. Protective measures, limited only to raising the water level in the area of alkaline fens with disturbed hydrological conditions, contribute little to inhibiting the expansion of forest vegetation (Stańko & Wołejko 2016).

Nevertheless, there are many examples that inhibiting the outflow is an effective protection measure, also in alkaline fens (e.g., Hedberg et al. 2012, Stańko & Wołejko 2016).

When choosing technical solutions, it is worth using those that will not require special care and frequent repairs in the future. Optimal solutions are those that will not require any maintenance for the assumed period of time, i.e., about 20 – 25 years. Unfortunately, even a perfectly made blockage or gate requires a check from time to time. Water pressure, which is often underestimated, can be the cause of its malfunction. Relatively often, the sides of the gate are washed out and a bypassing drain forms. When planning gates in dry periods it is easy to underestimate the drainage force that can occur after heavy rain or in the spring. Beavers, which take advantage of the opportunity to raise water level even higher, may also be the cause of the gate's malfunction. During the period of „use" of those blockages by the beavers, taking care of its tightness (as opposed to taking care of the protected fen, which may be flooded) is unnecessary. Problems may arise when beavers leave the dam formed on the gate, which in such cases is usually destroyed.

Over the last dozen or so years, many technical solutions used to neutralize the negative impact of drainage systems have been developed, tested, and described as part of many projects to protect fens and small retention areas (Pawlaczyk et al. 2002, Kujawa-Pawlaczyk & Pawlaczyk 2005, Pawlaczyk et al. 2005, Herbichowa et al. 2007, Makles et al. 2014, Center for the Coordination of Environmental Projects 2016). They are used on various types of fens and are also suitable for use as part of projects implemented to protect alkaline fens. Below is a description of several solutions that are still in use, based on the „Wetlands Protection Handbook" (Pawlaczyk et al. 2002), used mainly in ditches, but which can also be used to block small linear surface outflow channels, and also on small watercourses. It should be remembered that in order to improve water conditions of fens, it is usually not enough to block the drainage ditches.

Sand bags

Plastic bags, usually polypropylene geotextiles, filled with sand (such as those used to reinforce flood embankments) are well suited to blocking small drainage ditches. This solution, although effective, should be considered rather temporary. The advantage is simplicity of construction, low cost, and simple formal conditions (cf., chapter 9 – no water structures or facilities are created, the measure may be classified as „retaining water in ditches", not requiring even a water-law notification).

Fixed wooden partitions

One of the most frequently used solutions. Low costs, easy installation, easy integration into the environment, and relatively long service life often justify the use of such a technical solution.

These partitions guarantee stopping excessive water outflow or raising water level in ditches up to 4 – 5 m wide. The basic material for their construction are thick (4 – 5 cm), although not too wide (10 – 15 cm), wooden boards of various lengths (1.5 – 2 m) with a routed tongue. The best material for the partitions is hardwood, e.g., oak. Alder wood can be used in immersion conditions. Thick pine boards can also perform their function for several years. In many cases (shallow ditches with low flow rate), a period of several years is sufficient for a complete overgrowing of the ditch. The natural decomposition of the partition, which no longer fulfills its function, is in this case most desirable.

There are several different techniques of building wooden partitions (cf., Pawlaczyk et al. 2002, Kujawa-Pawlaczyk & Pawlaczyk 2005, Makles et al. 2014, Center for Coordination of Environmental Projects 2016). Boards sharpened at one end so that, when driven individually into the ground, they direct themselves and press the boards previously driven into place are used to install a tight wall partitioning the watercourse. The depth to which the boards are driven depends on the height of the gate and the hardness of the ground. They should be driven to the greatest depth in the place where the overflow is located. In organic soil, it can be even 2 – 3 times deeper than the height of the damming. In hard mineral substrates, a depth slightly exceeding the damming height is sufficient for the gate to be tight and durable.

A wooden partition can also be built of horizontally placed boards. They can be joined before being placed in the ditch. Unfortunately, it can be very difficult or impossible to drive the entire structure in – so the only way is to dig it in.

It is important that the water does not flow or seep under the partition, so the gates made of vertically driven, well-fitting boards are usually more effective.

Individual wooden partitions, especially when their damming capacity exceeds a dozen or so cm, may over time be deformed and curved under the influence of water pressure. Therefore, during their construction it is appropriate to support them from the tailrace side.

Partitions made of two watertight wooden walls, with filling the space between them with peat, clay, soil, or rocks, are very durable and effective.

An important element of the wall construction is the proper shape of the overflow. It should always be located in the middle of the watercourse and should be formed in such a way that during large water inflows, water flows over only in the middle and not on the sides of the partition. If this is not the case, the gate will be washed out and bypassed in watercourses with high flow velocity.

In order to avoid the effect of washing out and erosion of the banks and bottom of the watercourse, it is important to remember about safe levels of damming. These should be no more than 30 – 40 cm. In order to provide additional protection against undesirable effects of the partition, it is recommended to

Photo 53: A wooden partition made of two watertight walls with filling; perfect for ditches and watercourses with significant water flow (the Mielęcin-Bukowo site in the Drawa Forest, photo R. Stańko).

strengthen, for example with faggots, the edges and the bottom of a watercourse immediately behind a tight partition (so-called tailrace).

Wooden partitions made of boards are construction works and water facilities, therefore their construction requires obtaining of a number of appropriate permits (cf., chapter 9).

Partitions made of artificial materials

In addition to wood – which we recommend – gates can be built using various types of plastic and sheet metal. They have the advantage of being much lighter, easier to transport and cheaper. However, they may only be used where the substrate permits.

Sometimes simple board/plywood gates are used for ditch blocking. These are small structures that help to stop the drain by, for example, backfilling the ditch with local soil. The gate is made of one piece of board which is driven or pressed into the substrate.

Photo 54: A plywood partition is pressed into the fen into a gap (previously made by means of a thick metal sheet driven in and pulled out by an excavator) by means of a small excavator. Bags filled with sawdust (seen in the background) are intended to fill the ditch sections between the gates. Fen in the Franche-Comté region in Jura, France (cf., also chapter 7; photo R. Stańko).

Adjustable gates

The most commonly used technical solution in Poland so far, effective and durable, but constituting a foreign element in the environment. These gates consist of concrete walls with cut-out guides, into which horizontal boards/stoplogs are inserted. Another solution is based on a lifting metal slide gate; the connections of such gates to culverts under the dyke are frequent. Similar solutions installed at pond drains are called outlet monks. To prevent malicious alteration of the damming level, solutions should be provided for enclosing the gate or monk with a steel bar cage with a padlock.

Similar gates, with sliding stoplogs, can also be made of wood, which should be recommended as a more natural material.

Photo 55: Concrete gate with adjustable damming by means of a metal plate (photo B. Utracka-Minko).

Adjustable overflows with flexible pipe

A type of flow through a dyke that is popular in Great Britain, simple, cheap and ingenious, easy to regulate; in Polish conditions probably not sufficiently resistant to malicious human actions. It involves burying a flexible pipe up to 25 cm in diameter in the dyke and setting the height of its inlet and outlet in order to determine the desired water level. This is a good method to use in beaver ponds, where there is a problem with flooding of neighboring areas, although then the pipe inlet must be extended into the pond and adequately protected so that the beavers do not clog it.

Peat partitions

A form of permanent blocking of ditches and drainage channels on fens. The most common method is to backfill the ditch (approx. 2 – 10 m long), sometimes filling the space between two wooden walls. This type of solution may function on low flow rate watercourses, and the peat should be poorly mineralized. Ditch sections left between the partitions will spontaneously overgrow over time.

Peat partitions, made without the use of building materials, are not civil structures and do not require engaging in legal proceedings related to construction projects. However, they must be classified as a conversion of a drainage ditch - a water facility, requiring appropriate water-legal formalities (cf., chapter 9).

Damming with the existing hydrotechnical elements

Culverts under roads can be easily converted into a small damming facility. The construction of a stoplog seal at the inlet of the culvert (grooves in concrete walls, in which boards – stoplogs – are placed) allows for obtaining a dam with adjustable level, and building a well around the culvert inlet, for example using concrete rings, provides a damming and release structure. Damming thresholds can be built based on the existing bridges, which can serve for example as thresholds stabilizing the water level in the fen.

Throttling culverts

Another solution for improving water conditions within fens in the case of a dense network of drainage ditches surrounding the fen may be the construction of so-called „throttling" culverts, i.e., culverts with cross-sections naturally limiting the outflow. The parameters of the culverts used should be adjusted to the place where they are to be installed. The width of the ditch will determine the use of one or two pipes (preferably PEHD) with the right diameter. The construction of culverts with the use of pipes with relatively small diameter, embedded in a wooden and earth dam, will allow limiting the outflow of water from the fen, due to the reduction of the ditch outflow capacity. Such a solution is also extremely important when ditches make it impossible to reach the surface of the habitat covered by the conservation measures. Building such culverts of appropriate width may enable the owner to easily reach the wetland part of the fen in order to perform manual mowing, and thus significantly affect the owner's attitude to the whole process of habitat protection. If necessary, further reduction of water drainage can be achieved by clogging the culvert further with wooden plugs or sandbags.

This solution is attractive in practice also due to very simplified construction and water-legal procedures related to the construction of culverts (cf., chapter 9).

Liquidation of entire drainage ditches

Often the best solution is to backfill the entire drainage ditch from the fen. The most common material used for this purpose is local material from the immediate vicinity of the ditch. When gathering the material, one should strive to protect valuable fragments of the fen surface and the valuable species sites; however, in most cases one should not be afraid of local infringement of vegetation, which in conditions of sufficient moisture regenerates quite quickly. It is also possible to form local ponds – widening of the ditches, using peat to backfill the ditch in other areas

Backfilling entire ditches is often the most beneficial solution for fens, although it is sometimes the most expensive one.

If construction materials are not used, the backfilling of the ditch with local material in the current legal state is not subject to construction regulations. As the decommissioning of a water facility, it requires appropriate water-legal formalities (cf., chapter 9).

Partial filling of drainage ditches

Sometimes it is advisable to limit the drainage effect of drainage ditches to a certain extent, but without their complete removal. This can be achieved by reducing the cross-section of the ditches by backfilling them only to a certain level. Examples would include construction of a biological structure made of faggot bundles at the bottom of a ditch, filling the ditch to the desired height, and at the same time initiating the filling with rubble and silt carried by the water flowing through it. Biological structures made of faggot bundles are made up of cut wicker shoots tied together by wire in the form of bundles (approx. 20 cm in diameter), which are placed in the bottom part of the ditch across its entire width.

If construction products are not used (e.g., if the faggots are obtained locally by the entity implementing the project), the current legal status of the operation is not subject to construction regulations. If the operation can be justified by excessive washout of the ditch bottom and the need to restore its proper functioning, its execution may be qualified as maintenance of water facilities, which does not require any separate permits. If the objective is to change the functioning of the ditch in relation to the original assumptions, it is categorized as a conversion of the water facility, requiring a water-law permit (cf., chapter 9).

Biological structures made of herbaceous plants

Unmaintained ditches become overgrown relatively quickly. In order to increase the moisture content of the fen and inhibit excessive outflow, it is sometimes worth using this characteristic to speed up the process. A good material supporting the overgrowth of ditches are clumps of *Carex paniculata*, which are relatively easy to replant into the ditch as part of the so-called biological damming. However, it is only possible to use this solution for small ditches with low flow rates.

Photo 56: *Carex paniculata* clumps planted in a ditch inhibit the outflow of water from the fen (photo W. Spychała).

Anti-filtration walls

One of the exceptional examples encountered during the implementation of projects for the protection of alkaline fens is the cupola spring fen, cut with a channel – riverbed, causing the drainage of the entire dome of the fen. In the 1980s, the area of the fen was covered by drainage activities aimed at draining the fen and adjacent areas. These activities were also designed to prevent the erosion of the river bed by means of installing concrete steps and culverts, but ultimately they were not carried out, which is now contributing (together with the „maintenance" work carried out in recent years) to the deepening of the river bed and the systematic increase in the drainage of water from the dome. In order to improve the water conditions within the dome, it is planned to install an anti-filtration wall, which will limit the drainage of the dome by the river and will contribute to raising the groundwater level in the dome itself. A schematic representation of the wall is shown in the Figure below.

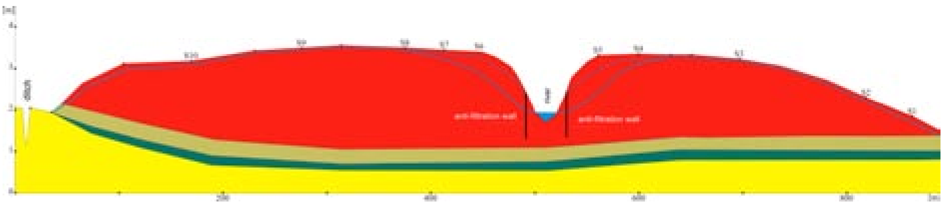


Fig. 2. The installation of an anti-filtration wall will slightly raise the groundwater level, which has been lowered as a result of the dome drainage by the river.

It is possible to make such a wall using various methods and materials, e.g., PVC sheet piles or walls made of oak boards, jointed with the so-called “tongue and groove” as in the case of making gates. The final solutions should be adapted to the field conditions within the site and the technical feasibility of constructing a wall with the least possible disturbance to the habitat during the works. Plastic foil can also be used instead of walls on the edges of fens.

Photo 57: Installation of plastic foil on the edges of the fen in order to limit its drainage by a neighboring drainage ditch (photo R. Stańko).

Beavers and the optimization of water conditions in fens

Different social groups may have varying opinions regarding the activity of beavers, which is understandable as their activities can actually hinder forestry and agricultural management. Beaver dams change the character of rivers, sometimes significantly affecting their ichthyofauna. On the other hand – on a landscape scale – beaver floods bring many environmental benefits by improving the circulation of water in the landscape, ensuring the uptake of biogenic nutrients, etc. (Janiszewski et al. 2014).

From the point of view of alkaline fens, the existence of beaver floods on a landscape scale may have an indirect positive impact as a factor improving water retention in the landscape and thus improving and stabilizing the supply of groundwater. However – on a local scale – there are cases of beavers flooding individual, sometimes valuable, patches of alkaline fens. This effect can be severe, especially when it comes to the last surviving patches of a moss fen.

Nevertheless, experience shows that in conditions of high anthropogenic pressure, the activity of beavers should be viewed positively. Local problems of fen flooding can and must be solved with simple and cheap technical solutions eliminating the negative impact of beaver dams. These are discussed in more detail in separate studies (Czech 1999, Szpaczyński 2003, Czech 2005, Campbell-Palmer et al. 2016). The most popular are pipe overflows in the beaver dams, where the pipe inlet is extended several meters into the beaver flood area and

Photo 58: Beaver activity, despite cases of excessive water level rise, should be assessed positively as it improves water conditions in all types of fens on the majority of the area (photo R. Stańko).

Photo 59: Cases of negative, excessive flooding of fens by beavers can be limited by special pipes inserted into the dams. „Cooperation" with beavers in fen protection is much cheaper and does not require laborious, often completely unnecessary, legal procedures (photo R. Stańko).

secured with a metal basket to make it difficult for the beaver to find the water escape place and clog it up[11].

5.3. Inhibiting vegetation succession

Alkaline fens in natural conditions develop and remain free of trees for a long period of time, counted in hundreds and thousands of years. This is evidenced, for example, by the thickness of moss peat as well as sedge and moss peat deposits in the studied fens. The current changes and observed dynamics of forest and plant vegetation, leading to the disappearance of vegetation characteristic for the habitat, are usually the result of changes that have taken place, and are still taking place in the environment as a result of human activity; these are described in the previous chapters. As a result, the supply system is disrupted and the peat dries, resulting in mineralization and strong eutrophication of the habitat and development of abundant rushes and herbaceous vegetation. This is

11 In the literature, especially in the USA, such a solution is sometimes described under the name of the „Clemson device" (incorrectly: „Clemson's cylinder"), from the name of the city of Clemson in South Carolina, USA, and from the university located there, from which the publication of this idea originated.

followed by favorable conditions for the expansion of forest vegetation, meaning that the flora typical of alkaline fens will disappear and its unique character will be lost. As such, fen protection measures, in addition to improving water conditions, focus mainly on preventing the development of plant and forest vegetation. Of the numerous methods, the most common is the use of felling and then extensive mowing. Descriptions of these activities are also included in numerous publications on wetland protection (Pawlaczyk et al. 2002, Pawlaczyk et al. 2005, Herbichowa et al. 2007, Šefferová Stanová 2008, Makles et al. 2014, Stańko & Wołejko 2016, Priede 2017).

It is worth emphasizing here that not all alkaline fens require such interventions. These actions are necessary when natural mechanisms maintaining the character of alkaline fen vegetation cease to work – most often when they are destroyed by human activities, e.g., drainage, drying, establishing a meadow use. Interventions in vegetation will usually provide artificial replacement of these natural mechanisms. They will make it possible to maintain some valuable natural elements (including valuable vegetation), but usually when they are started they must be maintained and repeated. Well-preserved natural fens usually do not require such active protection.

Mowing

Repeated mowing is used as a treatment to prevent the growth of trees, to partially remove dense, high vegetation, and in addition to remove some of the biogenic nutrients accumulated in the vegetation, which contributes to the temporary „defertilization" of the habitat, giving the chance to maintain the vegetation characteristic of alkaline fens. The „defertilization" mechanism is complex, including changes in the availability of nitrogen, phosphorus, and potassium to plants and their interactions (Venterink et al. 2009).

Mowing requirements must be assessed individually, and the decision to „mow or not to mow" is one of the most serious dilemmas in protecting alkaline fens (see also Priede 2017). Starting to mow a fen can prolong the existence of valuable vegetation on it, or it can produce, in place of a destroyed alkaline fen, valuable ecological systems in the form of floristically rich wet meadows (which is sometimes the only possible goal, cf., Klimkowska et al. 2010b, d). Usually, however, a fen once mown will have to be mown forever in order to maintain its natural values. Arguments against mowing should therefore include the natural character of the fen, fully natural water conditions, lack of drainage ditches and their remains, the stability of the water table in relation to the fen surface, low and loose vegetation in the moss fens, and good condition of the moss carpet. The development of tall, lush vegetation, reeds, and especially herbaceous communities with *Filipendula ulmaria*, *Urtica dioica*, *Cirsium oleraceum*, and *Cirsium arvense*, the clear expansion of alder, and the expansion of *Phragmitetum australis* reed rushes provide arguments for mowing.

Usually, undertaking mowing activities worsens the vegetation condition of valuable fens, close to their natural state, but improves the vegetation condition of strongly degraded fens. Our experience, however, shows (e.g., Stańko & Wołejko 2016) that in the case of many sites, it is possible to achieve a significant improvement in the natural value of vegetation.

The frequency of treatments and their time should be individually adjusted to each area; this usually depends on the objective, the degree of transformation that the fen has undergone and its current vegetation. The observations carried out indicate that the most intensive mowing is the right solution for the most strongly transformed sites, especially within which the water content was increased. In these areas, early mowing (e.g., June or July) can also be much more favorable than late mowing, especially if it is also intended to inhibit reed growth. Such fens require mowing practically every year. Especially when it is necessary to limit e.g., the expansion of *Phragmites australis*, even two mowing sessions per year may be advisable.

Other sites only need to be mowed once every 2 – 3 years. The specific flora and fauna conditions (e.g., the presence of certain species of butterflies, the presence of *Dactylorhiza sp. div.* orchids, like *Epipactis palustris*, *Gladiolus imbricatus*, *Trollius europaeus*) may lead to delaying mowing (even until the August – October period), to mowing not every year, or to leaving large unmown areas – different for each year.

At the same time, there are no set rules for choosing the right frequency and dates. Most of the valuable plant species favor late summer and early autumn mowing, although sometimes they can also endure mowing in spring and early summer. It is best to try different mowing patterns on different parts of the protected site, and often the most advantageous is to maintain the mosaic of plots mown at slightly different times and in a slightly different way (this sometimes happens naturally, as a result of the diversity of properties of plots on the fen).

It is important to collect and remove the cut material (swath). As a rule, it should not be left on the fen, even when mulched, as this will not have the effect of removing part of the biogenic nutrients, which is one of the purposes of mowing (see below).

Mowing can be done manually, which usually corresponds to the traditional management, but is expensive and often impractical due to labor shortages. Mechanical mowing may also be implemented, but the boggy conditions create significant limitations for the equipment used. As part of protective measures implementation, it is not recommended to lower the water level, even periodically, just to be able to use mechanical equipment.

The equipment currently available on the market significantly improves work efficiency, however it still does not make mowing an easy task. An important factor determining the intensity and costs of the labor is the size of the fen. Large areas (several hundred hectares) make it possible to use specialist, efficient equipment with large dimensions and higher output. In these situations, it is worth using „bespoke" technical equipment to meet all the necessary requirements for use in difficult terrain (e.g., large vehicles on special tracks (groomers) designed to operate on extremely boggy ground). Such equipment, together with appropriate systems for the use of the obtained biomass, may be an element of broader, ultimately self-financing nature protection projects (cf., Gatkowski 2015).

However, areas of this size are rare even in Central Europe (e.g., the Biebrza Valley). The use of even the best specialist equipment in difficult conditions of strong hydration unfortunately does not completely eliminate the risk of fen degradation. On the Biebrza River, research has shown (Kotowski et al. 2013) that mowing with groomers is beneficial for birds, but the impact on the flora and vegetation is varied and not always positive. The use of such equipment eliminates some rare and valuable plant species, probably because it transforms the microtopography of the fen. Problems with damaging the surface of fens by mechanical equipment used for mowing (including tractors of various types) are

Photo 60: A fragment of a fen surface destroyed by groomers in the Biebrza Valley, where they often pass by, is sometimes a necessary price to be paid to restore the mowing of the fens (photo R. Stańko).

Photo 61: Reaching the mountain flush fen with a brushcutter is sometimes possible thanks to the existing transport infrastructure, however it usually requires a few hours of walking (photo T. Bąkowski).

much more common (Michalska-Hejduk & Kopeć 2012, own observations in the Drawa National Park). In any case, the balance of profits and possible losses need to be taken into account. Unfortunately, it is often the case that this is the only practically possible solution.

Conducting the alkaline fen mowing treatments is particularly difficult in the case of medium and small sites. Depending on the possibility of access, sometimes only on foot (in the mountains), sites with a small area (a few, a dozen or so ares) most often use ordinary petrol brushcutters.

Where the area is larger (several hectares), and at the same time there is a relatively easy access by car, small single-axle tractors can be used (their weight is about 120 – 200 kg). Regardless of the water content, the best tractors for this purpose are those with rubber tracks with low pressure, not damaging the vegetation, especially of the moss layer (see below).

Mowing alkaline fens with all kinds of tractors and mechanical mowers must take into account the way in which they affect the structure of the fen surface. This problem concerns in particular fens supplied by waters with higher iron content, which can be easily confirmed by the presence of iron-oxidizing bacteria (rust suspension in the water in the valley), and by the occurrence of species characteristic almost exclusively for clumps (for most calcicole species, iron is toxic – cf., chapter 3 and literature cited therein). In this case, mowing with heavy equipment, which causes the clumps to be "pressed" into the hollows, is unacceptable.

Photo 62: Single-axle tractor – rubber track cylinder mower, perfectly coping with the most difficult conditions on a strongly hydrated fen, is a very good and effective technical solution. At the same time, it allows to mow an area about 4 – 5 times larger than that of a petrol brushcutter, using about 2/3 less fuel and causing little damage to the vegetation (photo R. Stańko).

Grazing

Livestock grazing is not a typical way of using alkaline fens, but it is applied in some areas. The impact of animals on the fen can vary and strongly depends on the characteristics of the site. Eating the vegetation is a form of „defertilization" and can sometimes allow the development of a moss layer or low sedges. In the case of fens, animals usually have a strong impact on the ecosystem by trampling on the surface. This may sometimes have positive effects, causing the fen surface to be pressed into the calcareous water impact zone, but e.g., with an increased iron content in the supply water, it will have negative effects (see above, cf., chapter 3). This method of protection should therefore be approached with great caution and only after a thorough analysis of the site. Under no circumstances should pasture or hay and grazing land use be regarded as a standard method of protecting alkaline fens[12].

12 It is also a mistake to routinely record pasture or hay and grazing land use as an obligatory conservation measure for natural habitat 7230 in the Conservation measures plans for Natura 2000 areas, as is unfortunately often the case.

Possibility to use agri-environment payments to support mowing

In connection with the Common Agricultural Policy of the EU, a farmer (including also an institution with registered agricultural activity, e.g., a national park, a forest inspectorate) possessing certain types of valuable natural habitats within their land, may – while managing these habitats in a specific way – benefit from the so-called agri-environment-climate payments (formerly: agri-environment payments). These are voluntary contracts in which an annual payment is due for compliance with the required use method. This possibility also applies to alkaline fens.

Within the Rural Development Programme for 2007 – 2013, a special „sedge-moss fen" variant was available, dedicated to the protection of vegetation of fens with moss and sedge communities, including alkaline and calcareous fens. The variant (so-called package in Polish) included annual mowing of 50% of the plot or the entire plot once every 2 years, from 15 July to 30 September, with the simultaneous prohibition regarding grazing and fertilization. Such a management regime entitled the owner to a payment of PLN 1,200 per ha per year (and in Natura 2000 areas – PLN 1,390 per ha). The plot could be qualified for the package on the basis of ascertaining and documenting by a certified naturalist's expert at least three indicator species (or two protected indicator species). The following species were considered to be indicator species: *Calamagrostis stricta, Carex buxbaumi, C. canescens (curta), C. chordorrhiza, C. davalliana, C. diandra, C. dioica, C. echinata, C. flava, C. lepidocarpa, C. panicea, C. pulicaris, Dactylorhiza spp., Drepanocladus spp., Epipactis palustris, Eriophorum angustifolium, Eriophorum latifolium, Helodium blandowii, Juncus filiformis, J. subnodulosus, Liparis loeselii, Menyanthes trifoliata, Paludella squarrosa, Parnassia palustris, Pedicularis palustris, P. sceptrum-carolinum, Pinguicula vulgaris, Polemonium coeruleum, Saxifraga hirculus, Scorpidium scorpioides, Sphagnum teres, Stellaria palustris, Tofieldia calyculata, Tomentypnum nitens, Triglochin palustre, Valeriana dioica,* and *V. simplicifolia*. Natural moss fens, which are in good condition without agricultural use, could also be classified as „natural land", where (up to 5 ha per farm) an annual payment of 550 PLN/ha was due for the mere fact of not worsening the condition of a valuable habitat, the removal of waste, and possible carrying out maintenance procedures prescribed by the expert. Some alkaline fens which did not show a sufficient number of indicator species were also qualified for the variants of „tall sedge rushes" (assuming mowing once every 5 years), or „semi-natural wet meadows" (assuming mowing once or twice per year) with payments of 800 PLN/ha. Some patches, previously heavily overgrown with herbs and rushes and not diagnosed as alkaline fens, after the restoration of mowing within the „wet meadows" package revealed their natural values and moss fen nature.

In the Rural Development Programme for 2014 – 2020 there is no special package dedicated to alkaline fens, but they may be subject to the „fens" variant. As before, the classification of an agricultural habitat plot to a package is based on a nature expert's report with appropriate authorizations, but nowadays it is required to confirm the presence of at least five species from a wider list of indicator species, or at least 60% cover with three species, and the vegetation of the site should „represent classes *Scheuchzerio-Caricetea nigrae, Oxycocco-Sphagnetea*, *Cratoneurion commutati* association, *Cladietum marisci* association or *Caricetum buxbaumii* association or be related to them". The list of indicator species, currently common for different types of fens, includes: *Andromeda polifolia, Aulacomnium palustre, Baeothryon alpinum, B. cespitosum, Calla palustris, Campylium stellatum, Carex buxbaumii, C. canescens, C. chordorrhiza, C. davalliana, C. diandra, C. dioica, C. echinata, C. flava s.l., C. heleonastes, C. hostiana, C. lasiocarpa, C. limosa, C. pauciflora, C. rostrata, Chamaedaphne calyculata, Chara spp., Cinclidium stygium, Cladium mariscus, Comarum palustre, Cratoneuron filicinum, Dactylorhiza spp., Drepanocladus sendtneri, Drosera spp., Eleocharis quinqueflora, Empetrum spp., Epipactis palustris, Erica tetralix, Eriophorum spp., Fissidens adianthoides, Hamatocaulis vernicosus, Hammarbya paludosa, Helodium blandowii, Juncus alpino-articulatus, J. filiformis, J. subnodulosus, Ledum palustre, Ligularia sibirica, Limprichtia spp., Liparis loeselii, Lycopodiella inundata, Meesia spp., Menyanthes trifoliata, Orchis palustris, Oxycoccus palustris, Paludella squarrosa, Palustriella spp., Parnassia palustris, Pedicularis palustris, P. sceptrum-carolinum, Philonotis spp., Pinguicula vulgaris, Pseudocalliergon spp., Rhynchospora spp., Saxifraga hirculus, Scheuchzeria palustris, Schoenus spp., Scorpidium scorpioides, Sesleria spp., Sphagnum spp., Stellaria crassifolia, Straminergon stramineum, Swertia perennis, Tofieldia calyculata, Tomentypnum nitens, Triglochin palustre, Utricularia spp., Vaccinium uliginosum, Valeriana dioica s.l., Viola epipsila,* and *Warnstorfia spp.*

Mandatory requirements in this option, for which a payment of 600 PLN/ha per year is due, include:

- ban on peat extraction, on afforestation, on fertilization and liming, ban on the use of mechanical equipment which interferes with the topsoil, ban on leaving mulched biomass,
- obligation to dispose of anthropogenic waste;
- felling of trees undergrowth and shrubs indicated by the nature expert in the nature documentation in the first year of implementation of the variant within the period from 15 August to 15 February of the following year;
- mowing the area where tree and shrub basal shoots occur or cutting them, every year or once every 2 years (mowing frequency determined in the nature documentation by the nature expert) in the period from 15 August to 15 February of the following year;

Additional requirements, which are decided by the nature expert and for which the rate of payment increases to 1206 PLN/ha per year, include:

- mowing of the sward from 15 August to 15 February of the following year (once, twice, or three times within 5 years of the commitment, but not more frequently than every two years, as determined by the nature expert in the nature documentation); it is permissible to leave up to 20% of the area of the agricultural plot unmown (as determined by the nature expert in the nature documentation). Different unmown parts should be left in subsequent mowing operations;
- an obligation to collect and remove the cut biomass (including the prohibition to leave the cut biomass in in the field). Within 2 weeks after mowing, the biomass should be removed from the agricultural parcel, or placed on prisms, or stacked.

In practice, some alkaline fens may also – as in the previous RDP – be included in the „wet meadows" variant, with 1 – 2 mowing operations per year.

Where mowing is required to protect alkaline fens, agri-environment-climate payments can be a good way to finance it. The key element is the so-called nature documentation prepared by a qualified expert – it should be ensured that the plots on the fen are classified as such under a variant whose regime meets local fen protection needs and that the expert's detailed requirements fully meet the protection needs.

Tree removal

Sometimes it is necessary to remove trees and shrubs growing over the fen, either as a preparatory treatment for mowing or as an independent protective treatment, inhibiting succession. For example, on some, even slightly degraded fens, occasional trees removal, repeated every 5 years, seems to be a sufficient protective measure (Stańko & Wołejko 2016).

The removal of trees and shrubs from alkaline fens usually concerns alder and willow. This procedure usually involves felling and cutting. Felling trees or cutting shrubs does not usually pose any problems; it is usually much more difficult and expensive to remove their remains to outside the fens, due to the boggy conditions, which often requires manual transport. Sometimes mulching the wood biomass and leaving it on the ground can be considered, but this has unpredictable consequences for fen vegetation (cf., Madaras et al. 2012) and cannot be recommended as standard.

The most important problem is the formation of basal offshoots which is typical for both alder and willow. If the removal of wood vegetation is not accompanied by regular mowing, regrowth may cancel out the effect of the treatment after a few years. In order to effectively destroy the offshoots, it may be desirable to mow with higher intensity up to 2 – 3 times a year during the first years after the removal of trees and shrubs. Successive manual removal is also possible (Klimkowska et al. 2010c). Some consider the use of herbicides, which we do not recommend, however, because of their strongly negative impact on the environment, particularly the aquatic one.

Selecting an appropriate cutting date may limit the growth of basal offshoots (according to the experience summarized by Priede (2017), autumn is the most favorable season). In order to eliminate the problem of regrowth, it is also possible – instead of felling trees – to remove them by girdling (taking off the bark with phloem around the entire circumference of the trunk, cf., Priede 2017).

When removing trees and shrubs is a pre-condition for mowing, it is important that the trunk is cut as low as possible so that it does not obstruct mechanical or manual mowing in subsequent years.

Biomass management

The biggest problem during mowing operations is usually the removal of the mown biomass.

Leaving the hay cut but not harvested on the ground usually has a negative impact on the vegetation as it creates a layer of dense felt; this leads to floristic impoverishment associated with an increase in the proportion of eutrophic species. Mulching, which is sometimes used, can also have similar negative effects. The negative effects of leaving biomass are not always evident. In some cases, at least during the first mowing operation, this is acceptable and sometimes „a lesser evil" than not mowing at all. However, it should not be routinely used as a standard. Usually, therefore, the biomass has to be removed at least outside the fen.

The hay produced is usually of poor quality, only partially dry, impossible to compress and mechanically harvest. Boggy conditions often make it difficult to use mechanical equipment to harvest hay, and the manual removal of biomass to the remote mineral edge of the fen is a hard and very expensive endeavor. Sometimes specialist equipment is helpful (see above), but in general there is no good solution. However, it is important not to omit the removal of biomass.

Another issue is the problem with the management of the mown biomass. Hay is often not of good quality and is not an attractive feed for animals. The collection, preparation for transport (e.g., pressing of underdried biomass), and the transport itself – often involves costs far in excess of the potential income, especially when small, dispersed areas are mown.

As a consequence, some complex projects to protect large areas of fen include systems of local biomass management, e.g., for heating (e.g. installation of special biomass furnaces) in order to generate local demand for hay from fens and to stimulate its collection (cf., Gatkowski 2015). However, this does not solve the problem of biomass from small and fragmented areas. Sometimes it is most beneficial not to use it – to remove it from the fen, but for example to leave it on the adjacent mineral ground for natural decomposition.

Photo 63: Preparation for the collection and the collection of the cut biomass with light horticultural tractors, even with wide or double wheels, is possible only for some of the fens; in the remaining cases the only solution is manual collection (photo R. Stańko).

5.4. Other protective measures

Improvement of water conditions and shaping of vegetation in many cases are not sufficient to achieve nature protection objectives, especially in strongly degraded fens (cf., e.g., Klimkowska et al. 2007). In specialist renaturalization projects, deeper, or even drastic, protective measures are sometimes applied.

One such treatment is the removal of the top layer of soil, i.e., usually the top layer of moorshified peat, together with the current vegetation (so-called „top-soil removal"). As a result, a well hydrated layer of bare peat is exposed, in the hope of regenerating fen vegetation (van Diggelen et al. 1997, Patzelt et al. 2001, Klimkowska et al. 2009). The treatment is sometimes effective, especially when the fen is completely decayed, but its hydration in the deeper layers remains stable. The prerequisite for success is at least relative stability of the water level (there must be no strong fluctuations). In order to solve this problem, mulching with hay obtained at a phenologically appropriate time from a species-rich and mown fen may be used as a limiting factor for the availability of diasporas of fen species (Klimkowska et al. 2007, 2009). However, such activities are difficult and very expensive to organize (the main problem is the management of harvested soil masses; cf., Klimkowska et al. 2010a), and at the same time they constitute a very deep interference with the ecosystem. Doubts also relate to the long-term effectiveness, especially when current hydrological conditions differ from the original ones (Grootjans et al. 2006). The possible use of this method on a scale that goes beyond the experimental one should be preceded by a very deep specialist diagnosis and carefully considered. So far, such actions go beyond the „good practices" that can be recommended for wide use.

Other measures, which deeply interfere with the ecosystem, are also considered as tools for the protection of alkaline fens, such as burning vegetation or liming (van Diggelen et al. 2015). However, they did not go beyond the stage of experimentation on small areas. The literature also describes experiments in the field of the reintroduction of moss species typical for moss fens (Mälson and Rydin 2007), but they also did not go beyond the stage of preliminary research.

6. Monitoring of alkaline fens conservation status

6.1. National Environmental Monitoring and the Chief Inspectorate of Environmental Protection methodology

Methodology

Like all types of natural habitats, the alkaline fens in Poland are subject to monitoring within the framework of the so-called National Environmental Monitoring commissioned by the Chief Inspectorate of Environmental Protection (GIOŚ). The monitoring method for habitat 7230 adopted by the GIOŚ for the assessment of the conservation status and monitoring of the national habitat resources (Koczur 2012) assumes expert surveys of selected sites, on average 4 in the Natura 2000 area (exceptionally, individual sites were located outside such areas). The „site" is generally understood to be a patch of a natural habitat. At each site, a transect of 200 x 10 m shall be designated in the habitat patch at the expert's discretion (with the possibility of modifying the dimensions if necessary). For documentation, three vegetation relevées are taken on 5 x 5 m surfaces (using the classic Braun-Blanquet scale): at the beginning, in the middle, and at the end of the transect, with the measurement of their coordinates by means of a GPS receiver. The idea of conservation status assessment is to describe and assess selected aspects of the ecosystem structure and services, the so-called structural and functional indicators, on a three-stage scale: good (FV), unsatisfactory (U1), and bad (U2). Indicators to be assessed for the entire transect:

- Percentage of the area occupied by the habitat on the transect (where the habitat has only been preserved in a mosaic with other ecosystems). 80 – 100% are rated as FV, 50 – 80% as U1, and < 50% as U2);
- <u>Number of characteristic species</u>. The occurrence of 9 or more species, or total coverage of characteristic species exceeding 50%, is assessed as FV, 4 – 8 species or coverage 20 – 50% as U1, lower coverage as U2. The following are considered to be habitat-specific species: *Bryum pseudotriquetrum var. bimum, Campylium stellatum, C. davalliana, C. dioica, C. flava, C. hostiana, C. lepidocarpa, C. panicea, C. pulicaulis, Ctenidium molluscum, Dactylorhiza incarnata, D. majalis, Drepanocladus aduncus, Eleocharis quinqueflora, Epipactis palustris, Eriophorum latifolium, Fissidens adianthoides, Hamatocaulis vernicosus, Helodium blandowii, Juncus alpino-articulatus, Limptrichia cossoni, Liparis loeselii, Orchis palustris, Paludella squarrosa, Parnassia palustris,*

Pedicularis palustris, P. sceptrum-carolinum, Pinguicula vulgaris, Primula farinosa, Scorpidium scorpioides, Schoenus ferrugineus, S. nigricans, Sweertia perennis, Sphagnum teres, Sph. warnstorfiii, Tofieldia calyculata, Tomentypnum nitens, Triglochin palustre, Valeriana simplicifolia, Warnstorfia exannulata, W. fluitans, and *W. sarmentosa*;

- Dominance structure (dominance of species characteristic for the habitat is assessed as FV, dominance of species not included in this group as U2);
- <u>Coverage and structure of the moss layer</u>. The total coverage of over 50% with the share of brown mosses over 70% is assessed as FV, the total coverage of 20 – 50% with the share of brown mosses 20 – 70% – as U1, lower parameters including the absence of brown moss or the dominance of peat mosses – as U2;
- Possible presence of invasive alien species. None is rated as FV, up to 5% as U1, more as U2;
- <u>Presence of expansive herbaceous plant species</u>. None is rated as FV, up to 5% as U1, more as U2;
- <u>pH of the surface layer of peat</u>, measured at five points along the transect using a field pH-meter or estimated by means of the Helig's method;
- <u>Overgrowth by trees and shrubs</u>. Lack or sporadic is assessed as FV, share up to 15% as U1, larger share as U2;
- <u>Degree of hydration</u> at the time of observation, at 5 points on the transect. A water level located between 10 cm below and 2 cm above the ground surface is assessed as FV, between 20 cm below and 10 cm above the ground surface as U1, deeper than the ground surface as U2. A practical criterion for the FV status is that "when walking on the fen, water is always visible, at least up to the height of the sole";
- Historical and current peat extraction. Traces of historical exploitation of up to 5%, without current extraction, may be evaluated as FV; modern, sporadic extraction on a small scale or larger scale of historical exploitation lower the rating to U1; larger scale of current extraction lower the rating further to U2;
- The presence of drainage systems - absence of ditches or complete neutralization of their operation is assessed as FV, the existence of overgrown or blocked ditches so that they have only a minor effect – as U1, ditches significantly deteriorating the hydration of the fen – as U2;

On the basis of the above-mentioned indicators, the expert evaluates the synthetic state of the parameter „structure and function" in the three-stage scale – FV – U1 – U2. Indicators: characteristic species, moss cover and species structure, pH range, herbaceous plant expansion species, tree shrub and undergrowth expansion, degree of hydration (underlined in the listing above) are treated as the so-called cardinal indicators, i.e., the synthetic evaluation of the structure and function cannot be better than the worst evaluation of these indicators. The interpretation of the impact of other indicators on the synthetic evaluation remains at the discretion of the expert.

In addition to this assessment of the habitat structure and function, the expert assesses two other parameters at the site:

- The surface of the habitat at the site. The assessment concerns the entire patch and not only the transect: a surface stable or increasing in relation to previous surveys or observations is assessed as FV, slowly decreasing as U1, and clearly decreasing as U2;
- Conservation prospects, i.e., chances for survival, behavior of the surveyed patch, taking into account both existing threats and the undertaken protective actions.

The overall assessment of the site is determined by the weakest assessment of these three parameters. In practice, it is usually determined by the assessment of the „structure and function" parameter, because it is in the structure and function of a habitat that both the first symptoms of surface decrease and the chances of effective habitat protection are usually expressed.

Interpretation of results

The methodology described above for the monitoring and assessment of the conservation status of habitat 7230 has been applied in practice as part of the National Environmental Monitoring. In 2009, it was used to survey 121 sites in Poland, and in 2017, the survey for 117 of these sites was repeated (Institute of Nature Conservation of the Polish Academy of Sciences 2018).

The adopted method makes it possible to follow synthetic changes concerning the entire group of all the surveyed sites. Indeed, a comparison of the results of 2017 and 2009 has already revealed such developments and, in addition, they are very worrying. The structure of protection status recorded at individual sites has clearly deteriorated. While in 2009, 16.5% of the sites were in good condition (FV), 58.7% in unsatisfactory condition (U1), and only 14.8% in bad condition (U2), repeating of the survey in 2017 showed that only 10.3% are in good condition (FV), and as much as 53.8% of the sites are in bad condition (U2).

Due to the principle of expert site selection, with the assumption of selecting approximately 4 sites for each Natura 2000 area where alkaline fens are subject to protection, the structure of the conservation status of the sites under study is not representative of the total habitat resources in Poland. The habitat inventory assessment carried out by the Naturalist's Club between 2008 and 2011, according to which only 4.96% of the habitat area were in good condition (FV), 44.08% in unsatisfactory condition (U1) and 50.96% – in a bad condition (U2), can be used as a reference. Therefore, the National Environmental Monitoring over-represents better developed and better preserved patches.

The Chief Inspectorate of Environmental Protection methodology ensures that the surveys are repeated in the same patches of the habitat, but does not ensure that phytosociological observations and relevées will be taken on exactly the same plot. Location of GPS monitoring points in the field is not sufficient for this purpose, because it is not possible to reach the same point with the help of it with an accuracy greater than several meters. Therefore, differences in scores between consecutive observations at the same site, especially relevées, cannot always be interpreted as representative of the actual changes.

The method was developed for selected and idealized forms of alkaline fens, referring to phytosociological approaches which today are out of date, and focus exclusively on the specific form of the habitat – sedge-moss fens (see chapter 2). Due to the significant diversity of alkaline fens in Poland, the calibration of binding indicators will not prove accurate for every type of alkaline fen.

The adopted list of typical species omits e.g., *Calliergon stramineum, Carex diandra, Cinclidium stygium, Juncus subnodulosus, Meesia triquetra, Menyanthes trifoliata, Valeriana dioica, Saxifraga hirculus*, which are undoubtedly important species characteristic for at least some forms of alkaline fens. As a result, fens dominated by vegetation such as *Juncetum subnodulosi, Caricetum diandrae*, or *Menyantho-Sphagnetum teretis* can obtain unfairly low assessments of their condition. Spring fen, including flush fens, even well-preserved ones which do not necessarily have to contain species typical of sedge-moss fens, will be given a completely inadequate rating.

The indicator „*overgrowth by trees and shrubs*" is calibrated very strictly. In practice, it is difficult to distinguish between „sporadic occurrence of trees and shrubs" (FV) and „tree and shrub cover of up to 15%". Many natural and well-preserved fens have trees and shrubs with a content of up to 10 – 30% that are normal and natural, and this proportion remains stable. Meanwhile, in the case of the Chief Inspectorate of Environmental Protection methodology, exceeding the 15% threshold already forces the assessment of U2 and may underestimate the condition of the fen.

Several indicators, e.g., *coverage and structure of the moss layer, pH of the surface peat layer*, are well calibrated to measure the progress of the alkaline fen surface acidification process. Indeed, this is a significant process under natural conditions. However, in the current situation of 7230 habitat in Poland, other trends are a much more serious threat to them. Many of the real patches of the habitat are now „peat-based meadows with sedge-moss fen elements" and are threatened by the disappearance of these fen species, either due to a lack of mowing or by inappropriate mowing regimes (e.g., biomass being left behind, mowing being too early and too low). The calibration of the above-mentioned indicators of the Chief Inspectorate of Environmental Protection assessment (as well as the „*number of characteristic species*" indicator) causes that such patches are initially assessed as being in poor condition (U2), and thus further deterioration of their condition will not be adequately exposed.

Therefore, we should warn against hasty interpretation of „unsatisfactory" and „bad" assessments of some indicators in the Chief Inspectorate of Environmental Protection methodology as a premise for immediate and not fully considered conservation measures plans for the improvement of these indicators. Such assessments may result simply from the local specific characteristics of the fen, which from an ecological point of view is in good condition. However, in most cases such assessments can indicate a real problem. Even then, the indicators may highlight the effects of deeper hydro-ecological changes rather than their causes.

Recording the status of particular parameters and indicators, ensuring repetitive visits to the same patches of habitat by the expert, and at least partial traceability of their changes over time, seems to be more important than the mere assessments on a three-stage scale in the case of the Chief Inspectorate of Environmental Protection methodology. Despite all the implementation and interpretation problems, the National Environmental Monitoring System has made it possible to obtain a collection of observations with a value that cannot be overestimated.

6.2. Good practices for designing local monitoring systems

In planning the protection of Natura 2000 areas, whether through drawing up conservation measures plan or conservation plans, *"the sets of indicators adopted on the basis of scientific knowledge for the purposes of monitoring referred to in Article 112(2) of the Act and reports referred to in Article 38 of the Act, supplemented, if necessary, by indicators specific to a given Natura 2000 site, are used for the assessment of the structure and functions of the natural habitat"*. This means that the status of natural habitats is assessed against virtually the same parameters (habitat area, structure and function, conservation prospects) and the structure and function of a natural habitat are assessed against the same set of indicators as those adopted in the National Environmental Monitoring (Regulation 2010a, b). The possibility of adding indicators "specific for a given Natura 2000 site" as well as omitting the indicators "impossible to apply in a given Natura 2000 site" was introduced into the regulations only in November 2017, and the previously used set of indicators had to strictly correspond to the set of indicators from the Chief Inspectorate of Environmental Protection methodology.

As a result, the indicators from the Chief Inspectorate of Environmental Protection methodology are often used as the basis for the formulated objectives of protection activities. The status reporting of Natura 2000 sites is also based on these indicators. Therefore, it seems reasonable to postulate that the list of parameters and indicators from the Chief Inspectorate of Environmental Protection methodology should be the core of the organization of local monitoring of habitat 7230 and its individual patches.

However, while National Environmental Monitoring is designed to obtain assessments and identify national trends in habitat resources, the objectives of local monitoring are different. In particular, it should provide early warnings against worrying changes in each of the monitored patches to enable appropriate response measures to be planned and implemented in a timely manner. The Chief Inspectorate of Environmental Protection methodology, applied without any additions, is not suitable for this purpose. In order to organize effective local monitoring, it is necessary to supplement and extend it. It is worth noting that although the procedure of planning the protection of Natura 2000 sites requires the use of a set of indicators for the assessment of the natural habitat status similar to those used in the Chief Inspectorate of Environmental Protection monitoring methodology, it does not require at all that the methods of analysis of these indicators be identical.

The aspects and elements described below are particularly important and require supplementing the Chief Inspectorate of Environmental Protection method. Although monitoring organized in the way recommended here will not be inexpensive, it will provide much better information and be far more useful for planning the protection of each of the monitored fens, while maintaining consistency with the nationwide methodology established by the Chief Inspectorate of Environmental Protection.

Water conditions. Water conditions are a key element for all fens and any change should be recorded and interpreted as quickly as possible. For alkaline fens, an important factor and indicator (see chapter 3) is also the stability of the water supply, i.e., the range of changes in the location of the water table in the peat in relation to the surface of the fen occurring during the year, and the reaction of the water table to wet and dry periods. It is therefore completely inadequate to monitor this element exclusively by means of organoleptic expert assessment, and only once every few years. Continuous water level monitoring is necessary in order to get a timely signal of problems with water conditions. The recommended technical solution here should be continuous (at least once a day) recording of the water level in the observation wells with the use of automatic recorders (divers). It should be remembered that even this type of organized measurement has its methodological limitations (cf., Pawlaczyk & Kujawa-Pawlaczyk 2017).

Usually, the monitoring of water conditions in fens requires at least a few observation wells with recorders. Sometimes, valuable information about the water supply can be provided by nearby observation wells with filtering at different depths, showing the hydrostatic pressure of the water in different layers of the fen.

In the case of alkaline fens, it is often recommended to monitor not only the water level itself, but also its characteristics, e.g., chemical and physicochemical. Only with this information does it become possible to interpret the hydrology and ecology of the fens supplied by groundwater (see chapter 3, and literature cited therein), by revealing the direction of this supply. They can also warn about the changes that threaten the fen. For such characteristics it is usually sufficient to examine them at longer intervals, e.g., once a year. Depending on the needs and specific features of a particular site, local monitoring should be extended in the direction of recording of selected physicochemical parameters of water at selected points in outflows and observation wells.

The guidelines for organizing the monitoring of water conditions are the same as those for recognizing the water conditions discussed in chapter 3

Herbaceous and moss vegetation. Changes in vegetation are often a good indicator of changes in the whole ecosystem; it is therefore important to capture them quickly. In alkaline fens, changes in the species composition of the moss layer are of great informative value – in this type of ecosystem, mosses often show processes more quickly and better than vascular plants, including disorders and unfavorable trends (Mälson et al. 2008, Hájek et al. 2015).

In order to identify changes in vegetation effectively and quickly, it is necessary above all to repeat the description of the vegetation on exactly the same area. The only way to achieve such repeatability is either to permanently mark the corners of the observation plot in the field, or at least to mark the observation point (in which case it is necessary to define precisely what is considered to be the observation area defined by that point). This can be done, for example, by means of posts with an underground metal marker, with distances measured to the characteristic features of the terrain. It is not possible to count on the fact that the repeatability of the observation points will be ensured by measuring their coordinates with the use of GPS. Of course the accuracy required will not be provided by a tourist-grade GPS receiver measurement (it has an average location error of 2 – 6 m, and this error doubles when it comes to the accuracy of repeated location of a point with previously measured coordinates. Even the use of more accurate and costly location techniques (GNSS, EGNOS, RTK corrections) is not sufficient since – although these techniques can achieve high accuracy in measuring the coordinates of a field point – it is still difficult in real time and outside the range of mobile network coverage to reach precisely the point with the set coordinates.

Although the estimated scale of Braun-Blanquet coverage used for phytosociological studies is well suited for describing and comparing vegetation, it does cause some loss of information when used for the study of changes in species coverage on fixed surfaces. In grades 1 and 2 of the scale, up to five changes in species coverage (clearly visible to the observer) may not be reflected in a change in rating. Furthermore, it is not possible to perform mathematical operations on the Braun-Blanquet grades, so the change cannot be measured. Some, but not all, of these drawbacks are limited by the so-called Barkmann modification, which breaks Braun-Blanquet grade 2 into 2a, 2b, 2m. Many advantages in monitoring studies, especially on fixed surfaces, would be provided by the so-called Londo decimal scale, in which the differences between relevées can be measured as the mathematical differences of assessment (Pawlaczyk & Kujawa-Pawlaczyk 2017, and literature cited therein). Therefore, it is worth considering the use of such scales.

In view of the informative value of the moss layer, it is necessary to ensure that observations are always made by an expert with bryological experience. This does not only concern the knowledge of the moss species themselves, but also the practical ability to notice them and correctly estimate the coverage of individual species.

Overgrowth with trees and shrubs. The process of overgrowing with woody vegetation is a serious problem for the protection of many alkaline fens. Good monitoring should therefore capture even small and unobvious but directional changes in this area, including allowing for reliable measurement of the rate of overgrowth. Visual expert assessment of the thickness of trees and bushes on the transect is not sufficient for this. Usually, the transect is located in the center of the fen; as a consequence tree changes taking place in the border areas are outside the scope of monitoring – at least until the habitat 7230 has started disappearing completely from the boundaries in e.g., a drop in surface area. The expert visual assessment, especially concerning a 200 x 20 m transect, which is often a surface that cannot be covered by eyesight, is also quite imprecise. The error of such assessment (including the differences between the assessments of different observers) is much greater than the changes it should capture.

This problem can be partially remedied by ensuring that subsequent assessments at the site are carried out by the same observer, who remembers the state of overgrowth of previous observations and is able to directly assess changes. However, this is not always possible in practice.

Effective assessment of changes in the overgrowth by trees and shrubs would require repeated photographic or similar recording, preferably in the form of both standardized, repeatable photographic documentation of the transect, as well as aerial or satellite documentation of the state of overgrowth of the entire patch (drone, aerial, or satellite photographs, LIDAR data). Measurements can be carried out on the materials collected in such a way, expressing precisely, in a quantitative way, the content of trees and shrubs at the site and its changes.

7. The experience of other countries in the protection of peatlands based on the visits of the team implementing LIFE projects and partners

Dorota Horabik, Magdalena Makowska (Makles)

Networking which involves the creation of a network of contacts with other projects to foster efficient sharing of experiences and know-how is one of many aspects of projects financially supported by the European Union, especially LIFE+ projects. This was the very purpose of the study visits to European countries: Germany, Austria, Italy, France, Lithuania, Latvia and Estonia.

During these visits, the participants explored several sites where representatives of host countries realized – or realize – the projects (mostly supported by LIFE+) aimed at conservation of peatland habitats. However, considering that these visits did not cover all interesting and worth mentioning fens, the authors decided to expand the contents of this chapter also by such areas. Although in some of these sites active protection measures concerned not only alkaline fens, but also raised bogs and transitional mires, their scope and method of implementation are presented below. This part of the Guidebook aims to show a range of possible activities to protect peatlands - also on the European arena. These activities focused mainly on the improvement of hydrological conditions within various types of peatlands, and the used methods can be effectively applied to various types of peatlands, including the alkaline fens.

ESTONIA

Ohepalu Nature Conservation Area is one of project areas targeted by the project LIFE14 NAT/EE/000126 LIFE Mires of Estonia *"Conservation and Restoration of Mire Habitats"* (2015 – 2020) https://soo.elfond.ee/en/. Ohepalu is composed of two big conservation areas: Põhja-Kõrvemaa Landscape Park and Lahemaa National Park. It is a huge complex comprising raised bogs, transitional mires, forests, and many small lakes. One of the most important aims of the project is to restore the natural hydrological regime of wetlands in order to halt Natura 2000 habitat degradation and to improve the conservation status of these habitats and species associated with them.

These objectives are implemented mainly through activities focusing on closing the drainage network of the bog by filling the ditches with peat or, as a

Photo 64. The raised bog with peat-producing vegetation (live) (7110) in Ohepalu (photo D. Horabik).

last resort, by building wooden gates. However, where it is possible, it is preferable to make peat dams because of the ease of construction, i.e. the natural material from which the dams are made is available. Such dams are made by means of an excavator, and only in places that are inaccessible to it, works are carried out manually (LIFE14 NAT/EE/000126). During the implementation of conservation works, including mainly those related to the improvement of hydrological conditions, the team relies on experience developed in other countries and guidelines included in the study titled „Ecological restoration in drained peatlands - best practices from Finland" made by Finnish organizations: Metsähallitus - Natural Heritage Services and Finnish Environment Institute SYKE (Similä et al., 2014).

Oidrema-Tuhu. An ideal example of non-degraded by human activity is complex of three types of mires in the surroundings of the Kiska locality.

The alkaline fen located on the fringes of this complex smoothly transforms into transitional mires and then, in the central part, into the raised bog. A nature trail leads through the complex, at the end of which there is an architecturally interesting wooden observation tower. The way the peatlands complex is made available for educational purposes does not adversely affect their conservation status, and at the same time allows you to get acquainted with a model example illustrating the natural development of peatlands through theirs various stages. Peatlands can be the model target when planning the restoration of the proper conservation status of natural habitats.

Photo 65. Habitat 7220 in the Viidumäe Nature Reserve with tufa precipitation on mosses (photo D. Horabik).

Viidumäe Nature Reserve is a botanical reserve of international importance harboring many valuable and rare plant species, mostly associated with alkaline fens (e.g., Lady's slipper orchid *Cypripedium calceolus*, yellow widelip orchid *Liparis loeselii*, and elder scented orchid *Dactylorhiza sambucina*). It is one of three project areas designated under the project LIFE12 NAT/EE/000860 LIFE Springday "*Conservation and restoration of petrifying spring habitats (code *7220) in Estonia*" (2013 – 2018) https://www.loodushoid.ee/SPRINGDAY_348.htm. It is an extremely scientifically interesting area of development of "hanging" alkaline fens parallel to the slope, separated by mineral shafts, fed with waters flowing from different aquifer horizons.

The aim of the project is to restore the proper hydrological regime of the petrifying springs and surrounding valuable natural habitats, including alkaline fens. Therefore, its actions focus on elimination of the draining character of the ditches by filling them with soil material, and the reduction of succession of plants characteristic of drier habitats (shrubs, reeds, etc.). (LIFE12 NAT/EE/000860).

Photo 66. Abundant hooked scorpion moss *Scorpidium scorpioides* and bladderwort *Utricularia sp.* in an alkaline fen (photo M. Ruciński).

Other calcareous fens of Saaremaa island. The limestone substrate of Saarema promotes the development of fens fed by calcium carbonate-rich waters, with the character of calcareous fens (code 7210 often with *Cladium mar-*

Photo 67. Habitat 7220 abundant in valuable species: a – yellow widelip orchid, b – musk orchid *Herminium monorchis*, c – bird's-eye primrose *Primula farinosa* (photo D. Horabik).

iscus) or alkaline (code 7230). An example may be wetland depressions of the similar character to calcareous fens (code 7210), in the south-western part of the island. Despite the intersection of the habitat with a road, two well-preserved patches of the habitat on both sides of the road are characterized by good water conditions and by a wealth of rare species such as *Liparis loeselii*, *Herminium monorchis*, or *Primula farinosa*.

LATVIA

The Slitere National Park is famous for a unique dune complex comprised of almost 180 dunes interspaced by narrow humid depressions where peat is deposited. From an ecological standpoint, these places are very interesting since some of these dune slacks are covered by fens supplied by groundwater, while others are fed by rainfall forming transitional mires and raised bogs (Grootjans et al. 2017). This interesting hydrological situation was investigated in 2016 under the project LIFE13 NAT/LV/000578 Wetlands "*Conservation and Management of Priority Wetland Habitats in Latvia*" (2014 – 2018) - http://www.mitraji.lv/, aimed mostly at implementation of wetland conservation and restoration measures. This project focuses on conservation of mire habitats: 7110 – active raised bogs, 7120 – degraded raised bogs still capable of natural or stimulated regeneration, 7140 – transition mires and quaking bogs mostly with *Scheuchzerio - Caricetea* vegetation, 7220 – petrifying springs with *Cratoneurion communtati* alliance and 7160 – fennoscandian mineral-rich springs and spring fens. (LIFE13 NAT/LV/000578).

Photo 68. The effect of implementation of conservation measures in a peatland (photo D. Horabik).

The project assumes *inter alia* construction of a series of dams on draining ditches. All activities were preceded by a detailed hydrological diagnosis, which in consequence allows to plan the most effective technical solutions corresponding to the specificity of a given place. Typically, it was planned to build cascade of peat or wooden dams made by hand or by using excavator, depending on the place where the works were carried out, the occurrence of valuable plant species within it etc. (LIFE13 NAT/LV/000578).

The Gauja National Park together with the largest peatland Sudas-Zviedru in this area is another site covered by the "*Conservation and Management of Priority Wetland Habitats in Latvia*" project. The park is one of the most valuable Latvian areas, gathering almost all ecosystems occurring in this country. Like in other countries, peatlands in Latvia, including Sudas-Zviedru, have undergone degradation by human interference, including mostly drainage, peat mining, afforestation or intensive agriculture (eutrophication, changes in land use). The main conservation measures include the removal of tree and shrub undergrowth, succession of which was caused by distortion of water conditions, and the blockade of drainage ditches in order to reduce the detrimental effects of the artificial drainage systems constructed in the past. The restoration of proper hydrological conditions facilitates the natural regeneration of the peatlands. Hydrological and habitat monitoring data demonstrated that elevation of water level in the peatlands had an almost instant effect, i.e. moss species structure was improved during one vegetation season, which was a sign of peatland regeneration (Pakalne 2017).

Photo 69. Water stagnating in a blocked ditch in the Sudas - Zviedru peatland (photo D. Horabik).

Engure Lake has been protected as a nature park since the 1950s. It is a Natura 2000 site of international significance for birds' conservation (IBA) and a Ramsar site, with an area of about 198 km^2. The shallow littoral lake, surrounded by rushes, is home of many migratory, rare species of birds, such as corncrake, green fodder and heron. In the transitional areas in which there is access to sea water, wading and nesting places for waterfowl are found. The surrounding meadows are grazed by cattle and horses.

On the spit of the lake, in the shallow basins, alkaline fens developed, calcarous fens with the remnant *Cladium mariscus* and limestone species from the *Caricion davallianae* alliance as well as transitional mires and quaking bogs. As a result of dehydration, the problem is the expansion of trees and shrubs and the disappearance of rare species of *Caricion davallianae* and *Cladium mariscus*. The area is famous for the richness of orchids present here (22 out of 32 species found in Latvia) (LIFE15 CCM/DE/000138).

It was a project area designated by the already completed project LIFE00/NAT/LV/7134 "*Implementation of the Management Plan for the Lake Engure Nature Park*" (2001 – 2004) aimed at the protection of rare and endangered habitats and species, the restoration and maintaining of meadows, and the protection of valuable forest habitats from extinction. The main actions for habitat conservation, including peatland habitats, involved the removal of trees and the establishment of the so-called micro-reserves (Račinska 2004).

The Engure Lake area is also the project area for the project LIFE15 CCM/DE/000138 "*Peat Restore*" *– Reduction of CO_2 emissions by restoring degraded peatlands in Northern European Lowland*" (2016 – 2021, https://life-peat-restore.eu, aimed in this area mostly at the improvement of water conditions by the construction of damming barriers. However, the aim of the project is only indirectly related to peatland conservation since the project principally focuses on a determination of the significance of intact and restored peatlands for combating climate change. These actions have not been performed yet so their effects cannot be assessed at the time of publication of this book. However, it can be expected that they will have similar benefits – as in other areas – leading to restoration of the natural peatland regeneration process (LIFE15 CCM/DE/000138).

LITHUANIA

Debesnu peatland in the **Varniai Regional Park** is a complex of fens, transitional mires and humid meadows located in the Natura 2000 area harboring valuable species on a European scale, including Liparis loeselii and Hamatocaulis vernicosus. The Debesnu peatland is an alkaline fen where conservation actions involving the removal of tree and shrub undergrowth and mowing have been conducted for more than a decade. The conservation actions planned for 2014 under the project financially supported by the Norway Grants involved mowing and grazing. Currently, these actions are continued by a local farmer for whom cattle were purchased in the framework of this project.

Photo 70. The edge of the fen after mowing (photo D. Horabik).

Žuvinto Biosphere Reserve was protected as a nature reserve already in the 1930s, and then it was included into the Ramsar and Natura 2000 networks. It was a project area for the project LIFE07 NAT/LT/000530 WETLIFE "*Restoring Hydrology in Amalvas and Žuvintas Wetlands*" (2009 – 2012) - http://www.wetlife.gpf.lt/en, which was aimed principally at the restoration of proper hydrological conditions and ecological functions of habitats in the Amalvas and

Photo 71. A part of the fen before and after performing conservation actions in the Žuvinto Biosphere Reserve (photo D. Horabik).

Žuvintas wetland complex (total area of this complex amounts to ca. 10,000 hectares) distorted, for instance, by artificial drainage, and the promotion of sustainable agriculture in this protected area. This complex appears to possess a model management system and well-planned and functioning technical infrastructure. It is also a prime example showing the advantages of large areas in executing conservative tasks, also from a cost-efficiency perspective. (LIFE07 NAT/LT/000530).

SLOVAKIA

Belianske lúky Nature Reserve, the largest Central European spring fen, is located in the Spisz Basin. This area has been protected as a nature reserve since the 1980s and, together with the surrounding remnants of fens, it was included into the Natura 2000 network. The total area after enlargement is 106 hectares. The uniqueness of this area on a European scale is attributable to the spring fen complex and humid meadows that harbor many valuable species such as mosses which are glacial relics: the three-ranked spear moss *Pseudocalliergon trifarium* (the only stand in Slovakia) and the three-ranked hump moss *Meesia triquetra*, and vascular plants: the northern bog sedge *Carex dioica,* bog sedge *Carex limosa*, and moor-king lousewort *Pedicularis sceptrum-carolinum,* as well as the critically endangered *Dactylorhiza lapponica*. In total, 266 species have been identified in this area, of which 55 species have been classified as endangered in Slovakia. The history of the fen is interesting and complex, reflected in the stratigraphy of peat and tufa deposits (Grootjans et al. 2005, Grootjans et al. 2012, Madaras et al. 2012).

Almost the whole area was mown in the past and biomass was removed manually and used as the feed for horses or as litter. However, in the 1970s the interest in agricultural use of the fen declined; most of plots were still mown but not every year. Paradoxically, establishing the nature reserve led to a complete abandoning of mowing in this area which, in combination with drainage systems constructed in adjacent parcels, resulted in the expansion of shrubs and forest species (Madaras et al. 2012). Detailed investigation of the ecohydrological conditions of the nature reserve was carried out under the Slovakian-Dutch project PIN-Matra *Ecohydrological research as a Basis for the Restoration of Calcareous Fens in the Slovak Republic.* In the years 2007 – 2009, with the support from UNDP–GEF to the project *Conservation, Restoration and Wise Use of Rich Fens in the Slovak Republic*, non-forest communities were restored by the removal of trees and shrubs from an area of 34 hectares, while mulching was performed over 46 hectares. After these actions were completed, these areas have been regularly mown with light equipment (Madaras et al. 2011). In order to collect additional data on the effects of mulching on vegetation, three plots differing in vegetation type were selected for monitoring. The monitoring data indicated that mulching

Photo 72. Belianske lúky nature reserve (photo D. Horabik).

limited the occurrence of some species (e.g., *Equisetum palustre* and *Potentilla erecta*), while cover of the other species increased, e.g., *Bryum pseudotriquetrum, Juncus articulatus,* and *Campylium stellatum*. The monitoring results indicated that species responded differently to mulching depending on their individual features; however, the type of cut wood and hydrological conditions could also have a significance. Experimental data confirmed that mulching could be applied in fens during two consecutive years (Madaras et al. 2012).

Sur Nature Reserve is the project area for the project LIFE03 NAT/SK/000096 "Restoration of the Water Regime in the Sur Fen Nature Reserve" and LIFE05 NAT/SK/112 "Restoration of the Wetlands of the Zahorie Lowland" (website of the projects unfortunatelly no longer exists).

The Sur Nature Reserve was established in 1952 and remains under state (as a nature reserve) and international protection as a Ramsar reserve and Natura 2000 area. The main aim of the project carried out in the reserve was to restore water conditions and to achieve appropriate conservation status of alder population in alluvial forest habitats. This project was realized from 2003 to 2007. The destroyed and obsolete water level controling facilities were reconstructed. The Fanglovsky Stream, which supplies the nature reserve with water, was cleared and the embankment was constructed at its end to keep water in the reserve. Other important actions included the construction of appropraite discharge devices in the "Chlebnicki Channel" and enlargement of a dike on the Černa Voda

Photo 73. Alluvial forest in the Sur Nature Reserve (photo D. Horabik).

Stream in order to prevent the peat bed drying out in the reserve. In this way, water excess can be released during high water level which protects the neighboring fields from flooding, but the proper water level required for this habitat can be preserved. (Thalmeinerova 2007).

This nature reserve harbors over 120 plant species included in the Red List and more than 50 species classified as rare, vulnerable, or endangered. Vegetation is mostly comprised of swamp alder forests. The uniqueness of the Sur Nature Reserve also relies on the fact that it has different types of habitats; on the one hand, alluvial alder forests, wet meadows, and wetland habitats, and on the other, Pannonian woods which are the last remnant of oak preire forests in the Danube Lowland.

Mesterova Luka and **Orlovskie vrsky peatlands** lies in depressions between sand dunes and comprises oases among sands and pine plantations on the Zahorie wetland. They show an exceptional richness of species, including *Drosera rotundifolia, Calla palustris, Liparis loeselii, Iris pseudacorus, Hottonia palustris*, and *Trichophorum alpinum*. This wetland was explored under the project LIFE05 NAT/SK/112 "*Restoration of the Wetlands of the Zahorie Lowland*" (http://www.broz.sk/wetrest). The main aim of the project was contributing to the of Natura 2000 network in the Zahorie Lowland by restoration and conservation of important wetland habitats and associated species. During the project, management plans were developed for eight Natura 2000 areas, forest management plans were

Photo 74. Mesterova Luka (photo M. Makles).

updated so that they corresponded with the needs of the habitats in these areas, and educational actions were initiated. Active conservation measures comprised: the blockading of drainage ditches and filling them with soil material, the restoration of fish passes in small brooks and construction on the Rudava River, and the restoration of species-rich hay meadows along this river.

Abrod Nature Reserve (http://www.broz.sk/abrod), located in Zahorie Lowland in Slovakia, was established in 1964 and belongs to the best known nature reserves in the Zahorie Lowland. It was created to protect rare plants of the *Caricion davallianae* and *Molinion* alliances as well as rare animal species. Due to its location, this area was extensively used by humans. Drainage works started in 1923, drainage ditches were dug and the Porec stream regulation was completed, which led to a dramatic lowering of the groundwater table in the whole catchment area in the years 1962 – 1966 when this area had already been protected as a nature reserve. These actions had a significant impact on the nature reserve, especially the peatland habitats. Initially, the sedge-moss fen located in the western part of the reserve covered an area of ca. 11 ha (of the total 90-ha area of the reserve). Fortunately, the most valuable part of the reserve survived. In 1994, the Daphne organization – in cooperation with the local administration – initiated studies of the floristic, hydrological, and geological features of the nature reserve.

Thanks to the knowledge about the values and condition of the habitats, their protection was also implemented. Funds for their implementation from the beginning of the 21st century have already been allocated by the Government of Denmark (under the project „Protection and sustainable use of fens in Slovakia"), Government of the Kingdom of the Netherlands (under the PIN-MATRA project „Ecohydrological research as a basis for conservation activities of carbonate peat bogs in the Slovak Republic"), UNDP / GEF (under the project „Protection, restoration and sustainable use of alkaline fens in the Slovak Republic") as well as by the State Treasury of the Slovak Republic (Grootians et al. 2012).

Photo 75. Abrod Nature Reserve in the part with dominating meadows and fens (photo K. Kiaszewicz).

GERMANY

Rosenheim raised bog located in Bavaria covers an area of 43 km^2 and, due to its size, is significant for peatland conservation not only in southern Germany but also in the whole Europe. On this area Bavarian Ministry of Environment and Health (Bayerisches Staatsministerium für Umwelt und Gesundheit) implemented project LIFE05 NAT/D/000053 „ROSTAM - Rosenheimer master basin bogs". The project was completed in 2010 and achieved its objectives, i.e., restoration of the proper (natural) water conditions over 400 ha, restoration and optimization of wet meadow habitat conditions, and development of a very broad educational program for the local community in peatland conservation. Special attention was focused on education of the youth by active games, and the preparation of places and trails for training courses which serve the local community up till now.

The raised bog were severely damaged by the exploitation of peat. The LIFE project mentioned above (http://www.life-rostam.de) completed in 2010 achieved the set goals. About 400 ha of raised bogs have been reconstructed by

Photo 76. Education Center built within the framework of the LIFE Rostam project (photo D. Horabik).

Photo 77. A view of the restored wetlands (photo D. Horabik).

raising the water level and removing trees and shrubs on116 ha. In total, 15 km of wooden and peat dams were built and about 200 km of drainage ditches were backfilled (clogged). As a result of these activities, the level of water in the raised bog increased and the development of typical swamp vegetation was stimulated. Interestingly, most of the conservation measures were carried out by the local society without the costs associated with the LIFE project. Extensive work with the community was therefore one of the very important aspects of the implementation of the enterprise.

Monitoring the condition of vegetation in the areas covered by the project indicates that the natural regeneration of a typical bog flora is possible in the long-term. At the same time, along with the creation of additional wetlands, water and wading birds, including teal, grebe and ringed plover, found their place of living there (LIFE05 NAT/D/000053).

The alkaline fens in Brandenburg is the project area designated under the project LIFE08 NAT/D/000003 – *Kalkmoore Brandenburgs – Preservation and restoration of base-rich to alkaline fens* - http://www.kalkmoore.de/. A hundred years ago the alkaline fens were still very common in Brandenburg; today, they belong to the most endangered habitats in Europe. In Germany, intensive endeavors to transform these terrains into agricultural areas, such as the construction of drainage systems, fertilization and covering by sand, practically eradicated the fens from Brandenburg. Therefore, the project aimed to protect the scanty almost intact habitat patches and to implement restorative actions in the degraded terrains.

These actions included:

- restoration of the proper water and soil conditions. Blocking the drainage ditches is only one small step in this direction. Drainage, fertilization, and agricultural technology significantly changed the top soil layer, whereas 90% of nutrients available to plants (biogenes) are concentrated in the top 25-cm layer of soil. The soils are often compact and have very limited capacity to accumulate water. Soil water balance is distorted to such an extent that the

Photo 78. Areas where a top soil layer was removed (left) and regenerated areas after planting (right) (photo R. Stańko)

soil is excessively loaded even after a short rainfall and then quickly dries out. Thus, in the project the removed soil was used for blocking the drainage ditches that is a common procedure in such cases.

- restoration of extensive hay production carried out in such a way as to remove tall herbaceous plants and shrubs but not low-growing species – suppressed by taller vegetation – that are characteristic of this habitat, and grazing by buffalo which, due to hoof structure and feeding preferences, have a positive effect on the sward species composition,

Photo 79. Grazing cattle (water buffalo) (photo R. Stańko).

- plantings of vegetation characteristic of this habitat (as well vascular plants such as brown and sphagnum mosses) in order to recolonize these terrains and restore the natural species composition.

AUSTRIA

The peatlands described below are situated in the Dachstein range in the Alps. Thus, these are peatlands located at a relatively high altitude above sea level, which is decisive for hallmarks of this habitat.

Langmoos bog. In the 18th century this area was exploited for salt mining purposes. Salt mining consisted in passing streams of water from the nearby bog through the salt deposits and then water was evaporated from the brine. Restoration works led to the discovery of a complex and extensively used system of ceramic pipes and wooden channels which systematically drained relatively small amounts of water from the bog. The amount of drained water was small enough not to ruin the whole bog ecosystem, but big enough to dry out the habitat and stimulate encroachment of such species as dwarf mountain pine that additionally shade and dry the whole surface, thereby hastening bog degradation and withdrawal of bog species.

Photo 80. In the area of Lagmoos bog (photo M. Makles).

Photo 81. The wooden reinforcement of channels and ceramic components of the drainage system (photo D. Horabik).

Conservation measures implemented in this terrain included the removal of most of the draining pipes and channels, and the construction of several tens of simple damming barriers down the slope which slow down erosion and water flow from the terrain located above the bog. A part of the pine seedlings was also removed, but there is hope that the rest will spontaneously withdraw after stabilization of the high water level in the bog. Many of these structures have been built relatively recently so their impact on the habitat was not yet visible; however, persistently high water level could already be observed.

Löckernmoos peatland was also protected by the construction of a barrier system suppressing water outflow from the mire. In some locations of this peatland, sedge-moss fen transforms into a transitional mire and then into the raised bog. The system of damming barriers constructed in this peatland utilizes the method developed by the team realizing the project, and is composed of barriers with characteristic V-shaped metal water outflow. This shape of the outflow negates the necessity to use regulated devices, and provides for appropriate water outflow rate, i.e., a low rate at low water levels and a higher rate at high levels.

Photo 82. Transition of the fen into the raised bog. An arrow indicates the direction of transition (photo M. Makles).

Photo 83. A damming barrier with V-shaped metal overflow (photo M. Makles).

Photo 84. Barriers slowing down surface runoff almost already completely blended into the landscape (photo K. Kiaszewicz).

Rohrmoos bog is situated on the other side of the Dachstein range in the Talbach River valley. It is a “condensation mire” which requires, among other things, the existence of the cooling effect of a tube with cold air which develops on the mountain slope between boulders. In winter, relatively warm air in this “tube” rises up – like in a chimney – while cold air sinks to the bottom of the tube maintaining the low temperature of the rock. Once a year (usually in April) this phenomenon undergoes reversion preserving, however, a permanently low ground temperature in summer. Under such conditions, water vapor condensates around the outlets of cold air that supports the development of the moss communities hanging above and around the outlets, thus creating ideal conditions for development of this habitat.

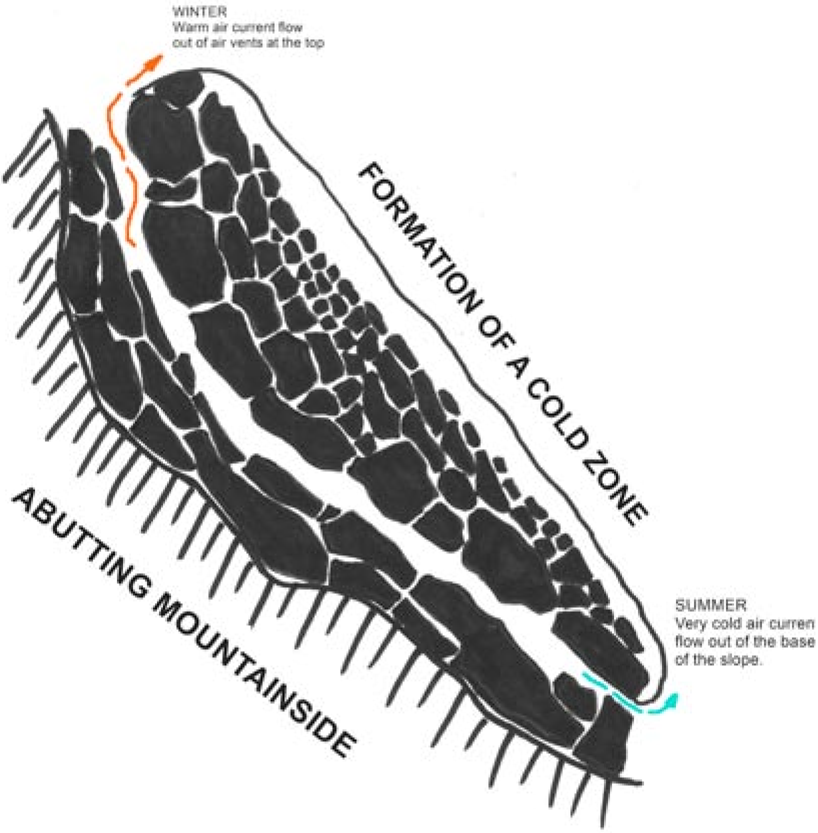


Fig. 3. One of the pre-requisites for the formation of this type of raised bog environment is the cooling effect of a wind tube syste. In winter, the relatively warm air within the hillside rises upwards as in in a chimney. Fresh, cold air drawn in through vents at the bottom, keeps the rock permanently cooled. Once a year, usually in April, this effect is reversed with the cold internal air now flowing downwards, keeping the ground cool all summer. A dead ice zone does not experience seasons (Makowska, original, based on information boards on the site).

Photo 85. The Rohrmoos slope covered by the fen (photo D. Horabik).

Photo 86. An outlet of cold air (the tube mentioned in above text) and the mire developing around it (photo M. Makles).

Saumoos peatland was very seriously degraded by rapacious management as large parts were destroyed by continued peat mining. Peat was mined for use as litter for cattle. Rapacious forest management on this terrain, involving cut-

Photo 87. Saumoos – the flattened slope of former excavation with transplanted vegetation (mostly sphagna) (photo D. Horabik).

Photo 88. Saumoos (photo R. Stańko).

ting tree branches for bedding and utilization of the remaining parts of trees for wood pulp and for plywood production, led to deforestation of this area. For this reason, farmers started to use peat mined in this terrain as bedding. When we were visiting the project area, we watched renaturalization works consisting mostly in restoration of the landscape distorted by excavations, and in the transplantation of plants from adjacent surfaces and construction of damming barriers blocking water flow from the peatland. Birch seedlings were also removed.

FRANCE

Jura peatlands are the area targeted by the project LIFE13 NAT/FR/762 "*LIFE Jura peatlands – Functional rehabilitation of the Jura mountains peatlands of Franche-Comté*" (http://www.life-tourbieres-jura.fr). This project intends to restore proper hydrological conditions of the Jura Franche-Comté's peatlands belonging to the Natura 2000 network in order to preserve or improve the conservation status of habitats and species of EU interest. The most interesting and the most important of them include: raised bogs, transitional mires and alkaline fens and the flora and fauna species: *Saxifraga hirculus* (the only stand in France), *Liparis loeselii, Hamatocaulis vernicosus, Porzana porzana, Maculinea nausithous, Euphydryas aurinia, Lycaena helle, Lycaena dispar, Coenagrion mercurial*, and *Vertigo geyeri* (the only stand in France).

One of challenges of the project is related to the restoration of peatlands destroyed by peat mining and artificial drainage systems through removal of the drainage network and improvement of water conditions that will offer a chance for restoration of the peatland vegetation.

Photo 89. Works carried out to block water outflow in drainage ditches. Solid wooden walls are driven into the peat bed and the ditches are filled with sawdust and covered with peat (photo D. Horabik).

Photo 90. After completion of the filling works, the surface was additionally compacted using heavy equipment (photo M. Makles).

ITALY

The **Virco** and **Flambro fens** are the project areas designated by the project LIFE 06 NAT/IT/000060 "*Conservation and restoration of calcareous fens in Friuli*"- http://www.lifefriulifens.it/. This project focuses on the conservation of the last existing alkaline fens in the Friuli Lowland (Friuli-Venezia-Giulia region), their renewal and restoration from terrains formerly in agricultural use, and the protection of their endemic species which have still survived in these areas. The Friuli Lowland is located at the foot of the Alps in a relatively narrow strip of land between the Alps and the Mediterranean Sea shore (the Trieste Bay). It is exactly this location and geological structure that is a key to conservation of the fens located therein. The main types of habitats occurring in the project areas include: calcarous spring fens, calcarous fens with *Cladium mariscus*, alkaline fens, and wet meadows with *Molinia sp*. The protected plant species discovered in this area include: yellow widelip orchid, march gladiolus *Gladiolus palustris* or almost extinct *Spiranthes aestivalis*, and the endemic species: *Euphrasia marchesetti, Senecio fontanicola, Erucastrum palustre*, and *Armeria helodes.*

In the frame of the project, the fen areas were purchased for the benefit of the Friuli-Venezia-Giulia Regional Administration and legally protected. Traditional hay production with biomass removal was restored, and seeds were collected in order to create a seed bank and to transplant seedlings cultivated from them into new stands (population strengthening). However, restoration of the original water conditions remained the main conservation action. With a huge investment of labor and cost, in the 1950s these areas were adapted for agricultural use (willow, corn). An attempt to restore the former soil and hydrological conditions was undertaken only in 2010. Large amounts of soil were removed, exposing the original layer of peat (sand-muddy and gravel-stony), owing to which groundwater flowing from the nearby Alps saturated with calcium carbonate started once again to flow to the surface of the restored "fens". As already mentioned, the key to success of this action is the location of the fens in a narrow strip of land between the Alps and the Mediterranean Sea shore. Such a location causes that the massif of mountains "presses" water under the surface. Fortunately, human attempts to prepare this area for agricultural use were unable to alter these conditions. In addition, seeds obtained from the seed bank collected from adjacent areas were used to cultivate seedlings, a dozen or so thousands of which were planted in the project area. As an additional reinforcement of these actions, mulched biomass was transferred there from the surrounding wet meadows. To paraphrase the words of a Polish singer: "there has been a stubble field here but there will be a fen"; it can be stated that in this way within over 6 years this area was transformed from a corn field into a calcareous fen with all its features, leading to the presumption that it will spontaneously achieve full regeneration.

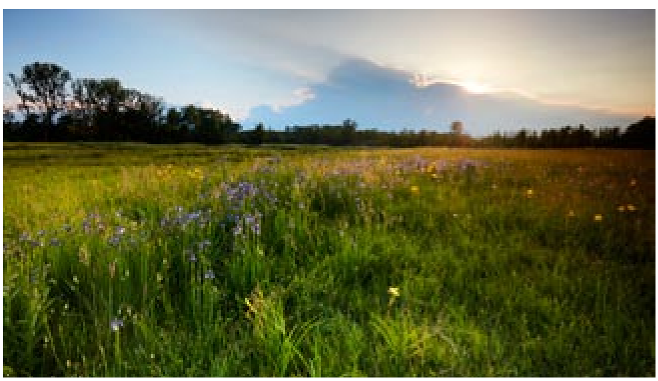


Photo 91. The restored "fen" after 3 years after earth works and planting (up, photo K. Barańska and K. Kiaszewicz) and 6 years (down) (photo S. Zanini)

Photo 92. Endemic species in the Friuli fen (from left): *Armeria helodes, Erucastrum palustre, Euphasia marchesetti,* and *Gladiolus palustris.* (photo K. Barańska, K. Barańska, S. Zanini, K. Barańska).

This project gained recognition on the European scene, confirmed by it being awarded the prize "Best LIFE-Nature Project" in 2013 as one of 8 best environmental conservation projects in Europe.

Danta di Cadore peatbog is the area for the project LIFE04 NAT/IT/177 "*Danta di Cadore peatbogs*" covering 20 ha (the project website is no longer available). It is one of the most phytosociologically valuable areas in Italy. Most of it is occupied by alkaline or calcareous fens and active raised bogs. Similar to many areas of this type, the loss of this habitat was attributed to abandonment of traditional hay production. Conservation measures implemented under this project restored this type of land use, and today the area is mown with a small tractor in autumn because at this altitude the soil is already frozen at this time but not yet covered by snow. This method of mowing does not destroy turf or micro-relief of the terrain.

Summarizing the experiences and observations made during our study visits in all these countries, the most valuable was an opportunity to see alkaline fens untouched (or almost untouched) by human activity and the different developmental forms of these ecosystems in variable physiographic, cultural and historic situations. The methods used in these projects to protect peatland habitats are similar and are modified only to account for the specificity of the individual habitats, their locations, and the surface or determinants of proper function. As such, it was also confirmation of the validity of the methods used in Poland. It also made us aware of how important is sharing experiences in conservation of habitats of the same types between teams from different countries. It also provides a chance to learn from the mistakes of others and to promote proper methods of habitat protection.

Photo 93. The peatlands with a view of the Alps (photo D. Horabik).

Photo 94. As in the Belianskie Luky Nature Reserve, tiny surface reservoirs with alkaline vegetation are formed (photo D. Horabik).

Photo 95. A damming barrier constructed under the project (photo D. Horabik).

The establishment of a network of contacts with different units engaged in similar actions in Europe, such as non-governmental organizations, municipalities, national and landscape parks, universities, etc. is also an unquestionable advantage of these visits. It will allow us in the future to benefit from this knowledge, establish international partnerships in new projects, or seek help in solving problems with habitat conservation in the country.

Another aspect worth emphasizing is related to the observation of long-term strategies, created under the projects, for conservation of habitats, especially when they belong to private owners, or to monitoring how the implemented actions directly influence areas in agricultural use. A comparison of conditions existing in our and foreign countries as well as drawing conclusions from the experiences of other countries enriches our strategies, paving new ways for the planning of nature conservation for decades to come.

8. Experience from national projects

Dorota Horabik

The protection of fen habitats in Poland has been carried out for several years by non-governmental organizations, national parks, landscape parks, institutions responsible for the implementation of environmental policy, i.e., regional environmental protection directorates, as well as State Forests. It is impossible to list all the projects concerned with the protection of peatland habitats that have been or are currently being implemented in Poland; most of them have already been described in numerous publications (e.g. Makles et al. 2014). Below is a description of the projects implemented by the Naturalists' Club, which provided a rich source of knowledge and practical experience on methods of protection of hydrogenic habitats used in the implementation of projects concerning the protection of alkaline fens. Some of them were (or are) focused strictly on the protection of the Natura 2000 habitat, others protected the habitat due to the valuable animal or plant species associated with it. Nevertheless, all the projects had one goal in mind: to protect what is most valuable in our nature. Each of the projects was a source of further experience, sometimes also a verification of the methods used to date. Individual projects are based on similar methods of habitat and species protection, and the differences result from the specificity of the region and the conditions of the habitat. A significant role in the selection of methods of fen protection is played by its surface area. Planning of protection activities in one of the largest fen complexes, e.g., the Biebrza Valley, differs significantly from planning for small sites which are, in addition, often dispersed on a large area or difficult to access (e.g., mountain flush fens).

8.1. Experience from projects implementation by the Naturalists' Club (Klub Przyrodników)

For several decades, the Naturalists' Club has been carrying out projects related to nature protection, including in particular the protection of fen habitats. One of the large-scale projects financed by LIFE financial instrument and dedicated to fens was "Protection of Baltic raised bogs in Pomerania". In the first stage of this project (2003 – 2007), inventories with natural documentation were prepared and the habitat management plans were drawn up on that basis. The results of this work formed the basis for the implementation of protective measures. These activities consisted mainly in blocking the outflow of water by ditch-

Photo 96. Blocking of the ditch by construction of 2 tight partitions filled with clay and with local peat on top (source: http://www.kp.org.pl/plbaltbogs/)

es (at 724 points), the construction of gates, dams and backfilling of drainage ditches, but also in removing invasive wildings and undergrowth of birch and pine trees (on the area of 727 ha). One of the elements was the experimental removal of the muck layer and the transplantation of peat mosses, which produced promising results, further developed in separate projects by the Foundation for the Development of the University of Gdańsk (Herbichowa 2014). In order to precisely adjust the damming structures to the needs of the habitat, a permanent system of water level monitoring in the bogs has been developed. The project also resulted in the recognition of 10 new nature reserves and the inclusion of 13 bogs in the Natura 2000 network (Herbichowa et al. 2007, Pawlaczyk 2007). Additional removal of shrubs from 133 ha and the blocking of water outflow at 90 points was performed as part of the next stage of the project, implemented in the years 2007 – 2010. The implementation of this project has shown that well-prepared and comprehensive actions, planned on the basis of a detailed field analysis, have the intended effect. Although these activities concerned Baltic raised bogs, they are consistent with the conservation activities carried out on degraded alkaline fens, i.e., mowing, removal of shrubs or construction of various types of dams aimed at raising the water level within the peatlands.

Similar activities in the field of active protection of wetland habitats were carried out in the Drawa Primeval Forest as part of several stages of the project "Comprehensive protection of wetlands in the Drawa Primeval Forest". These included active protection measures (the construction of gates, removal of shrubs, establishment of a water level measurement system), mainly in the Natura 2000 habitat "transition mires and quaking bogs" (7140). Experimental attempts were made to restore degraded transition mires by taking out a layer of muck, although the effects proved to be poor due to water level fluctuations. The protective measures also covered the Osowiec alkaline fen (nature reserve), where the mowing of reed was undertaken in implementation of the nature reserve conservation plan, which impeded its expansion for several years. Several further alkaline fens were included in the water level monitoring program, which was established as a part of the project. One of the activities of this project was also to combat the alien species of *Spiraea tomentosa.* The experiences from this activity were published in a broader context of the issue of invasive species of wetland plants in a book by Dajdok and Pawlaczyk (2009). The experiences from other activities and knowledge about fens in the Drawa Forest were summarized in a monograph publication (Kujawa-Pawlaczyk & Pawlaczyk 2014).

Photo 97. Blocking the outflow of water from the fens in the Stołowe Mountains National Park with the trunks of spruces felled as part of the conservation measures. The measure was implemented within the framework of the project "Protection and restoration of endangered hydrogenic habitats in the Central Sudetes" (photo A. Jermaczek).

One of the most important projects for the protection of peatland habitats in the mountains was the project „Protection and restoration of endangered hydrogenic habitats in the Central Sudetes"; it also covered mountain flush fens with features of alkaline fens. The implementation of the project has shown that the most effective method of blocking the excessive outflow of water in the mountains is to create a large number of micro-obstacles. The wood used in their construction came from the implemented trees removal treatments (cf., photo 97). The experience from the project and its result are presented in a publication (Jermaczek et al. 2012), and the method itself used during the implementation of protective actions in subsequent measures aimed at improving water conditions within the mountain flush fen - habitat 7230 (cf., photo 98).

The implementation of the projects described above, as well as other minor activities, was possible thanks to the cooperation with various institutions and the administration responsible for nature protection. Despite the difficulties and differences of opinion that often arise, many of these institutions did not hesitate to undertake joint actions for the benefit of nature. However, when planning any active protection measures, it is important to bear in mind that making appropriate arrangements with the owners or managers of the land before planning any specific protective measures is one of the most important elements to ensure the success of any project. The same applies to land owned by private individuals as to land owned by the State Treasury. It is wrong to believe that every manager (e.g., forest inspectorate official) who holds the land of the State Treasury and is responsible for nature protection "*ex officio*", will enthusiastically and joyfully endorse our ideas. While the majority of decision-makers, if we have the necessary funds for the project, will not object, some of them will certainly consider it an affront, especially those who (in their opinion) hold the land, not merely manage it. Regardless of the situation (limited time, financial possibilities, best relations with the manager, etc.), it is necessary to plan all actions in advance with the manager or owner of the land. The experience gained during the implementation of over a dozen projects unequivocally confirms the validity of such an approach. Another question is whether this is always possible. In our opinion – no! In the case of large projects, especially those distributed over a large area, agreement with all the owners, managers, supervisory authorities, etc., requires considerable amounts of time and financial resources, which no Polish non-governmental organization has. This problem also applies to the state administration. It does not have the adequate human resources or means to obtain all necessary approvals to implement the planned measures, e.g., in the reserve protection plans or in the plans of protective tasks for Natura 2000 areas, before obtaining subsidies for their implementation.

Active safety measures should be preceded by the necessary identification and sometimes quite detailed research. As in the case of the aforementioned arrangements, this entails additional financial outlays. In this situation, the experi-

Photo 98. Blocking of the outflow of water from the flush fen in the Gorce National Park. From the site previously trees and shrubs were removed as part of the protective measures. The measure was implemented within the framework of the LIFE project "Protection of alkaline fens in southern Poland" (photo D. Horabik).

ence of people implementing the project is helpful. It is also worthwhile to use the knowledge of experienced third party experts specializing in a given field. But even this option does not necessarily mean financial savings. It should be remembered, however, that the more details we learn about the functioning of a given ecosystem, and the more individualized approach we plan for its protection, the easier it will be for us to implement the planned conservation measures (Horabik et al. 2015).

8.2. Examples of fen habitat protection from recent years

The project "Conservation of wetland habitats of the Upper Biebrza valley" LIFE11/NAT/PL/422 (https://www.gorna.biebrza.org.pl/redir,index) has been implemented by the Biebrza National Park since 2012, and the project is planned for completion in 2019. Great emphasis has been placed on encouraging local farmers to restore the traditional extensive use of the wetlands, which had been abandoned for years. The main active conservation measures include the removal of shrubs from fen habitats, mowing, and the restoration of water conditions by eliminating the drainage system over a distance of approximately 35 km (LIFE11/NAT/PL/422).

The second project implemented by the Biebrza National Park is a four-year LIFE13 NAT/PL/000050 project „Renaturalization of the hydrographic network in the Central Basin of the Biebrza valley. Phase II" https://www.renaturyzacja2.biebrza.org.pl/, which has started in 2014. The main objective is to improve the conditions of protection of wetland habitats in the Central Basin of the Biebrza Valley, and the most important activities are focused on the restoration of the hydrographic network through the renovation of gates, construction of dams, declogging the Ełk riverbed, reconstructing the Modzelówka water facilities node, and modernizing the weir. In order to carry out the aforementioned tasks, as well as to carry out the active protection measures, land was purchased from local farmers. These activities are accompanied by meetings and workshops aimed at shaping appropriate attitudes of the local society towards nature protection. Experience confirms that one of the most important aspects of nature conservation is gaining public acceptance, which determines the effectiveness of the undertaken measures (LIFE13 NAT/PL/000050).

The Regional Directorate for Environmental Protection in Lublin is implementing the LIFE13 NAT/PL/000032 project „In accordance with nature - LIFE + for the Janowskie Forests" (2015 - 2019) http://janowskie.rdos.lublin.pl/. The project is aimed at comprehensive protection of the bogs and fens, including their valuable flora and fauna. The measures concern, among others, the improvement of the condition of such habitats as raised bogs and transition mires and depressions on peat substrate with vegetation of the *Rhynchosporion* alliance on an area of 94 ha. As part of the project, 35 gates and 8 throttling culverts were built to stop the water outflow and stop the peat moorshification process, which will improve the condition of the pine bog forests habitat and other wetland habitats on an area of approximately 150 ha. Conservation measures in wetlands, i.e., mowing and removal of shrubs, serve both to improve the condition of the habitat itself and the species directly related to it, e.g., *Tetrao urogallus*. It was also assumed that the nature-valuable land (30 ha) in the area of the European beaver *Castor fiber* would be bought back in order to create conflict-free habitats for this species. These measures, although carried out within transition mires and raised bogs, are consistent with those carried out within alkaline fens (LIFE13 NAT/PL/000032).

8.3. By protecting the habitat, we are protecting the species…

„Conservation of the aquatic warblers in Poland and Germany" LIFE05 NAT/PL/000101 (https://www.biebrza.org.pl/264,ochrona-wodniczki-w-polsce-i-niemczech) was a project carried out in the years 2005 – 2012 by the Polish Society for the Protection of Birds, the aim of which was the protection of the aquatic warbler *Acrocephalus paludicola*, as an umbrella species for fens. The biggest threat to aquatic warblers is the loss of habitat, and therefore the main activities of the project focused on the protection of fens, including alkaline fens, as a habitat for this species. These consisted mainly in maintaining the open nature of the habitat by removing reeds, shrubs, and trees and then restoring the previously abandoned extensive mowing. For this purpose, a special prototype of the mower has been designed, suitably adapted from the tracked ski piste groomers used on mountain slopes. These devices are used on very large areas where manual mowing is too laborious and economically unsound. On the basis of the monitoring carried out, individual conditions of use were determined for each patch. In the case of smaller areas, the decision was made to graze, while in the case of larger areas – to mow. These actions were determined mainly by the hydrological conditions prevailing in the given area. Currently, as part of the appropriate „aquatic warbler" package in the agri-environment-climate program, farmers can receive compensation for extensive management of current and potential aquatic warbler breeding sites. In the areas where the owners did not show a willingness to restore proper habitat management, about 1000 ha of land were purchased; 650 ha were bought out from private hands in the Biebrza National Park, the remaining 350 ha became the property of the Polish Society for the Protection of Birds and three new private nature reserves were created: Ławki-Szorce, Mscichy, and Laskowiec-Zajki (Zadrąg et al. 2011).

Another project of the Polish Society for the Protection of Birds – „Managing the aquatic warbler (*Acrocephalus paludicola*) habitat through the implementation of sustainable biomass management systems" (LIFE09 NAT/PL/000260) - http://www.wodniczka.pl/, was carried out in 2010 – 2015, and one of the objectives was to solve the problem of biomass management arising from mowing fens and marsh meadows. In order to use biomass from mowing, a pellet production plant was built in Trzcianne in the Podlaskie Voivodeship, while biomass in the Lubelskie Voivodeship is collected by three biomass-fuelled plants (two pellet factories and a cement plant). By guaranteeing the collection and use of biomass, it has ceased to be a problem in the conservation measures carried out (Gatkowski 2015).

Another project aimed at the protection of the species through habitat protection was the LIFE06 NAT/PL/000100 project „Protection and improvement of habitats of rare butterflies of wet semi-natural meadows" implemented by the Regional Ecological Center in the years 2006 – 2010, among others in the area of alkaline fens in the Natura 2000 area Bagno Całowanie PLH140001, Torfowiska Chełmskie PLH060023, and Torfowisko Sobowice PLH060024. The main activities in the field of active protection included the removal of shrubs, mowing (including the mowing of basal shoots, mainly willow) in time to allow butterflies to develop, and the removal of biomass resulting from the treatments. A number of implementation problems have been tackled (see chapter 5) such as difficulties in removing the biomass of trees and shrubs and biomass from mowing, and damage to the fens during mowing (Michalska-Hejduk & Kopeć 2012). One of the treatments in the area of Bagno Całowanie was the removal of the top layer of the fen with a thickness of about 30 – 40 cm which, due to the drying of the peat, transformed into muck. Hay from the target habitats was then spread onto the exposed areas, thus „feeding" the habitat with seeds of plants characteristic for it. Within the areas of disturbed hydrological regime, facilities were built or renovated to retain water in periods of drought and to allow excess water to drain off in „wet" periods. The declared result of these measures was the improvement or maintenance of the proper condition of butterfly habitats on an area of approximately 720 ha, including 300 ha where farmers started to implement the agri-environment program (Gatkowski 2010). Independent evaluation of the project in the Kampinos National Park (Michalska-Hejduk & Kopeć 2012), confirmed the success in the form of an increase in the share of the *Sanguisorba officinalis* – a host plant of gossamer-winged butterflies, but did not show that the project brought about significant changes in the quality of the habitats of *Lycaeana dispar*.

9. Legal aspects of fen protection

Paweł Pawlaczyk

The protection of peatlands, including alkaline fens, is carried out in a specific legal environment (Peters & Unger 2017, Pawlaczyk 2018). The provisions of Polish law, in part also transposing the obligations arising from the European Union law, which synthetically form this environment, are presented below. Legal tools can be of great help in preventing threats to peatlands (see chapter 4), although experience shows that they are not always fully effective. However, measures aimed at the protection and restoration of peatlands have their own legal conditions that often affect their feasibility and even force the selection of protection methods.

Nature conservation regulations

The legal basis is the Act of 16 April 2004 on nature protection (Act 2004) and its accompanying executive acts.

Peatlands, including alkaline fens, can be protected in the following forms of nature protection: national parks, nature reserves, landscape parks, protected landscape areas, Natura 2000 sites, ecological areas, nature and landscape complexes, and documentation sites. Under the EU Habitats Directive (Directive 1992), habitat 7230 is a so-called habitat type of Community importance requiring protection in Natura 2000 areas, i.e., such areas are designated, for example, for alkaline fens.

Most of the known alkaline fens in Poland are now actually protected under one of the forms of nature protection. As of 2017[13], 75.6% in terms of numbers and 92.5% in terms of surface area of alkaline fens were included in Natura 2000 habitat areas – respectively, 50.7% and 27.0% in protected landscape areas, 19.1% and 12.9% in landscape parks, and 10.6% and 12.9% in nature reserves and national parks. Only 8.0% in terms of numbers and 3.5% in terms of surface area of known alkaline fens remain outside these protected areas; however, even those were partially protected as ecological areas.

The inclusion of a peatland in the scope of one of the forms of nature protection imposes bans binding in principle for everyone, corresponding to the appropriate form (Act 2004):

13 Data based on the database of fens in Poland (http://alkfens.kp.org.pl/o-torfowiskach/ogolnopolska-baza-mechowisk/) compared with the boundaries of forms of nature protection http://www.gdos.gov.pl/dane-i-metadane.

- In national parks and nature reserves (forms of protection imposed by the Sejm (Parliament) with the participation of the Council of Ministers and by regional environmental protection directors), it is forbidden to *"use, destroy, intentionally damage, pollute and make changes to natural sites, areas and resources, formations and elements of nature; change water conditions, regulate rivers and streams, if these changes do not serve nature protection; exploit (...) peat, destroy soil or change the purpose and use of land, perform land works permanently distorting the relief of the area"* (the list of prohibitions results from the Act and is the same for all reserves). However, these prohibitions do not apply to *"areas under landscape protection* [14] *in the course of their economic use by organizational units, legal or natural persons and the exercise of property rights"*.
- In the landscape park and in the protected landscape area (forms of protection imposed by Voivodeship authorities), prohibitions may be introduced (but only after consultation with the Regional Environment Protection Directorate and the municipal council), such as: *"extraction of (...) peat for economic purposes, performance of earthworks permanently distorting the landscape, except for works related to storm, flood or landslide protection or construction, reconstruction, maintenance or repair of water facilities; making changes in water conditions if these changes do not serve nature protection or rational agricultural, water or fishing use or forestry; liquidation, backfilling and transformations of water reservoirs, oxbow lakes and wetlands"* (the list of prohibitions is determined on the basis of the statutory catalogue in the Act establishing the area). Even those prohibitions do not apply to the implementation of public purpose investments, and the extraction of minerals, including peat, belongs to this category.
- In relation to Natura 2000 areas, there is a general prohibition to *"undertake activities* [also outside the boundaries of the area] *which may, individually or in combination with other activities, have a significant negative impact on the conservation objectives of the Natura 2000 area, including in particular: deterioration of natural habitats or habitats of plant and animal species for whose protection the area has been designated, negative effect on the species for whose protection the area has been designated, or deterioration of the integrity of the area or its relations with other areas"*. An exception is made for projects resulting from imperative public interest, in the absence of alternatives, provided that adequate compensation is provided. These provisions implement Articles 6.3 and 6.4 of the EU Habitats Directive (Directive 1992);

14 According to the Polish law, the area of a national park or nature reserve can come under one of the following: strict, active or landscape protection, which is specified in the protection plan or protection tasks established for the park or the reserve. Landscape protection usually includes land under different ownership (e.g., private land) located within the boundaries of the park).

- In ecological land (forms of protection created by municipalities), which in particular may include wetlands and fens (listed directly in the Act), the following prohibitions may be introduced: *"destruction, damage or transformation of a site or area; performance of earthworks permanently distorting the landscape, except for works related to storm, flood or landslide protection or construction, reconstruction, maintenance or repair of water facilities; making changes in water conditions if these changes do not serve nature protection or rational agricultural, water or fishing use or forestry; liquidation, backfilling and transformations of water reservoirs, oxbow lakes and wetlands, extraction of peat for economic purposes"* (the list of prohibitions is determined on the basis of the statutory catalogue in the Act establishing the area). However, the prohibitions do not apply to *"implementation of a public purpose investment project in the absence of alternative solutions, after consultation with the body establishing a given form of nature protection"*.

For national parks, nature reserves, landscape parks and Natura 2000 areas, it is obligatory to prepare and establish plans for 1 – 20 years (conservation plans, protection tasks, conservation measures plans), which may provide, in particular, for active protection and renaturalization. For Natura 2000 areas, the Act explicitly requires that the premise of the plan is the maintenance or restoration of the appropriate conservation status of natural habitats being the objects of protection in the area – i.e., among others, alkaline fens represented by habitat 7230, if they have significant presence in a given area. For other forms of nature conservation, possible arrangements for active protection may be included in the Act establishing that form.

In theory, therefore, there are grounds for providing adequate protection for alkaline fens just on the basis of the nature protection regulations.

In practice, however, this system is weakened by numerous exemptions from protection prohibitions. Even in national parks and reserves, the economic use of land not owned by state, which is almost always eligible for so-called „landscape protection", is excluded from the prohibition regime. In landscape parks, protected landscape areas, ecological areas, nature and landscape complexes, or documentation sites, protective bans usually do not apply to precisely those types of activities that may threaten fens, i.e., peat exploitation (which as the exploitation of minerals is a so-called *„public purpose"*), as well as *„rational agricultural, water or fishing use or forestry"*. To date, only a part of national parks, nature reserves, landscape parks and Natura 2000 areas have had conservation plans or protection tasks drawn up, and their quality varies. Most frequently, the work on the plan includes an inventory of natural habitats, flora and fauna, but it is rare to carry out in-depth ecohydrological studies, which are important for good planning of the protection of alkaline fens. As a result, in the case of some sites such plans correctly and comprehensively identify alkaline fens, indicating actions necessary for their protection, but there are also plans in which the identification of alkaline fens is very incomplete, not to mention any proper planning of their protection.

Numerous peatland species are protected species with active prohibitions on destroying both the species and their habitats, unless a permit is issued by a nature protection authority. The occurrence of protected species therefore provides a protective umbrella over their habitat as well. Permits for the deviation from species protection may only be granted if there is no significant negative impact on the populations of protected species and no alternative solutions. In the case of strictly protected species, the permit may be granted only for reasons set out in a narrow statutory catalogue (including imperative public interest). In the case of partially protected species, a permit may also be issued due to *„important interest of the applicant"*. The lists of protected species are defined by regulations (plants – Regulation 2014a, fungi – Regulation 2014b, and animals – Regulation 2016). Strictly protected species include, for example, mosses typical for fens *Helodium blandowii, Cinclidium stygium, Scorpidium scorpioides, Hamatocaulis vernicosus, Paludella squarrosa, Meesia triquetra* as well as *Scheuchzeria palustris, Trollius europaeus, Gladiolus imbricatus, Tofieldia calyculata, Utricularia intermedia, Drosera spp., Grus grus, Leucorrhinia albifrons, Leucorrhinia caudalis, Leucorrhinia pectoralis, Vertigo angustior,* and *Vertigo moulinsiana*. Some of the partially protected species include all *Sphagnum spp*. peat mosses, *Menyanthes trifoliata*, and others. The beaver *Castor fiber* is also partially protected, however for this species the regional nature protection authority may permit killing of individuals and destruction of beaver dams also in the course of issuing local legal acts, which is relatively widely used. However, the practical effectiveness of the „umbrella" resulting from the presence of protected species depends on whether the sites of these species are known to interested parties and to the relevant authorities.

Art. 117(1)(1) of the Act states in general that the management of resources and natural components should take into account, among others, the protection, maintenance, or rational use of natural and semi-natural ecosystems, including fens and wetlands. However, the generality of this provision makes it difficult to apply in practice.

Earthworks which may change water conditions (which in theory also includes, e.g., desilting and maintenance of overgrown ditches) and maintenance works in watercourses (including desilting, removal of obstacles to flow) require, pursuant to Article 118 of the Act, notification to the Regional Director for Environmental Protection, who may order the obtaining of a decision setting out the conditions for carrying out such works and – if they violate the prohibitions – refuse to permit such works. However, the practical effectiveness of this provision is weakened by the fact that in the vast majority of cases the nature protection authorities have given their „tacit consent" to the proposed works. In addition, a significant proportion of maintenance work on ditches, including drainage ditches, is not reported, despite the obligation to do so.

According to Art. 60(2) of the Act, if stated or predicted changes in the environment threaten or may threaten plants, animals, or fungi covered by species protection, the nature protection authority is obliged – after consultation with the relevant regional environment protection board and the manager or owner of the area – to take measures to ensure permanent preservation of the species, its habitat or refuges, eliminate the causes of the threats, and improve the conservation status of its habitat or refuges. Pursuant to Art. 60a of the Act, if identified or predicted changes in the environment threaten or may threaten habitats included in Annex I of the Habitats Directive (also outside Natura 2000 areas), the nature protection authority is obliged – after consultation with the relevant regional environment protection board and the site manager or owner – to take measures to ensure the permanent preservation of these habitats, to eliminate the causes of the threats, and to improve their conservation status.

Alkaline fens, constituting Natura 2000 habitat 7230, are one of the subjects of the regulations of Article 60a of the Act. Theoretically, therefore, this regulation creates a very strong protective tool: if any fen of this type (even outside the borders of the forms of nature protection!) is threatened, the Regional Director for Environmental Protection is obliged to take, *ex officio* and at their own expense, appropriate preventive or remedial actions. However, there are hardly any cases where this provision is applied in practice. The problem is the limited competence and ability of regional environmental protection directors to undertake actions limiting or modifying the use of land not owned by the state, as well as taking necessary protective actions on such land. Only in relation to Natura 2000 areas does this body have an explicit competence, defined in Article 36(3) of the Act on Nature Conservation (Act 2004) „*If economic, agricultural, forest, hunting or fishing activity requires adaptation to the requirements of the protection of a Natura 2000 area, where no support programmes for decreasing profitability apply, the Regional Director for Environmental Protection may conclude an agreement with the owner or holder of the area, except for the managers of the State Treasury real estate, which contains a list of necessary actions, methods and dates of their execution, as well as conditions and dates of settling payments for performed actions and the value of compensation for lost income resulting from the introduced restrictions*". There is no explicit legal delegation for the regional director of environmental protection to introduce necessary restrictions in the activities conducted on behalf of the State Treasury. There is also a lack of authorization to carry out independent protection activities, if necessary, by a nature protection authority on the land not owned by the state. Although, in the Act on real estate management (Act 1997) it is indicated (Article 6(9b)) that the „*protection of endangered plant and animal species or natural habitats*" is included in the so-called public purposes, and the Act in chapter 4 sets out ways of forcing public objectives to be achieved, including on private land, where necessary. However, the funds provided for in this Act are limited only to investment projects (they refer to the decision on determining the location of a public purpose investment), and nature protection usually requires activities of a non-investment nature. Consequently, Art. 60a and Article 60(2) of the Act on nature protection (2004) remain largely a dead letter.

Although such situations are exceptions, it is sometimes the case that the regulations on nature protection may cause some problems for the restoration of fens. Sometimes, for example, it is necessary to obtain deviation permits from certain prohibitions applicable for protected species in order to carry out conservation measures. As a rule, the removal of trees and shrubs from non-forest areas requires a permit from the municipal authorities (Art. 83, Act 2004), and in order to obtain such a permit, all trees and shrubs must be inventoried in advance, which is costly and time-consuming. Fortunately, this provision does not apply to trees or shrubs removed as part of the tasks resulting from a conservation plan, protective tasks, or a conservation measures plan taking the form of nature protection (Article 83f(12), Act 2004). However, it can be a problem in situations where urgent conservation action needs to be taken in the absence of a formally established plan in which it is clearly set out.

Protection by means of an environmental assessment system

An important legal instrument for the protection of the environment and nature, including fens, is the Act of 3 October 2008 *„on the provision of information on the environment and its protection, public participation in the protection of the environment and on environmental impact assessments"* (Act 2008). Protection on its basis is carried out by means of administrative proceedings, in which the impact of the project on the environment is considered before granting the consent for such a project. The basic mechanism is the obligation to obtain, for certain projects, the so-called decision on environmental conditions for the implementation (in short: the environmental decision). The system implements the requirements of the EIA Directive (Directive 2011) and, to some extent, the requirements of Articles 6.3 and 6.4 of the EU Habitats Directive (Directive 1992).

The list of types of projects for which an environmental decision is required is set out in the Regulation of the Council of Ministers of 9 November 2010 on projects with potentially significant environmental impact (Regulation 2010c). Most of the projects which may pose a potential threat to alkaline fens are covered by this requirement; in particular, an environmental decision is necessary for:

- extraction of peat or lacustrine marl from the deposit (regardless of the volume of extraction and the involved area);
- deforestation of riparian forests, alder forests, or bog forests (regardless of the involved area);

- drainage of meadows, pastures or uncultivated land (regardless of the involved area), drainage of other land in forms of nature protection or in the buffer zones of national parks, reserves, landscape parks; drainage in other cases occupying > 5 ha or accumulating up to >5 ha of drainage carried out within a radius of 1 km in the last 5 years;
- water reservoirs or ponds > 0.5 ha in forms of nature protection, or in the buffer zones of national parks, reserves, landscape parks or non-arable land;
- structures for raising the water level to > 1 m; structures for raising the water level, irrespective of their height, on watercourses free of such structures, or on watercourses on which such structures are located within a radius of up to 5 km; all structures in forms of nature conservation or in the buffer zones of national parks, reserves, and landscape parks (with the exception of damming < 1 m based on the protection plan, protective tasks, or plan of protective tasks established for the form of nature protection);
- groundwater abstraction facilities for abstractions > 10m^3/hour; and if closer than 500m to other abstraction facilities, for abstractions > 10m^3/hour, excluding the so-called "normal use of water" (see further).

The vast majority of these projects belong to the group of „potentially likely to have an impact on the environment", i.e., the body competent to issue the environmental decision decides (after consultation with the environmental protection authority and other entities) on the need to carry out the environmental impact assessment, or on the lack of such a need. The reasons taken into account in such preliminary decision of the need for assessment include: location in wetlands or other areas with shallow groundwater retention, and location in areas requiring special protection due to the presence of plant, fungi, and animal species or their habitats or natural habitats under protection.

If the obligation to carry out the environmental impact assessment is imposed, the investor must prepare an environmental impact report; in the procedure, public participation is required (the procedure is announced, giving the general public an opportunity to submit comments and applications; special provisions are applied that give environmental organizations the right to become a party to the procedure, the right to appeal against the decision, and the right to appeal to the administrative court against the final decision; the decision requires prior agreement with the environmental protection authority).

In the case of projects which may potentially affect a Natura 2000 site, the requirement of assessment (focused only on the potential impact on the site) may be extended to all other projects. The authority issuing any administrative decision permitting the implementation of any project should consider the possibility of potential impact on the Natura 2000 area and, if such risk is identified, refer the matter to the Regional Director for Environmental Protection, who will decide on the possible need for a full assessment.

Theoretically, the regulations for when environmental assessments are required, as well as the requirements governing the process of conducting these assessments, form a relatively tight system. In practice, however, the following problems can be observed:

- Some small projects with impact on fens (particularly if they concern small sites or when the effect of several such projects is cumulative) escape the system because they are implemented in practice without prior notification and administrative decisions, and this fact is not effectively prosecuted. This applies in particular to the drainage of fens as a result of the renovation (maintenance, restoration) of old ditches in order to improve the water outflow, mainly from agricultural land (sometimes even completely overgrown ditches which are reconstructed to the state when water drainage is possible). This also applies to the digging of small ponds in fens.
- The mechanism of preliminary qualification of projects for the environmental impact assessment (or for the Natura 2000 site impact assessment), although theoretically correct, does not work when the administration bodies do not have sufficient knowledge of the natural values of the fen subject to possible impact. Sometimes the decision-making authority is not at all aware of the existence of the fen within the range of the impact of the project, not to mention the awareness of its value, features (including the qualification as an alkaline environment), natural significance, and role in the landscape. The sites of protected species are only to a small extent studied, inventoried, and known to nature conservation authorities. In the case of alkaline fens, this problem is of particular importance (cf., Pawlaczyk 2015), as these are ecosystems which are particularly difficult to observe, correctly recognize and diagnose; also protected species typical for them are sometimes difficult to notice and recognize, even by people with general naturalist knowledge.
- Despite the theoretical obligation it is problematic to take into account the cumulative impact of various different projects, carried out at different times and by different investors in environmental assessments. At times, in individual administrative proceedings, such projects, due to the very small size of each of them, are considered on a case-by-case basis, not to have a significant impact, whereas their total summary impact proves to be significant. Such small projects may include, in particular, maintenance of drainage ditches for fens, or cases of the so-called normal use of water in private ground (water abstraction or introduction of sewage up to 5m^3/day).

Even when an assessment of the impact on an environment or a Natura 2000 site is carried out, quality can be a problem. The basic document to be considered is the impact report commissioned by the investor. Theoretically, it should comprehensively describe all aspects of the natural environment and present the impacts. In practice, especially for smaller projects, the information provided is usually limited to a partial description of the flora and fauna in the area covered by the investment. In the case of alkaline fens, there is a high risk that in superficial nature inventories, bryophytes and invertebrates typical for this ecosystem will remain unnoticed, and the type of fen itself is often misdiagnosed (cf., Pawlaczyk 2015). Typically, there are no data on the structure of peat deposits or more precise data on the water conditions. There is also often a lack of analyses of distant impacts (e.g., water abstraction in places distant from the soligenous fen, but related to the supplying aquifer; projects distant from the fen, but disturbing its water supply). Neither the body conducting the proceedings, nor any other parties thereto, usually have the possibility to supplement such data, therefore the decisions made are not always accurate. It happens that the authority accepts incorrect and flawed expert opinions attached to the report simply because they are signed by the experts hired by the investor. Due to their specific nature, alkaline fens are more vulnerable to this problem than other types of ecosystems.

Theoretically, the environmental impact assessment procedure is an excellent place to take into account also the functions of fens in the landscape, including the so-called ecosystem services they provide (cf., Makowska 2018). No practice has been developed for taking this aspect into account in any way either in environmental impact reports or in assessment procedures. This is probably due to the lack of developed, effective and practicable methods for the assessment and valorization of ecosystem services on a local scale[15]. Accurate, reliable, and credible assessment of the economic benefits provided by a specific ecosystem is most probably not possible at all (cf., Pawlaczyk 2017); however, for the purposes of environmental impact assessments, the average parameters of services provided by specific ecosystems would be useful, enabling at least a rough understanding of the economic aspect of their functioning in the landscape. Proposals for such parameters, however, are still very rare in Polish literature and practice[16].

The regulations on environmental impact assessments may also have an impact on the projects of fen renaturalization and protection. For example, a frequently used protective measure such as the construction of damming structures may also require an environmental decision; all the more so if the damming is to be carried out in some form of nature protection site or its buffer zone. Although the law exempts from this obligation projects undertaken on the basis of the binding protection plans, plans of protection tasks, and protection

15 In the Polish scientific literature, there are many publications discussing the issue of ecosystem services in general, however, it is still rare to try to apply this approach in practice to specific real landscapes and ecosystems. Interesting samples of qualitative analysis were presented by e.g., Hewelke & Graczyk 2016, Solon et al. 2017, and valuation attempts, e.g., Andrzejewska et al. 2014 (although the description of fens was not fully correct), Panasiuk & Miłaszewski 2015, Humiczewski et al. 2017, and Biedroń et al. 2018.

16 A notable exception is the study by Biedroń et al. 2018, which summarized and proposed specific economic coefficients for the valuation of basic river ecosystem services, proposing a scheme for a simplified cost-benefit analysis for the decision-making process for the performance of the so-called watercourse maintenance works. A similar approach, if developed, would be very useful for the decision-making process regarding the impact on fens.

tasks, in practice there are cases of renaturalization and protection of fens when an appropriate plan has not yet been established, and the necessity to block the outflow of water is obvious and urgent. If this requires the construction of damming structures, a relatively long and costly administrative procedure has to be taken into account (see also below).

Protection in spatial planning and development regulations

The basis is the Act of 27 March 2003 on spatial planning and development (Act 2003). In general, it states that *„environmental protection requirements, including water management and the protection of agricultural and forestry land, shall be integrated into spatial planning and development"*.

The development and implementation of spatial policy is to a large extent the responsibility of municipalities. For its entire area, the municipality prepares and adopts, and then every five years thereafter, assesses the validity and, if necessary, updates, the so-called study of spatial planning conditions and directions, which is a general planning document. It should identify, among others, the conditions resulting from the condition of the environment; it should also define areas and principles of environmental protection and its resources. The study is not an act of local law, however it is binding for more detailed local plans, and compatibility with the study is also required for land afforestation, location of renewable energy sources, and exploitation of minerals. However, it is not binding for the location of other investments. The studies cover the entire country. For a part or all of its area, the municipality may prepare and establish a local spatial development plan, which is an act of local law, binding for the development of the area and the location of investment projects. However, some types of investments, e.g., road or flood protection projects, can be located on the basis of the so-called special acts of law, regardless of the arrangements in the local plans.

The Environmental Protection Law Act (the 2001 Act) stipulates in Article 72 that studies and spatial development plans are to ensure, among other things, the conditions for maintaining the natural balance and rational management of environmental resources. For the purposes of the study and plan, *„documentation describing particular elements of nature in the area covered by the study or plan and their mutual relationships"*, also called an eco-physiographic study, is prepared. Theoretically, therefore, all fens, as „elements of nature", should be identified in such a procedure. Draft studies and plans are subject to an environmental impact assessment procedure which includes, among other things, the preparation of the forecast of the environmental impact of the project.

Practical applications of the provisions on spatial planning and development are widely varied. In Poland, the degree of coverage of municipalities with legally binding local spatial development plans varies from 0 to 100%, with an average of 27%. In many municipalities, extreme fragmentation of areas covered by local plans, including the practice of preparing plans for individual plots only, is a practical problem, as a result of which the environmental context of their location is not properly taken into account. The quality of the eco-physiographic studies varies, and in consequence the quality of identification of environmental and natural planning conditions varies as well. Unfortunately, there is no hard requirement that would force planning studies to take into account fen areas and areas of naturally high hydration. Despite theoretical possibilities, there is no well-developed practice to identify ecosystem services in studies, analyses, and plans, and to spatially arrange the ecosystems that would provide such services in an optimal way (see above). The above comments on problems in the functioning of the environmental assessment system apply to the environmental impact assessment of studies and plans.

Protection in forestry law regulations

The Act of 28 September 1991 on forests (Act 1991a) in Article 13(1)(1) obliges all forest owners to „*preserve natural bogs and fens in their forests*". Many alkaline fens are surrounded by forests and under the control of forest owners and therefore potentially covered by this provision.

However, the interpretation of this provision remains unclear. There is no doubt that it involves a prohibition of deliberate destruction of „*natural bogs and fens*". However, it may be questionable which bog and fens the legislator has considered to be „*natural*". It is also unclear whether this provision also provides for more far-reaching obligations: to take, if necessary, active conservation measures at the initiative and expense of the forest owner, where these are necessary for the „*preservation of natural bogs and fens*". Although such an interpretation has systemic and purpose-based foundations, the dominant forest management agency in Poland, i.e., State Forests, uses this provision as a base to claim that such activities could at most be commissioned from State Forests by the state administration. Consequently, that provision remains a dead letter in that regard.

From 1 January 2018, an additional, bizarre provision introduced by the new Article 14b(3) of the Act on forests came into force, establishing a legal fiction[17]: „*Forest management performed in accordance with the requirements of good forest management practice does not infringe the regulations on the protection of particular resources, formations and elements of nature*". In accordance with the statutory delegation, the Regulation for the requirements of good practice in forest management (Regulation 2017) was issued on 18 December 2017. The only requirement that applies to fens is that „*total felling shall not be made directly next to (...) fens and spring areas (...) at which natural ecotone zones are recommended to be left or created, in particular by planting shrubs, in case of their absence, and by taking care of them*". Forest owners complying with this requirement would therefore be able to ignore the nature conservation provisions relating to fens

17 The concept of „legal fiction" in legal jargon is not pejorative but neutral, meaning a legal rule requiring a counterfactual recognition of a legal fact which did not occur in reality.

with impunity. This risk is only theoretical, as no such cases or intentions have been identified so far. However, the future of this regulation is uncertain due to its apparent contradiction with European Union law.

Requirements concerning agricultural land and farming

The Act of 3 February 1995 on the protection of farmlands and forests (Act 1995) recognizes *"lands of fens and ponds"* as agricultural land within the meaning of the Act, setting, for example, the following objectives: *„restriction of land use for non-agricultural or non-forest purposes; (...) the maintenance of fens and ponds as natural water reservoirs"*. As a consequence, fens may be designated for non-agricultural and non-forestry purposes only in the local spatial development plan. If there is agricultural land on the peats, its exclusion from agricultural production requires a prior decision (which, however, for class IV and lower land is only of declaratory nature) and payment (e.g., for 1 ha of class V meadows – approx. €27,780).

At present, there are no regulations directly regulating farming on fens. The current Regulation of the Minister of Agriculture and Rural Development of 09.03.2015 on the standards for good agricultural production in line with environmental protection (Regulation 2015) does not set any standards relevant for the protection of fens; the standards in force until 2015 preventing the destruction, through improper agricultural use, of protected natural habitats or habitats and sites of protected species have been abolished.

A farmer who owns an alkaline fen within their land may benefit from the so-called agri-environment-climate payment, in the form of a voluntary contract, obliging the land holder to certain methods of management. This possibility is discussed in more detail in chapter 6.2. It is important to note that the use of this possibility means a prohibition for *„the creation of new drainage systems, extension and restoration of the existing ones, with the exception of the construction of equipment aimed at adjusting the water level using the existing drainage systems to the requirements of the fen habitat, if such activities are described in detail by the expert naturalist in the natural documentation"*, as well as other prohibitions specific to the applied package. It is true that the possible sanctions for violations of these prohibitions are not very severe.

The majority of agricultural land is also subject to the so-called direct payments, implemented under the EU Common Agricultural Policy. The condition for these payments is the performance of agrotechnical treatments, e.g., mowing. This is sometimes an incentive for farmers to pursue activities harmful to fens, for example to clean drainage ditches so that the required mowing can be carried out easily using mechanical equipment. There are no effective legal mechanisms in place to block these types of threats.

Water law requirements

The Water Law Act of 20 July 2017 (Act 2017), transposing the requirements of the EU Water Framework Directive (Directive 2000) into Polish law, introduces the concept of environmental objectives for waters and protected areas dependent on water. These objectives are set out in the river basin management plans – in the case of protected areas, for each site individually. The objectives for protected areas containing fens include, among others, the preservation or restoration of the water conditions of the fen. In Natura 2000 areas protecting alkaline fens, the standard objective is *„to maintain or achieve correct protection status. The correct protection. status of mountain and lowland alkaline fens of the flush fen, sedge and moss fens nature (7230) requires: water level in the range of 10 cm below ground - 2 cm above ground. Stable supply with pH >7 groundwater. Lack of drainage ditch and channel networks or other elements of drainage infrastructure draining the fen or drainage infrastructure sufficiently „neutralised" as a result of the applied protection measures (backfilling of ditches, construction of gates, etc.)"*. Where there were plans for protective tasks setting more detailed objectives, these objectives were transferred as elements of the environmental objectives for waters. According to other provisions of the Act, environmental objectives are binding for water management, including the process of issuing water-legal permits.

The Act also regulates the issues of the so-called water facilities which include, in particular, ditches and ponds, as well as damming structures. This is important both for the protection of fens against the impact of such equipment and for the construction of such equipment for the purpose of fen renaturalization. As a rule, the construction, reconstruction, and decommissioning of water facilities requires a water-legal permit. Social organizations are not allowed to participate in the proceedings for issuing the permit. The construction of ponds which are not filled as part of water services, but exclusively by rainwater or melting water or groundwater, with an area of at most 500 m^2 and a maximum depth of 2 m, shall only be subject to notification. Retention of water in ditches does not require any notification or permit. However, Article 17(3c) of the Act extends the provisions applicable to water facilities, including the requirement to obtain a permit or submit a water-legal notification for their execution, to all *„works in water and other works which may cause changes in natural water flows, standing water status and groundwater status outside the boundaries of the ground property on which they are carried out"*.

The regulations on water-legal permits and notifications are important in the projects of fen protection and renaturalization, as they also concern the construction, conversion, and liquidation of various ditches, partitions, and gates, as well as all works with an effect on water relations.

Pursuant to Art. 33 of the Act, landowners are entitled to the so-called normal use of water in or on their land that includes, among others, abstraction of groundwater up to 5 m^3 per day for their own household or agricultural purposes, as well as the introduction of the same volume of sewage into water or land. This does not require any permits, notifications, or fees. However, such water use can sometimes be a threat to alkaline fens supplied by groundwater, especially when the usual use of the water is accumulated by several owners using the same aquifer which also provides water supply to the fen.

There is a general prohibition (Art. 234 of the Act) „*to change the direction and intensity of outflows of rainwater or melting water, or outflows of water from sources, to the detriment of neighboring land*"; as well as an order „*to remove obstacles and changes in outflows of water from the land, resulting from an accident or the actions of third parties*", to the detriment of neighboring land. In the event of an impact on neighboring land, the municipality head may, at the request of the owner of the affected land, issue a decision ordering „*the restoration of the previous condition or the construction of facilities preventing damage*". There is no legal basis for any other way of handling the matter, for example by paying damages. This provision is sometimes a limitation for renaturalization plans if they affect neighboring areas.

Mining law

The Act of 9 June 2011 – Geological and Mining Law (Act 2011) categorizes peat as a mineral. Consequently, any peat extraction requires obtaining an appropriate license. In the current legal situation it is not possible to „*extract peat for own use*" from own land only on the basis of a notification (this possibility remained only for sands and gravels in the amount of < 10 m^3 per year). The license application must be accompanied by a previously obtained decision on environmental conditions. Issuing a license must be agreed with the municipality head (as to the purpose of the property in the spatial development plan, and if there is no plan - as to its consistency with the study of directions and conditions of spatial development and separate provisions). In areas exposed to the risk of flooding, the award of licenses must be agreed with the authority of the State Water Management Authority (Wody Polskie). The possibility of the participation of social organizations in the procedure is excluded if a procedure for an environmental decision has already been conducted with public participation. Granting a license may be refused if the intended activity is contrary to the public interest, in particular related to environmental protection, including rational management of mineral deposits, or would prevent the use of the property in accordance with the local spatial development plan or separate provisions, and in the absence of such a plan would prevent the use of the property in the manner specified in the study of the conditions and directions of spatial development of the municipality or in separate provisions.

A license for open-case extraction of peat from areas < 2 ha with an annual production of < 20,000 m^3 is granted by the *starosta* [the district administrator] with an opinion by the marshal) and for higher production – the marshal of the voivodeship. The starosta's route simplifies the formal requirements for the award of licenses and for subsequent extraction. In the case of the license awarded by the marshal, the so-called deposit development plan is prepared, specifying the requirements for rational management of the mineral deposits, in particular through the use of production technology ensuring the reduction of negative environmental impacts. Extraction then requires the preparation of a so-called mining plant operation plan. In the case of a license granted by a starost, instead of drafting the deposit development plan; the operation of the mining plant is described (it should include environmental protection) together with the plan for decommissioning the plant.

Upon the completion of mining activities, the mining company is required to take the necessary measures to protect the environment and to reclaim the land after mining activities which, however, is understood in accordance with the provisions of the Act on the protection of agricultural and forestry land.

Production under the license is subject to the mining fee which currently amounts to 1.25 PLN/m^3 (0.3 €/m^3) for peat and 0.25 PLN/m^3 (0.06 €/m^3) for lacustrine marl. The sanction for the extraction of minerals without a license is the imposition by the mining supervisory authority of an increased fee, amounting to 40 times the mining fee.

Repairing the effects of unauthorized activities

Pursuant to the Act of 13 April 2007 on the prevention and repair of environmental damage (Act 2007), if an entity using the environment (i.e., anyone who uses the environment professionally and not privately; in the course of business, including agricultural or forestry activities) causes or threatens to cause environmental damage, it is obliged to take appropriate preventive and remedial action, agreed with the Regional Director for Environmental Protection. If it fails to do so, the Regional Director for Environmental Protection may order appropriate action by way of a decision. Damage is considered to be a negative, measurable change in the condition or function of natural elements – including protected species or natural habitats – which has not been previously predicted and approved by a relevant decision, order, or approved forest management plan. These regulations are the implementation of the so-called EU environmental damage directive (Directive 2004).

If the above provisions of the environmental damage legislation are not applied then – in the case of the actions taken without an appropriate assessment and permit, which may have a significant negative impact on the objectives of Natura 2000 area protection (e.g., on the condition of alkaline fens protected in this area), or in the case of such actions taken *„contrary to the provisions of the* *conservation measures plan or the conservation plan of Natura 2000 area*" – the Regional Director for Environmental Protection issues a decision ordering, depending on the needs, their immediate suspension or taking the necessary preventive or remedial actions. This provision, resulting from Article 37 of the Act on nature protection (Act 2004), concerns everyone (not only economic entities) and is not dependent on fault.

At least in theory, the provisions mentioned above should create a mechanism for enforcing the repair of the effects of measures taken without proper identification of their effects on protected habitats (including fens), which may cause damage to these habitats, at least in Natura 2000 areas. However, the practice of applying both mechanisms is not fully satisfactory.

In the case of the damage legislation, the current line of interpretation of the General Directorate for Environmental Protection goes in the direction of classifying only truly serious events, significant for the resources of the habitat at the national level as „environmental damage". In the case of Art. 37 of the Act on nature protection (Act 2004), the authorities tend to disregard activities whose significant negative impact has not been revealed in reality, to disregard the significance of the impact, and to delay the proceedings for long enough that the remedial actions no longer make sense. On the other hand, the practice of not introducing any provisions „in the form of prohibition" (see above) prevails in the plans of protection tasks for Natura 2000 areas, as a result of which no activities will be contrary to these plans.

Legal problems with renaturalization and active protection

The system of regulations protecting the environment, spatial order, safety, and property rights is a constraint on actions infringing these values, but it may also be a constraint on actions aimed at restoring environmental values, including actions related to the renaturalization and protection of fens. Some aspects of these restrictions are already described above.

The first and basic limitation of the possibility of protection and renaturalization is the right to the area. The necessary protective measures may be taken where the entity concerned by the protection – whether a nature protection authority or another entity (e.g., an environmental organization implementing a nature protection project) is the owner or holder of the land on which they are to be carried out, as well as of the entire land on which they are to have an impact; or where it has an explicit consent of the owner or holder of the land.

Despite the fact that „*protection of endangered plant and animal species or natural habitats*" has been recognized as a public objective in the Act on real property management (Article 6(9b), Act 1997), it is not possible in practice to apply statutory legal solutions enabling the implementation of public objectives against the ownership rights of third parties (mandatory establishment of easement, expropriation against compensation). The nature of these solutions only pertains to investment projects. An absolute prohibition *„to change the direction and intensity of outflows of rainwater or melting water, or outflows of water from sources, to the detriment of neighbouring land"* (Art. 234, Act 2017) often prevents the restoration of water conditions of the fen if its impact would also apply to neighboring land – and due to hydrological conditions, such cases are frequent.

In practice, surprising problems with the right to the area where fen protection would have to be carried out occur also in some parts of Poland on the land managed by the State Forests. Although State Forests themselves are obliged to *„preserve natural bogs and fens in their forests"* (see above), according to some lawyers they cannot make their land available free of charge to third parties for the implementation of the protection of such ecosystems (cf., chapter 10). Fortunately, such interpretations are not common.

The implementation of protective and restoration measures may require prior obtaining of an entire package of relevant decisions and permits. The time and cost needed for this can often exceed the time and cost needed to perform the protective measures themselves.

In general, the formal aspect of preparation of protection and restoration measures on sites located within the boundaries of national parks, nature reserves, landscape parks, in the surrounding areas of the listed forms, and in Natura 2000 areas is significantly simplified if these measures are adequately included in the protection plan, the plan of protection tasks, or the protection tasks established for a given form of nature protection. It is important that this approach is sufficiently specific and precise, i.e., that the plan provides explicitly for the implementation of the action concerned. This results in exemption of the measure from prohibitions appropriate for a given form of nature protection, exemption from the obligation to obtain a separate permit for removing trees or bushes from non-forest land, and exemption from the obligation to obtain an environmental decision for the construction of damming facilities on small ditches (raising the water level < 1m).

If the intended conservation measures do not result from the plan or protective tasks established for the form of nature protection, a separate permit is required for the removal of trees or shrubs, and a decision on environmental conditions (the so-called environmental decision) must be obtained for the construction of damming facilities in the forms of nature protection or their buffer zones. Furthermore, in the possible proceedings for the environmental decision, the obligation to submit a report on the environmental impact or on the Natura 2000 area may be imposed on the construction of the damming facilities, which will entail the preparation of a full environmental impact assessment with public participation. The consequence of such an assessment, regardless of its conclusions, will be the lack of possibility to use the simplified procedure of construction notification for the construction of appropriate structures and the requirement to obtain a full building permit (see further).

If the intended protection measures do not result from the plan or protective tasks established for the form of nature protection, in national parks and nature reserves, it will also be necessary to obtain a separate decision of the Minister or the General Directorate of Environmental Protection (Art. 15(3) and (4), of Act 2004), permitting a derogation from the prohibitions in force in a given form of protection.

Where conservation and renaturalization measures require a breach of prohibitions applicable to protected plant, fungi, or animal species, it is always necessary to obtain an appropriate permit for derogation, usually issued by the Regional Director for Environmental Protection (Article 56, Act 2004). The protection of fens is in principle a prerequisite for granting such a derogation, but it can only be granted if there are no alternative solutions and if it is not detrimental to the conservation of the population of protected species.

If the intended activities include earthworks which may change the water conditions (and the improvement of water conditions is also their change), then prior to their execution they must always be reported to the regional director of environmental protection pursuant to Art. 118 of the Act on nature protection (Act 2004) – even if the Directorate is a co-initiator or partner of the project within which the activities would be carried out – even if the activities result from the protection plan or protection tasks established by the same body. The performance of the measures may commence when the Regional Directorate for Environment Protection does not object to the notification within 30 days, or when it informs in advance that it does not object to the notification.

Among the measures used in the protection and restoration of fens, the construction, extension, reconstruction, or liquidation of water facilities (including ditches, and any damming devices), the change of land configuration on land adjacent to water having an impact on the conditions of water flow, the location of any construction facilities in the so-called „flood risk areas", any so-called special use of water (including damming, abstraction), as well as all *„works in water and other works that may cause changes in natural water flows, standing water status and groundwater status outside the boundaries of the ground property at which they are pursued"*, require obtaining a water-legal permit issued by the State Water Management Authority (Wody Polskie) (Art. 389 and Art. 17(1)(4), Act 2017). When applying for a permit, it is necessary to prepare and submit the so-called water-legal study. In exceptional cases, a conversion of a ditch consisting in the construction of a culvert or another closed section at a length of up to 10 m (even if it had an additional damming function) may be carried out in a simplified procedure, using the so-called water-legal notification (Articles 394 and 423, Act 2017; the implementation may proceed if the authority does not raise an objection within 30 days). On the other hand, retention of water in ditches, inhibiting water outflow from drainage facilities; interception of rainwater or melting water with the use of water drainage equipment – provided that it is implemented with the use of already existing water facilities or without the use of any facilities – does not require any water-legal consent.

Sometimes the protection and restoration of fens requires the construction of so-called civil structures, which means that the provisions of the Construction Law Act of 7 July 1994 (Act 1994) apply. In the current legal state, civil structures are buildings, constructions, or small architectural objects, together with installations ensuring the possibility of using the object in accordance with its purpose, erected using construction products[18]. As a rule, the construction of a civil structure requires a building permit issued by the starost of the district (*poviat*), and in order to obtain such a permit, a building design must be presented which meets detailed requirements[19], in particular – made on a „map for design purposes" on a scale of at least 1:2000. Usually such a map has to be made from scratch for fens, becoming the most time- and cost-intensive element of project development. Some civil structures may be constructed following a simplified procedure, the so-called construction notification (it does not require a full design, but only a description, sketches and drawings of the project; works may be commenced if the authority does not raise an objection within 21 days). This simplification applies, among other things, to damming structures raising the water level < 1m, however only outside the area of national parks, nature reserves, and landscape parks and their buffer zones (Art. 29(1)(14) and Art. 30(1), Act 1994). The simplified notification procedure also applies to the construction and conversion of drainage facilities (e.g., ditches) belonging to the owner of the land affected by the facilities (Art. 29(2)(9) and Art. (30)(1), Act 1994). The construction of culverts on ditches does not even require notification (Art. 29(1)(11b), Act 1994). However, these simplifications will not apply, and consequently a building permit will always be required if an environmental impact assessment or a Natura 2000 impact assessment was required for a given project (Art. 29(3) of the Act 1994).

18 Such a wording of the definition of a civil structure was introduced by the Act of 20 February 2015 amending the Construction Law Act and certain other acts (Journal of Laws, item 443) and came into force on 28 June 2015. Previously, the definition did not require that a civil structure be constructed using construction products. A „construction product" is *„any product or kit manufactured and placed on the market for incorporation in a permanent manner in construction works or parts thereof, the characteristics of which affect the performance of construction works in relation to the basic requirements for construction works"* (Regulation 305/2011 of the European Parliament and of the Council of 9 March 2011 *„laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC"*). As a consequence, from June 2015 the Construction Law Act does not apply at all to facilities where construction products are not used – e.g., to ditches, earth, and peat barriers made of local material, partitions made of locally obtained tree branches, etc. (see also the interpretation of the Ministry of Infrastructure: http://senat.gov.pl/gfx/senat/userfiles/_public/k8/documents/stenogram/provisions/services/7302o.pdf).

19 They are defined by the Regulation of the Minister of Transport, Construction and Maritime Economy of 25 April 2012 on the detailed scope and form of the construction project (Journal of Laws of 2012, item 462, of 2013, item 762, and of 2015, item 1554).

A legal problem which is difficult to solve is permanent deforestation of an area classified in the land register as a forest in favor of restoring a forestless fen. This is precluded by legislation on the protection of agricultural and forestry land, which provides for a procedure for deforestation for agricultural purposes, as well as for deforestation for investment purposes, but does not provide for any procedure for deforestation for nature protection purposes.

Complicated legal requirements that have to be fulfilled before taking conservation or restoration actions on fens cause that some materially needed protection projects turn out to be impossible to implement at all, and in other cases it is necessary to adapt the planned methods of protection and renaturalization not only to the actual needs of fens, but also to the ability to efficiently and rationally carry out the required formal procedures. Especially in the case of technical solutions to block the water drainage (see chapter 6.1), their planning is sometimes based on local hydrotechnical conditions, but also on the complexity of the procedure necessary to apply a given solution.

10. Social conditions of protection – practices of cooperation with land owners and managers

Dorota Horabik, Katarzyna Kotowska, Magdalena Makowska

The implementation of projects for the protection of natural habitats, especially those of a national or regional range, requires appropriate arrangements to be made with the owners or managers of the land on which such activities are planned. Of course it is easiest to protect nature on land to which we have property rights, but this situation is very rare and practically impossible when planning comprehensive measures for a particular type of habitat throughout the country.

The projects for protection of alkaline fens carried out by the Naturalists' Club were implemented both on State Treasury land managed by the State Forests, district (poviat) starost offices, agricultural real estate agencies (currently the National Agricultural Support Center), and drainage and water facilities governing bodies (currently, the State Water Management Authority, Wody Polskie), as well as on municipal and private land.

The best solution already at the stage of planning any activities is to make advance (already at the stage of applying for financing) appropriate arrangements with the owners and managers of the area. This is possible in the case of land owned by the State Treasury (obtaining consent from the forest inspectorate or the regional director of the State Forests), but very difficult, if not impossible, in the case of private land. As already mentioned in the previous chapters, there is a need for a very large amount of time and financial resources for the arrangements process (obtaining the owners' data, finding them, persuading them, and obtaining relevant approvals). Most organizations simply cannot afford this without being sure of obtaining funding for the planned activities. As a result, the majority of arrangements regarding private land are made at the project implementation stage.

10.1. Nature protection on State Treasury land

The ownership of plots with alkaline fens varies from one part of the country to another. In northern Poland, the implementation of protection measures within alkaline fens concerned mostly land owned by the State Treasury and managed by the State Forests (about 70% of the area), whereas in the southern and central part of Poland this was only a few percent. The agreements signed with the forest inspectorates guaranteed the possibility of carrying out active protection activities, i.e., preparatory mowing, removal of tree and shrub wildings, or improvement of water conditions through construction of various types of dams and/or gates. The possibility of involving representatives of the unit managing the given alkaline fen and their support facilitates and accelerates the implementation of the planned measures and guarantees effective maintenance of their sustainability, often as a result of the forest inspectorate's agri-environment-climate commitment. If the planned measures were previously included in an established management plan or a conservation plan, the support of the bodies for the implementation of the protection measures is achieved because it enables the forest inspectorate to fulfil its obligations without incurring any costs. It should also be noted that in most cases just the willingness and possibility to contribute to the protection of valuable ecosystems is the most important argument for consenting to the implementation of conservation measures.

However, there are exceptions to every rule. There is a general belief that it is easier to carry out protective activities on land owned by the State Treasury than on private land, but some experiences of the Naturalists' Club in recent years are to the contrary. It should be noted, however, that this is not due to the growing awareness of private owners and their positive attitude towards nature protection on their land, but rather to the increased resistance of the administration managing State Treasury property. The difficulties encountered (reluctance to make land available on the basis of agreements) were due to various reasons, but were usually justified by the imprecision of the legal provisions. The fears of forest administration employees were also related to the various perceptions of co-operation with a non-governmental organization by superiors. Therefore, there were cases when the Naturalists' Club was forced to lease the land managed by the forest inspectorate in order to perform protective activities on it. Bearing in mind the maintenance of the good conservation status of the habitat, the need to maintain the sustainability of the implemented measures, and the possibility of undertaking a commitment to an agri-environment-climate program, such solutions are considered acceptable. On the other hand, there were absurd situations when a non-governmental organization was asked to lease the land for the construction of gates on ditches or, worse still, lease the entire area within their impact range. Apart from the questionable legal aspects (the lease formula by definition assumes that the lessee obtains benefits from the leased area), in our opinion it is unacceptable to pay any state organizational body for the possibility of carrying out the protection of natural habitats and species that the same unit is legally required to protect.

There are still no systemic solutions enabling effective protection and management of habitats protected on land that should not seem problematic, yet they, unfortunately, include State Treasury land owned for example by the National Agricultural Support Center (formerly agricultural real estate agencies). For most of these lands, after the information about the necessity of carrying out protective measures in order to maintain or restore valuable habitats located there, a tender procedure was launched in the form of an auction for the lease of these lands, in which the Club usually participated. However, the best solution for land that has not yet been leased is to transfer it to the permanent management of the relevant regional environmental protection directorate, on the basis of the Act on the management of agricultural property of the State Treasury (Act 1991b). However, in the last few years only one unit, the Regional Directorate for Environmental Protection in Szczecin, used this legal possibility and took over the agricultural land with alkaline fens in permanent management. Thus, in accordance with the Act, it was also exempted from management fees due to the use of agricultural property for nature protection purposes.

In the case of carrying out activities on the grounds owned by poviat and municipal authorities, no significant difficulties were noted in the implementation of activities for the benefit of nature protection. Usually, these units, after learning about the objectives of the implementation of the measures and, having become aware of the valuable land they occupy, show much goodwill for the planned measures. The local administration appreciates the existence of rare and unique natural habitats in its area, which it often did not know about before, and considers the protection of these areas as something to be proud of.

The biggest challenge is the implementation of measures to improve water conditions in the area of fens through the construction of various types of gates and dams, which is a basic and necessary measure in the protection of fens. In the case of State Treasury land, these activities were carried on areas managed by forest inspectorates, starosties and municipalities, and were planned within ditches and watercourses currently belonging to the State Water Management Authority (Wody Polskie). These arrangements usually take the longest time in the project due to the very sensitive issue of changing the water conditions in the area. However, on the land managed by local government units and forest inspectorates, in most cases there were no problems related to the implementation of these measures (except for the above-mentioned situation with the condition of leasing land for building gates).

10.2. Nature protection on private land

The implementation of active conservation measures on private land is a very important challenge, especially if it involves a significant number of sites located in different regions of the country. In the projects for protection of alkaline fens implemented by the Naturalists' Club:

- *"Protection of alkaline fens (7230) of southern Poland"* – conservation activities were carried out almost entirely on private land (~94% of the area of the habitat covered by the project were private plots),
- *"Protection of alkaline fens (7230) in the young glacial landscape of northern Poland"* – private plots constituted about 20% of the area of the habitat protected under the project.

As mentioned in the previous chapters, it is very difficult to make all the appropriate arrangements when applying for subsidies. Therefore, the arrangements process is usually initiated at the beginning of the project implementation. In the case of non-governmental organizations, it is precisely the fact that they have signed a project subsidy agreement that entitles them to obtain the registration data from the real property register, together with the personal data of the owners and managers of the parcels in question.

In order to seek an agreement, it is first necessary to identify and find the owner of the land who could express such an agreement (Fig. 4).

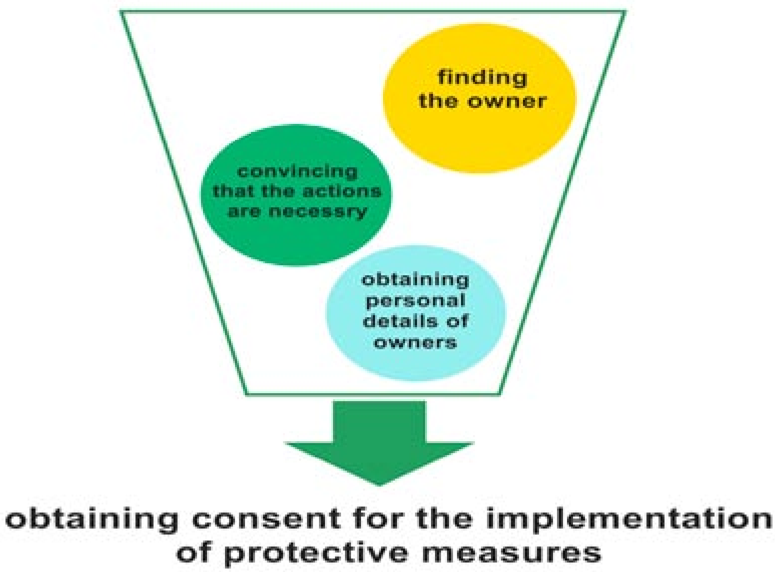


Fig. 4. The path to obtaining the owner's consent for the implementation of protective measures

Experience has shown that the legal interest of a non-governmental organization in obtaining the data on landowners is not recognized in all cases, therefore the process of obtaining extracts from the land register or the lists of land plots and their holders may in some cases take up to 2 years (!). In practice, we often encounter sites with very large fragmentation of land plots, e.g., for a site with an area of about 3.5 ha, there are 65 plots of land and almost the same number of owners (Natura 2000 area Pakosław PLH140015). There are extreme cases where the area of about 15 ha of the habitat is located on 305 plots of land owned by over 110 owners (Łąka w Bęczkowicach PLH100004). In mountain areas, flush fens are often located in mountain pastures or forest glades which are the property of land communities – this was the case in the Natura 2000 area Ostoja Popradzka PLH120019, where one of the plots with a flush fen, with the surface area of 8 ares, belongs to 32 owners.

Unfortunately, obtaining owners' data is only part of the work; the next step is to find them and convince them to agree to implement the protective measures. This stage is the longest and the most important one in the entire process of arrangements; it decides whether we gain the owner's favor for our activities, but also we play a key role in the owner's future attitude towards nature protection.

During the implementation of the projects, we conducted group meetings with the owners as well as individual interviews. If it was not possible to meet the owner in person, e.g., due to them working abroad, the owner was contacted by phone, traditional mail, or e-mail. Experience has shown that many factors influence the time frame for the arrangements, which will be presented below. In the central part of Poland, group meetings were held, at which the project assumptions and objectives were presented. These meetings were organized in the late afternoon, when most of the owners had already returned from work, near their place of residence, in local watchtowers or community houses, and there was a lot of interest in them. On the other hand, a similar formula of meetings did not work in other parts of the country, where the only way of reaching the owners was by individual meetings.

In total, as part of the alkaline fen protection projects implemented by the Naturalists' Club, several group meetings were held, but the most important were individual meetings with private owners, that were carried out several hundred times. Often several meetings were held with a single owner; only a few decided to sign an agreement or give oral consent to carry out protective measures during the first meeting. It should be noted that when obtaining the owner's consent for the implementation of the project's activities, it was attempted to obtain immediate approval for the continuation of these activities (in order to protect the habitat and maintain the sustainability of the activities carried out) in the future, either by the owner themselves or by the Naturalists' Club. Approximately 300 agreements were signed and dozens of oral approvals were obtained, which made it possible to implement protective measures on almost 700 plots of land.

Developing an appropriate attitude of private owners towards the protection of alkaline fens on their land through an appropriate approach to the entire process of arrangements also results in a change of social attitudes with respect to comprehensive nature protection.

Photo 99. Group meetings in central Poland and south-western Poland (no one except the organizers) (photo D. Horabik).

Photo 100. An individual meeting with a farmer in the field (photo D. Horabik).

The factors influencing the length of the process of arrangements with private owners are as follows:

- joint ownership – it is more difficult to obtain a unanimous decision from several owners, especially if some of them do not agree due to, for example, family conflicts;
- the owner is deceased – it is necessary to search for heirs who are not listed in the plot register data, often these are still succession cases which have not been settled;

- land under lease – additional talks with the lessee, it is often necessary to obtain the consent of both the owner and the lessee;
- unregulated property rights – in particular in the case of community lands; in 2015 the Land Community Development Law (Act 2015) was amended, requiring the establishment of a list of persons entitled to participate in the land community, the procedure in some cases has not been completed for a period of two years, which made it impossible to obtain the consent of legal decision-makers to take protective actions;
- the owner works outside the area – these are often cases of work abroad, in which case a meeting with the owner is possible only during major holidays;
- change of residence of the owner which was not noted in the excerpts from the land register;
- various types of contact problems (atypical work schedule, illness);
- lack of support among local authorities, activists – owners often condition their consent on obtaining support from local activists, the village administration, etc.;
- the owner decides to lease; in this case it is possible to carry out protective measures only as a result of signing the lease agreement; setting the terms of lease is another separate process;
- lack of understanding of the Natura 2000 network and the need to protect Natura 2000 habitats – which requires additional meetings to present the functioning principles of Natura 2000 areas, etc.;
- general suspicions, especially of the protection of fen habitats; over the last several decades fen have become wasteland on which no economic activities have been carried out in agricultural space, therefore the owners are suspicious that land of no value to the farmer is of interest to third parties;
- planned sale or transfer of land to offspring – it is often impossible to make any arrangements at all during the process;
- insufficient financial benefits – this applies in particular to cases where the area of the cadastral parcel is too small for the owner to make an agri-environment-climate commitment and obtain compensation for it, and also in the case of the leasing of small cadastral parcels or leasing of only the area of the habitat where the rent is very low;
- prevailing plans to obtain fuel from a fragment of the plot overgrown with alder and birch trees;
- lack of decision on the part of the owner – in the case of young owners who are no longer interested in farming, there are no arguments for restoring the traditional way of using the land, while older owners who would like to return to the old extensive mowing of the fens, make their decision dependent on the offspring they want to inherit the farm and the land in the future;

- lack of knowledge about the location of their land – owners are often unaware that they have ownership rights to a given land with alkaline fens; due to the abandonment of agricultural use of difficult areas and their treatment as wastelands, the knowledge about the land and its location has disappeared over the course of several decades;
- arrangements concerning the works on ditches – this is the most difficult subject to reach an agreement on, and any change in water conditions within habitats and ditch works results in the most emotional reactions and fear (often unjustified) about flooding the adjacent farmed land; the arrangements are accompanied by greater resistance when flooding occurs or has occurred in the past as a result of the activities of the beavers;
- negative view of the formal process – in some cases, owners were concerned about signing any agreement or contract, in which cases appropriate oral arrangements were made under which the protective measures were carried out.

Factors/arguments that determine the owner's consent to carry out protective measures and to continue to do so in the future:

- return to the roots, i.e., the possibility of restoring the old way of use and the old landscape, by preparing the plot for use, as a result of carrying out preparatory mowing and removal of shrubs from the plot, which are the most difficult and costly measures after years of leaving the habitat unused;
- financial benefits (lease) – so far, it has been one of the most effective arguments for nature protection on private land; the possibility of renting out a plot of land and receiving rent is preferred in the case of distant use traditions, lack of possibility/willingness to use the land, or in the case of heavy fragmentation of plots;
- financial benefits (agri-environment-climate measure) – preparation of natural documentation entitling the holder to apply for financial aid for the implementation of the agri-environment-climate commitment is effective in the case of sufficiently large areas, when the compensation for lost benefits is high enough to allow the farmer to undertake the commitment, or in the case of long-standing use traditions;
- providing the possibility of free use of the forest/wood located on the plot (in the case of fens within forests); it should be emphasized that the biomass obtained from the protection measures is always the property of the owner, and only in cases where the owner expresses their will to the contrary is it used by the entities performing the measures;
- support of local activists/authorities – as mentioned earlier, support of local naturalists, village administration, municipal council, landscape park employees and employees of regional environmental protection directorates is

sometimes of key importance when the owner makes their decision dependent on the opinions of others;

- natural benefits – this argument, although secondary from the point of view of the owner, also often proved convincing during the arrangements procedure – it is most effective in conjunction with financial benefits;
- lack of formal process – in cases where the owner agrees to carry out protective measures, but for various reasons is afraid of signing a formal agreement, it is justified to rely on the verbal consent of the owner; in the case of several owners, collective statements of consent to carry out the measures and their continuation after the completion of the project have been used to date;
- improvement of tourism and recreation attractiveness – an argument particularly effective in the case of municipal or communal land.

On the basis of the experience gained in arrangements with private owners, it can be concluded that:

- individual arrangements (especially for sites with a high degree of fragmentation of ownership) are very time-consuming and costly (travel costs, working time, etc.), but are more effective and allow private owners to change their attitude towards nature conservation on their land;
- group meetings are a good solution in the case of information meetings about the objectives and assumptions of the project and activities; during group meetings it is not possible to determine individual conditions for the implementation of activities, the owners are also reluctant to make decisions (extensive peer pressure, fear of what the neighbor will say);
- it is easier to obtain consent for one-off measures than for a longer period of time of protection of a habitat or species at a given site, which on the one hand often allows for timely implementation of the tasks set out in the project (by shortening the period of arrangements), but on the other hand does not solve the issue of future habitat/species protection or project sustainability;
- owners are relatively rarely interested in making an agri-environment-climate commitment (only in case of large areas), and are more often interested in selling or leasing the land;
- each fen (and not only) site/area has its own specific ownership structure, on which the planning of protection measures in a given area should to a certain extent be made dependent;

- a more systemic approach to habitat protection on private land is necessary, focused more on the involvement of both local naturalists and the entity managing the protected areas – the regional environmental protection directorates; an optimal solution would be to sign long-term agreements on habitat protection in a given area;
- the most effective solution for nature conservation on private land is to convince the owners, not for financial gain, nor because such an obligation has been imposed on them, but for their own satisfaction and pride that they can protect something valuable and unique in their area,
- individual, repeated meetings with land owners, despite significant costs, are in our opinion the best form of education of the local society in the field of nature protection, including the Natura 2000 network, as they help to clarify many doubts, overcome reluctance, and correct many mistakes made during the implementation stage of the Natura 2000 network.

Summary

Among all types of European peatlands, alkaline fens in many respects belong to the group of the most interesting ones. They are distinguished by an extraordinary wealth of species with specific adaptive features, most of which are rare, protected and threatened by extinction. The specificity of alkaline fens is imparted to vegetation growing on it, usually dominated by numerous species of bryophytes forming dense carpets, with sedges recognized only by expert botanists. These natural plant communities develop and can last for thousands of years only in hydrologically undisturbed conditions, the understanding of which is quite a challenge for people who have at the same time specialized knowledge in the field of geomorphology, hydrogeology and ecology. Both in Poland and in whole Europe, there are not many areas with natural water conditions, and the subsequent ones disappear almost every day. Together with them, alkaline fens are also dying. Among the experts involved in nature conservation, these are well-known facts! The problems described here are also not foreign to administrations responsible for the broadly understood environmental protection.

Over the past dozen or so years, along with Poland's accession to the European Union, awareness of the needs related to the protection of various types of habitats, including alkaline fens, has undoubtedly increased. They are subject to special protection - at least in theory - within the framework of the Natura 2000 network. Special conservation plans are prepared for their protection, and numerous projects are prepared and implemented to preserve them. Sometimes, though too rarely, to emphasize the value of alkaline fens, they are covered by reserve protection. Unfortunately, even the most valuable (such as the Rospuda Valley) are often threatened by destruction due to ill-conceived or simply stupid decisions.

The signals reaching us about subsequent drained or bulldozied in valuable peatlands confirm on one hand the thoughtlessness of a large part of society, on the other - the powerlessness of the services responsible for their protection. Analyzes of various reports or results of research on habitat 7230 conservation status do not give optimism! Attentive readers of this book have certainly noticed that the easiest and most effective way is to protect alkaline fens „unpolluted" by human activity. In a simple way, not requiring any financial means – covering by legal protection (as reserves) and leaving in holy peace. Unfortunately, in the case of those in some way disturbed (we have a vast majority of them!), effective protection requires dealing, it seems, an infinite number of endless problems. From correct identification, through the recognition of the development his-

tory, the specificity of hydrology, identification of hydrochemical conditions to the history of use burdened with many nuances and questions. And this is just a diagnosis, an introduction to real problems. Problems with the selection of appropriate methods of protection (usually very individualized), a compromise between the needs of protection and the use of the peatlands themselves or their neighborhood. Problems related to changing legal conditions that do not match the needs. Finally, the important financial problems arising from the need to undertake costly but necessary activities.

This Guidebook on Good Practices, we hope, will not only help many readers understand the complex aspects, but above all will encourage to overcome the problems related to the protection of alkaline fens at every step. An encouragement and at the same time a proof that nature protection, especially peatlands, is possible, let it be mentioned here numerous national as well as foreign examples.

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