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CHANGES IN MEADOW COMMUNITIES ON ABANDONED MARSHY MEADOWS

Summary

The study was carried out in the years 2010-2013 on drained, unused meadows situated on organic soils (wet and humid) in central Poland. The paper presents the changes and transformations of habitats and meadow communities that have taken place on these meadows due to reduced anthropopressure. Analysed post-bog meadows were formed by reclamation and drainage of lowland bogs. In the early 90s of the XX century they were still used agriculturally and had valuable meadow communities of the Molinio-Arrhenathereteae class growing on them. As a result of discontinued maintenance of drainage equipment and reduction in pastoral agricultural practices, a large increase in water logging of the post-bog meadows had been observed. This resulted in their conversion into swampy habitats and marshy meadows. Valuable agricultural grasses of the Molinio-Arrhenathereteae class and other humid habitats species receded and the share of herbs and weeds of wet and wetland habitats and/or sedges or Phragmites australis increased. Communities of Scheuchzerio-Caricetea or Phragmitetea classes formed. The problem is still relevant today as similar changes and transformations of plant habitats and communities occur in many valleys.
***Key words**: abandonment, permanent grasslands, habitats, post-bog meadows, reduced use*

PRZEOBRAŻENIA ZBIOROWISK ŁĄKOWYCH NA NIEUŻYTKOWANYCH WTÓRNIE ZABAGNIANYCH MURSZOWISKACH

Streszczenie

Badania prowadzono w latach 2010-2013 na zmeliorowanych, nieużytkowanych łąkach położonych na glebach organicznych (wilgotnych i mokrych) w Polsce Centralnej. W pracy przedstawiono zmiany i przeobrażenia siedlisk i zbiorowisk łąkowych jakie zaszły na tych łąkach w wyniku zmniejszenia antropopresji. Analizowane łąki pobagienne powstały w wyniku zmeliorowania i osuszenia torfowisk niskich, które jeszcze na początku lat 90-tych XX wieku były użytkowane rolniczo utrzymując wartościowe zbiorowiska łąkowe z klasy Molinio-Arrhenathereteae. Na skutek zaniechania konserwacji urządzeń melioracyjnych i obniżenia poziomu pratotechniki nastąpiło bardzo duże zwiększenie uwilgotnienia łąk pobagiennych, co spowodowało przekształcenie ich w siedliska bagienne lub łęgi zastoiskowe. Z runi ustąpiły trawy rolniczo wartościowe z klasy Molinio-Arrhenathereteae oraz inne gatunki siedlisk wilgotnych a zwiększył się udział ziół i chwastów siedlisk mokrych i bagiennych oraz/lub turzyc czy trzciny pospolitej. Wykształciły się zbiorowiska należące do klas Scheuchzerio-Caricetea lub Phragmitetea. Problem jest nadal bardzo aktualny, gdyż podobne zmiany i przeobrażenia siedlisk i zbiorowisk roślinnych występują w wielu dolinach.
***Słowa kluczowe**: zaniechanie użytkowania TUZ, siedliska, łąki pobagienne, ograniczenie użytkowania*

1. Introduction

Plant communities on permanent grasslands were formed mostly after irrigation and drainage, this caused the loss of their natural or semi-natural characteristics [10]. Irrigated and drained areas were managed and used agriculturally. In the beginning of the 1990's, in the XX century, there was a decrease in permanent grasslands use, some were abandoned while the area of permanent grasslands used extensively increased. In a few years after abandonment, gradually the share of species valuable in terms of forage value decreased, frequently in these communities expansive species such as *Filipendula ulmaria*, *Urtica dioica* and others started to dominate. This caused a drop in agricultural value and biodiversity [19, 20].

Reduction in or abandonment of agricultural pastoral practices on meadows and pastures with the simultaneous cessation of hydrological measures caused a rise in groundwater levels (GWL) and the resulting wetness of meadow communities [9]. In the case of increased moisture the habitats were often transformed until they became boggy, the plant communities were not affected by shrub and tree growth [10].

Dewatering of organic soils as a result of drainage accelerated mineralisation of organic matter and trophic growth of the soils worsening their physical-hydrological properties [3, 4], shrinking the organic layer and often allowing the emergence of new habitats [16]. Changes in meadow habitats and levels of management are the main causes of alterations in the plant cover and transformations of meadow-pasture plant communities [5]. Changes in communities and habitats happened gradually in phases, because the previous agricultural management and fertilization of meadows and pastures had a higher trophic value that was limiting the return of typical species of marshy habitats [9].

Post-bog permanent grasslands created as a result of draining and drying lowland bogs were the object of the research. They were managed agriculturally as meadows and pastures and were characterised by somewhat positive hydrological conditions. Currently they are in their majority

unused or used extensively, they are characterised by very changed and varying wetness conditions.

The aim of the study was to present the changes and transformations of habitats and meadow communities on unused wet meadows as a result of long-term abandonment (aprox. 20 years) – the simultaneous increase in their wetness until they became marshy.

2. Site description

Studies were carried out from 2010 to 2013 in two areas on previously drained abandoned meadows situated on organic soils in central Poland:

- in the mesoregion Kotlina Szczercowska (318.23) area "Dolina rzeki Pilsi", on its left-bank effluent - Pila, sites: Podwódka 14 (site 1), Wierzchy Kluckie 11 (site 2), Parzno 8 (site 5).

Peatlands situated in the source regions of Pilsa's effluent on which the studies were carried out, until the end of the 1950's of the XX century, were subject to paludification and had peat soils with predominantly low sedge communities growing on them.

- in the Równina Piotrkowska (318.81), sites placed on peatlands of the river Luciąż in its left-bank valley eflluent of the river Prudki, sites: Szczepanowice 6 (site 4) and Wilkoszewice 17 (site 3).

Sites in the valley of the river Prudka were situated on peats with varying degrees of decomposition. Halfway through the XX century these irrigated fens had grassy vegetation growing on them and were used as meadows.

Until the beginning of the 1990's these permanent grasslands had 2 cuts done on them while the third was usually recovered by grazing. The yield was usually >6, and even >10 t of dry mass from a hectare [9].

3. Materials and methods

On studied permanent grasslands, situated on organic soils with diverse levels of wetness, 5 research sites were chosen where the following were determined: soil type (via soil horizons), ground water level (GWL) was measured in permanent wells during the first cut (at the turn of May and June) and the second cut (late July and the beginning of August), botanical composition using Klapp's method (the procedure was repeated in subsequent years).

All sites had their typological habitat units determined.

Each site had its wetness value (WV) calculated, using the phytoindication method, in order to compare wetness changes between habitats. This method is based on the knowledge of moisture requirements of individual plant species determined in a 10-point numerical scale by Klapp [6], adapted to Polish conditions by Oświt [15].

The wetness value of the plant community is determined by the average air-water ratios in the soil of the habitat in which the community occurs. Based on WV, habitats were assigned to a specific category of habitat wetness.

Plant communities were characterised based on their species composition. The syntaxonomy units and taxonomic affiliations of individual species were done according to Matuszkiewicz [13]. The nomenclature of plants was given according to [14].

Transformations in communities and habitats were evaluated based on:

- moisture levels of the community
- classification of the wetness habitat
- phytosociological classification
- typological habitat category
- the number of species decreasing their share in the community or disappearing, and species increasing their share in the community or emerging in the sward based on wetness value acc. Kozłowska [9].

For the comparison of changes in the habitat of post-bog meadows earlier studies, conducted mostly on the same sites in the years 1991-1999 [9], were used.

4. Results and discussion

4.1. Soils characteristics and their transformations

In the 1950's of the XX century, peat soils with high GWL (0.1-0.2 m) limiting the decession of organic matter were found on research sites. After drainage carried out in the 1960s these peat soils developed into post-bog peat-muck soils or mineral-muck soils.

During the research period, in the 1990s of the twentieth century, the analysed sites have changed into post-bog soils with a moderate or low degree of decomposition and a diverse thickness of the organic layer. These soils developed from parvocaricetum peat (sites No. 1, 2) or reed peat (site No. 3), alder swamp (site No. 4), while on site No. 5 mineral-muck soil formed from parvocaricetum peat (Table 1).

In the examined habitats, GWL and the associated level of moisture varied and changed in particular years, cuttings and sites. In all years and cuttings there were large fluctuations in GWL, depending on the amount of rainfall, with a tendency to increase its value with a varying intensity depending on site.

The research areas was characterized by very varied precipitation in individual years. The year 1991 was one of the years with an optimal distribution of rainfall. In the following years there was an increase in precipitation:

- over 250 mm in June 1999, in July 2011, in June and July 2012, May and June 2013,
- very dry spring (2011), dry July 2013 and August 1999.

Table 1. Groundwater level on sites in particular years and cuts (cm)
Tab. 1. Poziom wody gruntowej w latach badań (cm)

Site	Soil type	Research year and cut											
		1999[1]		1999[1]		2010		2011		2012		2013	
		I	II	I	II	I	II	I	II	I	II	I	II
1/Podwódka 14	Mtlac	70	40	34	23	23	40	45	26	27	60	10	38
2/Wierzchy Kluckie 11	Mtla1	60	+9	17	+9	+2	36	29	22	2	5	6	-1.+2
3/Wilkoszewice 17	Mtllcc	40	33	47	32	+1	10	45	2	15	9	25	+1
4/Szczepanowice 6	Mtllcc	50	25	9	55	3	5	2	2	+2	+2	1.-2	+2
5/Parzno 8	Mr11	40	20	24	33	4	39	49	21	5	10	1.-2	+2

Source: own study / Źródło: opracowanie własne

After 1991, due to the limited maintenance or abandonment of drainage equipment, changes in GWL and waterlogging of meadows occurred. Initially GWL ranged from 40 to 70 cm in the first cut and 9 to 40 cm in the second cut (Table 1). In most habitats there was a gradual increase in GWL but its pace was different and the fluctuations high. The fastest rise in GWL occurred on site No. 2, located in the valley additionally supplied with water from adjacent dunes and in the vicinity of watercourses, then in 1999 on site No. 4.

In 2012 and 2013, the level of GWL also rose on sites No. 3 and 5 (Table 1).

In the last years of research, the highest GWL occurred in meadows located on peat-muck soils, often with water on their surface (sites No. 2, 4, 3), and quite often on site No. 5. High soil moisture and low air content inhibited growth and development of agriculturally valuable species and prevented their use.

4.2. Transformations of meadow communities

At the beginning of research in 1991, meadows and pastures had grass or sedge-grass associations from the *Molinio-Arrhenatheretea* class occurring on them, the majority of communities being from the order of *Molinietalia - Calthion* association. At that time, all communities were used agriculturally with differing intensity - cut twice and in the third recovery grazed [9]. Among the grasses there was a high dominant of grasses with good agricultural value (sites No. 1, 2) mainly: common meadow grass (*Poa pratensis*) and the much less numerous meadow foxtail (*Alopecurus pratensis*) (Table 2). Meadow foxtail (*Alopecurus pratensis*), common meadow grass (*Poa pratensis*) and red fescue (*Festuca rubra)* belong to the most durable fodder grasses on organic soils [1, 7] . From the grasses of poor agricultural value mainly tufted grass (*Holcus lanatus*) appeared and its number at the end of the research clearly increased. On the remaining sites (No. 3,4,5), the share of grasses was smaller and amounted to about 40% with a significant share of common meadow grass (*Poa pratensis*) and red fescue (*Festuca rubra*) among other grass species (Table 2). Initially, the share of plants from the group of herbs and weeds was small, about 20% (site No. 2, 3 and 5) or even trace (site No. 1). Sedge plants in sites No. 2, 3, 5 accounted for about 30%, and in stand No. 1 there were none. In the analysed communities there were also legume plants in a small share of up to 4%, (none on site No. 1).

At the beginning of the 1990s, abandonment of the maintenance of drainage facilities resulted in increased GWL, this caused changes in habitat conditions and meadow communities [9]. The result being an increase in the share of medium and weak grasses, mainly tufted hairgrass *Deschampsia caespitosa* (site No. 1 to around 60% and site 5 to 20%) at the end of the 1990s. The share of herbs and weeds increased only on sites No. 2 and No. 5, not much (up to 4%) on site No. 1. Site No. 4 where there were high fluctuations of GWL up to the flooding during the growing season, the species composition of herbs and weeds had changed, meadowsweet (*Filipendula ulmaria*) and purple loosestrife (*Lythrum salicaria*) began to dominate. As humidity increased, the share of sedges also increased. On other sites, the share of sedge varied, from several to several dozen percent (Table 2).

At the end of the study, the largest changes in the communities occurred in highly moistened habitats (site 4, 2, 3 and 5), agriculturally valuable grasses disappeared, the share of sedges, mainly bottle sedge (*Carex rostrata*) and common sedge (*C. nigra*), increased (No. 2, 3, 5), the common reed (*Phragmites australis*) dominated on site No. 4 (Table 2).

On site No. 1 abandonment and increased moisture caused the growth of tufted hairgrass (*Deschampsia caespitosa*) and in smaller amounts the growth of sedges (*Carex gracilis, C. riparia, C. vesicaria*), weeds and herbs.

In habitats transforming into very moist and wet habitats (sites 2, 3, 4, 5) due to abandonment and increased moisture there had been a big and very big species exchange in communities. The communities had mainly WV 5-7, and to a small extent> 7, species receding from them (Table 3). Both valuable grass species such as the meadow foxtail (*Alopecurus pratensis*), meadow fescue (*Festuca pratensis*), common meadow grass (*Poa pratensis*) and grasses of medium and low agricultural value have receded: rough bluegrass (*Poa trivialis*), tufted grass (*Holcus lanatus*); herbs and weeds: creeping buttercup (*Ranunculus repens*), plantain (*Plantago lanceolata*) and common sorrel (*Rumex acatosa*) [9].

In place of the receding species with a WV of 5-7, in the communities the species with a WV value above 7 appeared. In highly moist, wet habitats, with a constant level of ground water (sites No.1 and 4), due to increased moisture, agriculturally valuable species gave way to herbs of wet and swamp habitats and sedges with a negligible share of valuable grasses. Mostly this were quite numerous species of dicotyledonous plants, such as the marsh cinquefoil *(Comarum palustre*), marsh willowherb *(Epilobium palustre*), purple loosestrife (*Lythrum salicaria*) and sedges: acute sedge (*C.gracilis*), bottle sedge *(C.rostrata*), common sedge (*C.nigra*) and compact rush (*Juncus conglomeratus*) (Table 2).

Table 2. Botanical composition changes (%) of meadow communities in the years 1991-2012
Tab. 2. Zmiany składu botanicznego (%) zbiorowisk łąkowych w latach 1991-2012

Plant groups	Sites and years																			
	1				2				3				4				5			
	91	99	10	13	91	99	10	13	91	99	10	13	91	99	10	13	91	99	10	13
Grasses	100	94	90	90	54	30	7	4	45	39	10	9	40	21	4	3	43	32	25	12
Meadow foxtail (*Alopecurus pratensis* L.)	15	5	1	2	3	-	-	-	+	r	r	-	r	-	-	-	3	r	r	-
Meadow grass (*Poa pratensis* L.)	72	5	3	4	18	1	r	+	10	+	+	1	7	3	-	-	18	+	r	-
Tufted hairgrass (*Deschampsia caespitosa)*	1	60	65	60	+	7	-	-	3	r	r	-	r		-	-	5	20	15	3
Other grasses	12	24	21	24	33	22	7	4	32	38	9	8	33	18	4	3	17	12	10	9
Legumes	-	-	-	-	3	-	-	-	1	r	-	r	2	-	-	-	4	r	r	-
Sedges	-	2	6	6	30	50	75	70	32	41	70	75	20	40	94	97	30	38	55	74
Herbs and weeds	r	4	4	4	13	20	18	26	22	20	20	16	38	39	2	+	23	30	20	14

+ share of species approx. 0,5%, r – single species *Source: own study / Źródło: opracowanie własne*

Table 3. Number of species decreasing their share or disappearing (D**)** and increasing their share or emerging **(**E**)** In the sward depending on wetness value in the years 1991[1], 1999[1], 2013[2]

*Tab. 3. Liczba gatunków zmniejszających udział lub zanikających **(Z)** oraz zwiększających udział lub pojawiających się **(P)** w runi w zależności od liczby wilgotnościowej w latach 1991[1], 1999[1], 2013[2]*

Sites	D, E	Years	Number of species and wetness value (WV)							Σ	Sum
			9	8	7	6	5	4	0		
1	D	1991-1999	-	-	1	1	2	-	-	4	14
	E		1	2	3	1	2	-	1	10	
	D	1999-2013	-	-	1	-	2	-	-	3	16
	E		1	4	3	2	3	-	-	13	
Σ	D	1991-2013	-	-	2	1	4	-	-	7	30
	E		2	6	6	3	5	-	1	23	
2	D	1991-1999	1	1	6	3	6	-	-	17	37
	E		10	7	2	1	-	-	-	20	
	D	1999-2013	5	8	3	2	1	-	1	19	37
	E		6	3	6	2	-	-	1	18	
Σ	D	1991-2013	6	9	9	5	7	-	-	36	74
	E		16	10	8	3	-	-	1	38	
3	D	1991-1999	-	-	3	1	6	1	1	12	23
	E		6	4	1	-	-	-	-	11	
	D	1999-2013	4	3	9	1	3	-	1	21	33
	E		6	4	1	1	-	-	-	12	
Σ	D	1991-2013	4	3	12	2	9	1	2	33	56
	E		12	8	2	1	-	-	-	23	
4	D	1991-1999	2	2	3	2	7	-	1	17	38
	E		7	8	6	-	-	-	-	21	
	D	1999-2013	11	13	13	3	5	-	1	46	47
	E		1	-	-	-	-	-	-	1	
Σ	D	1991-2013	13	15	16	5	12	-	2	63	85
	E		8	8	6	-	-	-	-	22	
5	D	1991-1999	-	2	2	3	5	-	1	13	24
	E		6	4	1	-	-	-	-	11	
	D	1999-2013	2	7	3	1	2	-	-	15	24
	E		4	3	1	1	-	-	-	9	
Σ	D	1991-2013	2	9	5	4	7	-	1	28	48
	E		10	7	2	1	-	-	-	20	
Σ Σ	D		25	36	44	17	39	1	5	167	293
	E		48	39	24	8	5	-	2	126	

Source: own study / Źródło: opracowanie własne

The arrival of other species and the simplification of plant communities predominated, this was observed especially on site No. 4. Despite the growing amount of species on site No. 1 the species exchange there was the lowest. From the dominating meadow grass (*Poa pratensis*) a community with an advantage of tufted hairgrass (*Deschampsia caespitosa*) belonging to moist meadows emerged [13]. In the central regions of our country they occupy as much as 50% of the meadow areas [12]. Tufted hairgrass (*Deschampsia caespitosa*) is a species with a wide ecological range. It spreads easily both on mineral and organic soils, under conditions of excessive flooding and periodic drying, insufficient fertilization and dehydration, as well as improper meadow use [8, 11, 12, 18]. On other sites rising GWL and moisture caused the species exchange to swap species for those with a higher WV and the transformation of plant communities that reflect higher WV of communities occurring there (Table 3, 4).

On practically every site over several years the WV value of the communities increased. The largest change in WV value of a community took place on site No. 4 (by 2.75 WV units) where GWL was highest, and on site No. 3 (by 1.70 WV units).

Changes in soil and water conditions and the associated species exchange such as the loss of humid and highly humid species and the increase in numbers of swampy and aquatic habitat species, reflect the increase in the WV value of communities from medium to very large (Table 5) which caused a change of the moisture habitat (Table 4). The largest change in moisture habitats occurred on site No. 4, from a wet habitat it turned into a water-land habitat, site No. 3 from a highly moist habitat changed to a permanently marshy (Table 4).

During the studied 23 year timespan rising moisture on most sites caused significant changes in typology habitats. On former moorsh meadows, that were still used agriculturally just at the beginning of the 1990s of the XXth century, increased GWL caused their transformation into bogs or marshes (Table 5). High moistening of habitats and communities, despite their transformation into bogs, was a factor limiting the invasion of trees and shrubs into plant communities. In conditions of high GWL and low air content in the soil, the process of organic matter accumulation dominates while soil mass decession is inhibited [2]. These communities occurring in more moist habitats became more naturally valuable than those growing on less moist and dry habitats [17].

Table 4. Meadow wetness habitats (acc. Oświt) [15] in the years 1991[1], 1999[1], 2013[2] on studied sites
Tab. 4. Łąkowe siedliska wilgotnościowe (wg Oświta) [15] w latach 1991[1], 1999[1], 2013[2] na badanych stanowiskach

Type of wetness habitat	Wetness value (WV)	Sites in years		
		1991[1]	1999[1]	2013[2]
C Fresh and moist				
C 2 moist and drying	5,9 - 6,3	1	-	-
C 3 moist	6,3 - 6,6	-	1	1
D Very moist and wet				
D 1 very moist	6,6 - 79	3	-	-
D 2 wet	6,9 - 7,3	4,5	-	-
D 3 very wet	7,3 - 7,7	2	5,3,4	-
D 4 bogging	7,7 - 7,9	-	2	-
Boggy				
E 1 drying periodically	7,9 – 7,2	-	-	5,2
E 2 weak drying	8,2 – 8,5	-	-	-
E 3 permanently boggy	8,5 – 9,1	-	-	3
F Water - land				
F1 water - land	9,1-10,0	-	-	4

[1] studies by Teresa Kozłowska, [2] own studies *Source: own study / Źródło: opracowanie własne*

Table 5. Changes in typological habitats in years 1991[1], 1999[1], 2013[2]
Tab. 5. Zmiana rodzaju siedliska typologicznego w latach 1991[1], 1999[1], 2013[2]

Site	Year		
	1991[1]	1999[1]	2013[2]
1. Podwódka 14	proper moorsh	proper moorsh	proper moorsh
2. Wierzchy Kluckie 11	proper moorsh	boggy moorsh	bog drying periodically
3. Wilkoszewice 17	proper moorsh	boggy moorsh	proper waterlogged marsh
4. Szczepanowice 6	marshying moorsh	spilling marsh	sunken waterlogged marsh[3]
5. Parzno 8	wet-ground forest moorsh	boggy moorsh	bog drying periodically

[1]studies by Teresa Kozłowska, [2]own studies, [3]water-meadow habitat

Source: own study / Źródło: opracowanie własne

5. Conclusion

1. Abandonment of use and maintenance of water and drainage equipment resulted in increased ground water levels and increased wetness of meadow habitats, which led to changes in habitat conditions and transformations of plant communities. There was a reduction in the share of grasses, mainly those valuable in agriculture, until their total disappearance. Their place is occupied by various species of grass mainly *Deschampsia caespitose* and by herbs, weeds, sedges or reeds, thus the communities lost their agricultural value.
2. The level of wetness determined the pace and direction of changes in the species composition of meadow communities.
3. The high increase of moisture in habitats due to abandonment caused an increase in the share of sedges, while decreasing the share of tufted hairgrass and halting the expansion of trees and shrubs, simultaneously increasing the natural value of plant communities.

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