

Letter to Editor

Disappearance of *Molinio-Arrhenatheretea* Meadows Diagnostic Species in the Upper Płonia River Valley (NW Poland)

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Abstract

Our work is aimed at a multifaceted analysis of the present floristic composition of meadow assemblages in the upper Płonia River Valley and at comparing it with historical data. Special attention was paid to the disappearance of the species typical of the *Molinio-Arrhenatheretea* class, and the causes underlying the transformations observed.

Keywords: meadows, management, rare species, Western Pomerania

Introduction

Contemporary human activities have led, in a relatively short time, to considerable and unprecedented transformations of the natural environment. Biotope fragmentation and the resulting isolation of small populations is one of the main problems caused by recent land-use changes [1-3]. Such changes are faster than organismal evolution, for which reason adaptive processes, dominant so far, have succumbed to processes leading to species die-out, whereby the most sensitive species may be exterminated [4]. In recent decades the rate of global floral depauperation has rapidly accelerated [5]. Initial, and most distinct, signals are observable primarily on a local or regional scale. Examples have been provided by detailed floristic research in the Barlinek Lakeland which showed that semi-natural meadows suffered the largest reduction of the number of species typical of those habitats. The persisting sites frequently showed reduced abundances of those species [6].

Płonia Valley and Miedwie Lake is a Natura 2000 habitat site (PLH 320006). The area surrounding the upper Płonia River Valley is one of the most valuable, not only in the Barlinek Lakeland, but throughout Western Pomerania. The high diversity of the vegetation of the area has been extensively documented [6-8]. The work described here was aimed at a multifaceted analysis of the present floristic composition of meadow assemblages and at comparing it with historical data. This way, changes in the distribution of species characteristic of the *Molinio-Arrhenatheretea* class can be followed, and the causes underlying the observed transformations sought.

Material and Methods

In 2001-02 detailed floristic surveys were carried out on grasslands supporting meadow vegetation from the *Molinio-Arrhenatheretea* class. A total of 39 relevés were taken, including 13 on fresh meadows from the *Arrhenatheretalia* order and 26 on wet meadows from the *Molinietalia* order. Distribution maps of species noted in the studied area were prepared with an ATPOL grid square [9].

Table 1. Participation of geographical-historical groups in meadow flora of the upper Plonia River Valley.

Group	All meadows		Fresh meadows		Wet meadows	
	Share of species number	Share of records number	Share of species number	Share of records number	Share of species number	Share of records number
Sp	82.6%	93.2%	84.2%	80.5%	97.1%	90.3%
Arch	11.3%	5.0%	12.1%	14.3%	1.9%	5.7%
Ken	5.2%	1.6%	3.2%	3.9%	1.0%	4.0%
D	0.9%	0.2%	0.5%	1.3%	0.0%	0.0%

Sp – native species, Arch – archaeophytes, Ken – kenophytes, D – diaphytes

The Profit 2.0 package [10] was used to set up databases of releves and species, which subsequently aided in the comprehensive analysis of floristic composition of the contemporary meadows in the area. The floristic richness, expressed by the number of taxa and the spectrum of life forms was analyzed, as was the phytosociological rank of the species and their origin. Individual species were assigned to life form groups developed by Raunkiaer, following Zarzycki et al. [11]. The syntaxonomic classification of the species follows that of Matuszkiewicz [12] and Zarzycki et al. [11]. The list of anthropophytes is based on that of Zając [13] and Zając et al. [14]. The threat status of the species in Western Pomerania follows Żukowski and Jackowiak [15].

Results of the original studies and the literature data from various historical periods (starting in 1870) were used to assess changes in the floristic composition of the meadows, with special attention being paid to disappearance of the species typical of the *Molinio-Arrhenatheretea* class.

Results

Analysis of the results allowed us to conclude that the meadows in the upper reaches of the Plonia River are, despite unfavourable transformations, still relatively floristically rich, both in terms of the number of species and the proportion of rare and protected plant species. The mean number of species in a floristic relevee was 48.5 (43.9 for fresh and 50.7 for wet meadows). The total number of species recorded on the meadows surveyed was 326 (231 on fresh and 247 on wet meadows). It should however, be emphasised that more than 100 species were found only sporadically, and most of those were not typical meadow dwellers, e.g. 30% of them are accidental migrants from cultivated fields located nearby (segetal weeds) and human settlements (ruderal weeds). Their presence is an indication of unfavourable changes taking place in the meadow flora. The group of very rare or rare species present in the upper Plonia meadows also includes species that are endangered in Western Pomerania (V category): *Alchemilla glabra*, *Carex diandra*, *C. lepidocarpa*, *C. limosa*, *C. tomentosa*, *Juncus subnodulosus*, *Ophioglossum vulgatum*, and *Trollius europaeus*.

The most important Raunkiaer life forms are hemicryptophytes that accounted for 52.5% of all the species recorded on the upper Plonia meadows (Fig. 1). In addition, fairly numerous were geophytes (14.1%) and therophytes (18.7); the high proportion of the latter evidences considerable anthropogenic transformation of meadow flora. Analysis of the origin of the species recorded revealed native species to account for more than 80% of the meadow flora, alien species being rare (6.8% of all the species records). The percent contribution of geographically alien species was clearly higher on fresh meadows from *Arrhenatheretalia* order (Table 1), which were found to support 33 archaeophytes, 9 kenophytes and 3 diaphytes. The wet meadows were inhabited by as few as 14 archaeophytes and 10 kenophytes, which points to a clearly lower degree of anthropogenic effects in the flora of the habitats studied, and their higher resistance to invasions of alien species. *Sonchus oleraceus*, found in 10 releves, was the most common anthropophyte on the meadows surveyed. A conspicuous predomination of alien species was seen in 1-3 releves only.

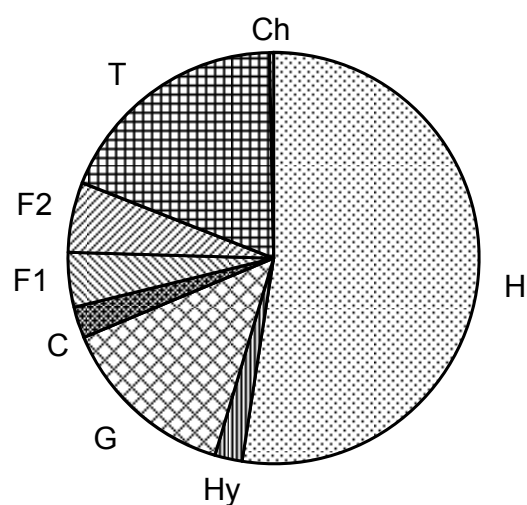


Fig. 1. Spectrum of life forms in meadow flora of the upper Plonia River Valley.

C – herbaceous chamaephyte, Ch – woody chamaephyte, F1 – megaphanerophyte, F2 – nanophanerophyte, G – geophyte, H – hemicryptophyte, Hy – hydrophyte, T – therophyte.

Table 2. Disappearance of the selected meadow species stations in the upper Płonia River Valley.

Name of species	Stations		
	according to Libbert	according to Bacieczko	present-day stations
<i>Betonica officinalis</i>	SE from Barlinek, Janowo (1941)	Płonia Valley (1995)	-
<i>Dactylorhiza incarnata subsp. ochroleuca</i>	S from Barlineckie Lake (1935, 1938, 1941), Sitnik (1938)	-	-
<i>Dactylorhiza majalis</i>	Janowo (1932, 1938), Paper-Mill [Młyn-Papiernia], Niepołcko, Sitnik (1938)	Niepołcko (1991), Żydowo (1996)	-
<i>Euphrasia rostkoviana</i>	Janowo, Niepołcko (1938)	Płonia Valley (1995)	-
<i>Gentianella amarella</i>	Janowo (1938, 1941)	-	-
<i>Gentianella uliginosa</i>	Janowo (1938, 1941)	-	-
<i>Lathyrus palustris</i>	Janowo (1938, 1941)	-	-
<i>Leontodon hispidus</i>	Jagów, Janowo, Sitnik (1938)	Płonia Valley (1995)	Barlinek
<i>Ophioglossum vulgatum</i>	Janowo (1938), Niepołcko, Żydowo (1938, 1941)	-	Żydowo, W from Żydowo
<i>Orchis militaris</i>	Głębokie Lake (1938, 1941)	-	-
<i>Ostericum palustre</i>	Niepołcko (1938), between Laskówko and Niepołcko, Barlineckie Lake (1941)	-	-
<i>Saxifraga granulata</i>	Chrapowo Settlement, Dobrzysław, Janowo, forester's lodge of Barlinek (1938)	Płonia Valley (1995)	-
<i>Senecio aquaticus</i>	Barlineckie Lake (1941)	-	-
<i>Serratula tinctoria</i>	Równo (1938, 1941)	-	-
<i>Succisa pratensis</i>	Janowo (1935, 1938)	Żydowo (1996)	-
<i>Trollius europaeus</i>	Niepołcko (1935), Barlinek, Janowo, W from Żydowo (1935, 1938, 1941)	W from Żydowo (1991, 1996)	W from Żydowo

The syntaxonomic analysis confirmed that the core of the meadow flora still consisted of species typical of *Molinio-Arrhenatheretea* or lower units of the class (Fig. 2). A considerable number of those species were the most common ones on the meadows, recorded in more than half of the releves collected (*Dactylis glomerata*, *Cirsium oleraceum*, *Scirpus sylvaticus*, *Alopecurus pratensis*, *Equisetum palustre*, *Lathyrus pratensis*, *Valeriana officinalis*, and *Deschampsia caespitosa*). Important also were species representing rushes (*Phragmitetea*), flooded meadows (*Agropyro-Rumicion crispis*), deciduous forests (*Quercu-Fagetea*), as well as xerothermic grasslands and fringe communities (*Festuco-Brometea*, *Trifolio-Geranietea*). Numerous, particularly on fresh meadows, were segetal species and pioneer ruderal plants (*Stellarietea*), as well as ruderal perennials (*Artemisienea vulgaris*) which evidence unfavourable changes in the flora of the grasslands studied. Laying some meadows fallow and the consequent accumulation of non-decomposed plant material led to the considerable presence of nitrophilous perennials, particularly *Urtica dioica*, *Galium aparine* and *Rumex obtusifolius*, which dominated some studied patches of vegetation cover.

Analysis of the literature data and the available unpublished materials documenting the almost 140-year-long

period of geobotanical research carried out in the upper reaches of the Płonia Valley showed many of those materials to be based on a single observation, on some selected ecosystems, or on small areas. The most comprehensive geobotanical studies that could serve as a point of reference to the current research include works published by Libbert [7, 16-19] and Bacieczko [8, 20-23]. In 1950-90, botanical research in the area remained at a standstill, with a resultant gap in the comparative materials.

The available information shows that, at the turn of the 20th century, the number of meadow indicator species representing the *Molinio-Arrhenatheretea* class was significantly higher in the area of study. A change in the meadow management resulted in a gradual disappearance of those species. The first to disappear were the most sensitive species of the *Molinion* meadows, followed by plants typical of *Calthion* meadows. The study described failed to confirm the presence of 20 species representing the *Molinio-Arrhenatheretea* class, some of them being last seen in the 1930s and 1940s (e.g., *Dactylorhiza incarnata subsp. ochroleuca*, *Gentianella amarella*, *G. uliginosa*, *Lathyrus palustris*, *Orchis militaris*, *Ostericum palustre*, *Senecio aquaticus*, *Serratula tinctoria*) or in the first half of the 1990s (e.g., *Betonica officinalis*, *Dactylorhiza majalis*,

Dianthus superbus, *Euphrasia rostkoviana*, *Saxifraga granulata*, *Succisa pratensis*). Numerous species are still losing their sites, e.g., *Galium uliginosum*, *Juncus subnodulosus*, *Leontodon hispidus*, *Molinia caerulea*, *Ophioglossum vulgatum*, *Trollius europaeus*, and *Valeriana dioica* (Table 2, Fig. 3). The still occupied sites showed a clear reduction in the number of specimens, e.g., in the case of *Juncus subnodulosus* and *Trollius europaeus* [24].

Analysis of changes in distribution of the indicator meadow species revealed some of the plants to show strong apophytic tendencies, with a resultant expansion onto anthropogenic habitats, and hence an increase in the number of sites. This group is represented primarily by the species typical of fresh meadows, e.g., *Achillea millefolium*, *Dactylis glomerata*, *Taraxacum officinale*, *Veronica chamaedrys*, and *Arrhenatherum elatius*, dispersing to roadsides, forest paths and fringes, next to buildings, and in forest clearings and nurseries. Among the meadow community plants, a strong expansion is typical of *Deschampsia caespitosa*, which colonizes abandoned grasslands, particularly where the water regime is perturbed.

Discussion and Conclusions

The species composition of traditional hay meadows is the result of a complex combination of abiotic and biotic factors, management regimes, continuity of management and varying dispersal conditions [25]. In the case of meadow species, the terms ‘hemerophile’ and ‘hemerophobe’ are relative and are not constant traits of a plant [26]. The species representing assemblages of *Molinion* meadows of varying water content have dispersed due to human activities that deforested river valleys by mowing but did not apply fertilizers. Regular autumn mowing (the hay being used as litter) facilitated the occurrence of rare vascular plants, and – in consequence – the emergence of the most valuable semi-natural plant communities of Poland [12] and Europe [27].

In the Plonia Valley, the single-mown meadows covered vast areas in the early 20th century (e.g., near Niepołcko), and their flora contained rare and valuable species [7]. Historical maps show that in the upper course no regulations of the Plonia River had taken place and few man-made ditches were present on the map of 1834. Heavy drainage work was performed in the 1930s. This was repeated after the Second World War [28]. A negative effect of drainage on species richness was proved by Grootjans et al. [29]. Changes in the water regime of river valleys, as well as intensive fertilization and mowing several times a year, resulted in most grasslands being transformed into commercially more profitable, but floristically poorer multi-mown fresh meadows from the *Arrhenatheretalia* order. The consequence involved the disappearance of numerous species typical of *Molinion* meadows, which was observed in the study area. The subsequent intensification of agriculture, replacement of traditional meadow and pasture use with new techniques such as ploughing and sowing species of the highest feed value, resulted in profound changes in the struc-

ture of plant assemblages, noted in numerous papers [30–34]. The earlier first mowing and the cutting of plants closer to the ground made it difficult for some species to renew, which reduced the floristic richness of meadows.

In the 1990s, the meadow flora was observed to change in still another aspect. Due to societal and economic transformations in progress in Poland, state farms collapsed and tending of meadows and pastures became unprofitable. Cessation of human economic activities and the associated absence of meadow tending and fertilizing were equally unfavourable for the meadow flora, and triggered succession

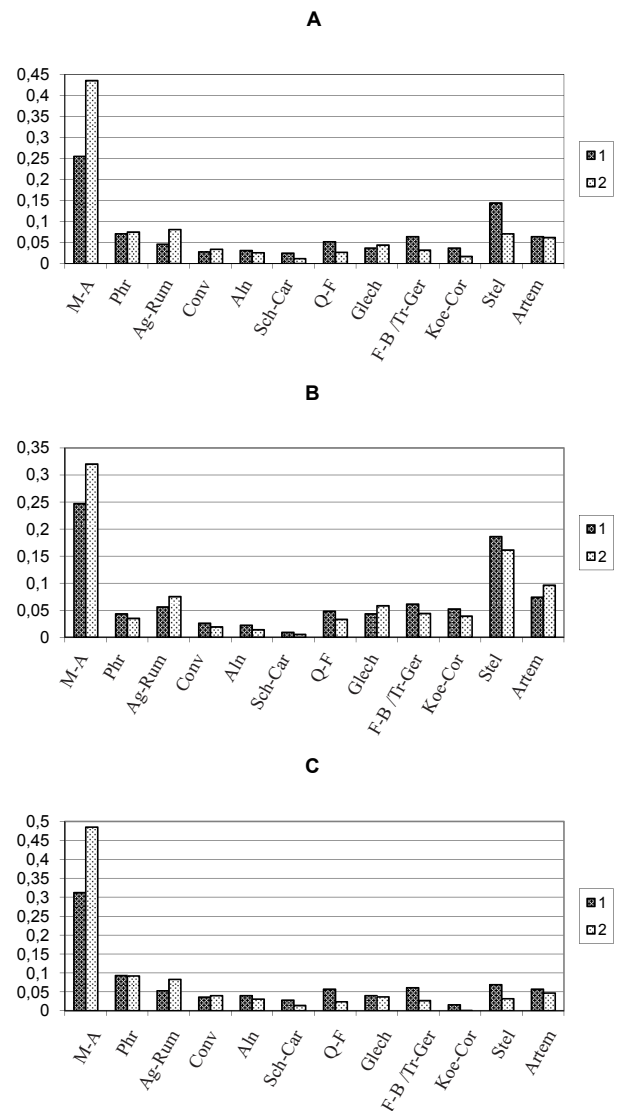


Fig. 2. Participation of the main synthaxonomic groups in meadow flora of the upper Plonia River Valley; A – All meadows, B – Meadows from *Arrhenatheretalia* order, C – Meadows from *Molinietales* order

1 – percentage of number of species, 2 – percentage of number of records, M-A – *Molinietales caeruleae* and *Arrhenatheretalia*, Phr – *Phragmitetalia*, Ag-Rum – *Agropyro-Rumicion crispae*, Conv – *Convolvuletalia sepium*, Aln – *Alnetea glutinosae*, Sch-Car – *Scheuchzerio-Caricetalia*, Q-F – *Quercus-Fagetalia*, Glech – *Glechometalia hederaceae*, F-B – *Festuco-Brometalia*, Tr-Ger – *Trifolio-Geranietalia sanguinei*, Koe-Cor – *Koelerio glaucae-Corynephorsetalia canescentis*, Stel – *Stellarietalia mediae*, Artem – *Artemisienea vulgaris*.

processes. The accumulation of litter is one of the most important mechanisms, changing species composition after abandonment [35]. Germination is especially sensitive to litter accumulation [36]. As a result of abandonment, specialist species are often replaced by generalist species, and a decrease of species diversity is observed, as well as the establishment of woody or invasive species [35]. In Płonia Valley all agricultural activities have stopped in the peat areas. Only at the valley flanks, where sometimes very productive soils are present, is some agriculture still taking place and also irregular mowing, but in the wet peat areas the vegetation has not been mown for many years. The existing botanical nature values have survived a lack of management due to the fact that groundwater is still seeping in the meadows locally, preventing tall herbs and shrubs to dominate the vegetation and to out compete the rare meadow species. Also, high amounts of travertine in the top soil of some areas restrict the rapid growth of tall species [37]. In spite of this the appearance of nitrophilous species, reducing the floristic richness, was observed in the study area, as well as increases of the proportion of forest and alien species. Similar results were published from other areas [38-41].

Researchers are agreed that the remaining hay meadows are of high conservation value and should be managed in a way that maintains their biological qualities [25, 42-43]. Preservation of remnant species-rich meadows may be important in full restoration of neighbouring former semi-natural grasslands by reintroducing grazing or mowing [44]. The complex and temporally variable relationships between various forms of the use of vegetation cover and the dispersal, persistence, and disappearance of certain types of plant communities and the species they supported pose a particularly difficult situation for the practice of nature conservation [26-27]. The success of meadow conservation is very often dependent on the degree to which the conservation is tied with the need for meadow use, particularly when an area is private property. The most valuable meadow fragments should be granted legal protection, for example by awarding them the status of an area of ecological grounds, and the owners should receive financial compensation for carrying through conservation-oriented recommendations [40, 45]. Such procedures are possible thanks to agricultural-environmental programmes in progress for a few years. The new Development Plan for

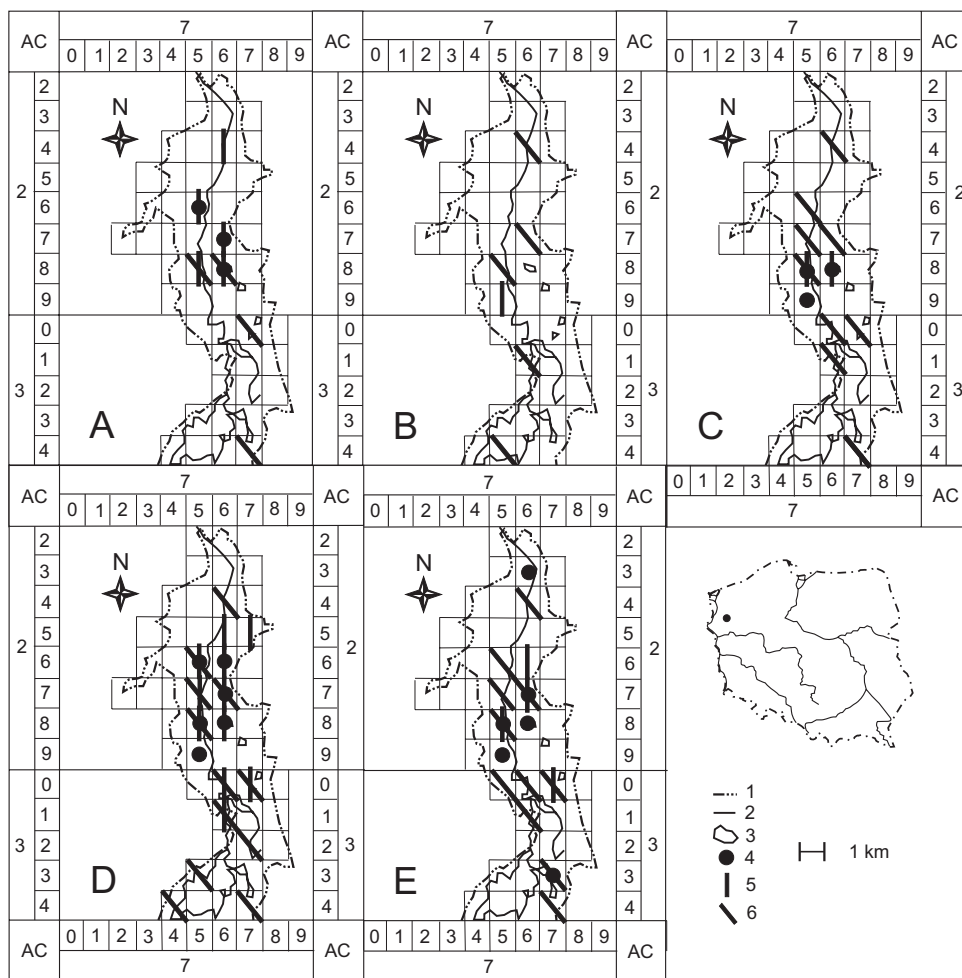


Fig. 3. Distribution maps of selected meadow plant species in the upper Płonia River Valley, with ATPOL grid square [41]; A – *Dactylorhiza incarnata* subsp. *incarnata*, B – *Dianthus superbus*, C – *Galium uliginosum*, D – *Juncus subnodulosus*, E – *Trollius europaeus*, F – *Valeriana dioica*.
 1 – border of study area, 2 – rivers, 3 – lakes, 4 – stations noted in present, 5 – stations noted by Bacieczko (1991-96), 6 – stations noted by Libbert (1930-41).

Rural Areas for 2007-13 seems to be particularly beneficial for endangered plant communities. A precise classification of valuable habitats and the necessary expert documentation and opinions will hopefully make it possible to assess true natural qualities of grasslands more accurately than before, and hence their protection and conservation will be more effective, as conservation-oriented tasks recommended for implementation in a habitat will have to be carried through [46].

Unfortunately, it is hardly expected that farmers in upstream Płonia Valley would mow very wet, unproductive meadows on steep relief. They do not have special mowing machinery and would have to mow by hand, which is not really an economic option. Without appropriate management a large part of the existing biodiversity in the abandoned peatlands will be lost in the near future. This situation can be solved through a buy-out and subsequent land consolidation by a nature-oriented organization. An international project between Poland and the Netherlands, "Multifunctional use of Polish Peatlands; A chance of preserving Biodiversity" (PIN/Matra), has been developed to strengthen nature conservation organizations. It focuses on sustainable preservation of biodiversity in landscape parks, which still have high biodiversity, but in contrast to national parks in Poland landscape park authority have no legal or financial means to impose appropriate management to maintain the existing biodiversity [47].

According to the PIN/Matra project, upstream areas of Płonia Valley peatlands will be bought for the Polish private nature conservation. The first task is to re-introduce sustainable management. A second priority is to take hydrological measures to stop the ongoing peat mineralization, eutrophication and soil degradation. Large-scale rewetting, by eliminating existing ditches, could be a productive way to conserve the peat. Increasing the water level in Miedwie and Płoń lakes with 1-1.5 meters is technically possible and historically justified. The necessity of supplying clean water for the city and the need to fulfill the obligations arising from the Water Framework Directive are acting as positive feedback in considering the scenarios of increasing lake levels and damming the upper courses of the Płonia River. The step-wise ponding of clean groundwater could eventually result in local restoration of peat- and travertine depositing conditions [28]. Within the project, it was proved that shallow peat extraction could be introduced as a new tool for restoring species-rich fens or wet meadows. Soil analysis has shown that topsoil removal has resulted in a considerable decrease of phosphorus (total P) and in mineral nitrogen (NO₃). If local target species and their seed banks have become extinct, introduction of fresh seeds from hay collected in well preserved hay meadows could be applied [48].

It is obvious that without sustainable economic activities it will not be possible to preserve all existing biodiversity in landscape parks. Some experiences from other countries in Europe could be applied in Poland. International cooperation provides excellent results in nature protection, including ecological restoration of wetlands.

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