

# Changes in Floristic Composition of Meadow Phytocenoses, as Landscape Stability Indicators, in Protected Areas in Western Lithuania

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## Abstract

Perennial vegetation is one of the most valuable ecological components when forming healthy living environments, natural and cultural landscape values, and general ecological stability, especially in protected areas. In various countries, increasing attention is being paid to research into biodiversity of meadow phytocenoses. Research in Western Lithuanian meadows was conducted from 2003 to 2006 with the aim to determine how the regime of management and different ecological conditions over several years influences floristic composition, frequency, and stability of meadow sward. Field sampling plots were set up on two semi-natural floodplain meadows in protected areas: in the meadow of the Minija mid-river banks (used for agricultural activities – grazing and cutting), and in the Veiviržas landscape reserve in the flood-meadow land (with no farming activities for the last ten years). The article discusses the relevance of the dominant species on the stability of phytocenoses. Each habitat was estimated for ecological conditions, i.e. soil moisture and vascular plant species indicating soil acidity.

**Keywords:** meadow, plant species, frequency, stability, ecological groups

## Introduction

Based on the European practice, landscape monitoring is going to be oriented toward analysis of ground cover. In landscape monitoring it is especially important to estimate not its individual components, but those characteristics of the landscape that describe it as a system. Each type of vegetation is a determined combination of certain abiotic landscape components [1-3]. Biodiversity plays an important role in the functioning of ecosystems [4, 5] since it increases likelihood of establishing new species resistant to various ecological factors and that can enhance the efficiency

of resource utilization [6]. Potential vegetation is a visual expression of edaphic conditions in the landscape [7].

During recent decades, human activities have resulted in significant changes in the biodiversity of perennial vegetation. As soon as human impact on the natural environment declines, the process of re-naturalization becomes more intensive. Meadow naturalness varies, and non-specific species of other ecosystems become established in Lithuania [8]. The major threat to some grasslands is posed by plant succession. An effective method of their protection is a return to traditional methods of farming, i.e. to moderate, alternate grazing or hay harvesting [9]. Changes in floristic composition over a short period of time in Slovenian grasslands in relation to different management practices were determined [10].

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Different phytocenoses form under different conditions of plant habitat. It becomes vital to search for effective methods to identify the anthropogenic effect, to estimate it and to alleviate its negative effect. One of the ways to achieve this is comprehensive research on phytocenoses. At present, new possibilities in Lithuania to preserve botanical diversity of the communities in the natural and restoring semi-natural meadows have appeared [8]. There is still a need for much more study. It is very important to conserve and enhance landscape character, to protect existing species-rich meadows. At present, only a few percent of meadows qualify as species-rich priority habitats within the Lithuanian Biodiversity Action Plan. Due to uncontrolled melioration and other negative processes during the time of the Soviet government, the number, size, and species diversity of semi-natural grasslands have dramatically declined in Lithuania. Floodplain vegetation is very sensitive to the annual variation of moisture and nutrient conditions, which causes fluctuations in the species composition of plant communities. Spatial processes and environmental control are the two distinct, yet not mutually exclusive, forces of community structuring [11].

The aim of the present study was to estimate the changes in functional trait composition of flooded meadow plant communities over 4-years in relation to management regimes and different edaphic conditions. The study areas with its environment is a distinctive standard for land use planning, trying not only to develop agricultural functions of the landscape, but also preserve the natural environment. Studies on naturalization and succession can to reveal the temporal and spatial changes in structure of meadow phytocenoses. A key challenge of conservation management in semi-natural grasslands is to find ecologically cost-effective management regimes that will maintain the ecological functionality and biodiversity of a community [12].

## Experimental Procedures

### The Object and Study Area

The objects of our research – semi-natural floodplain meadow communities in western Lithuania (Klaipėda district) in protected areas under Natura 2000 (landscape conservation area). Investigations on changes in meadow communities were carried out in 2003-04 and 2006. According to edaphic conditions, reflecting the complex feature of potential vegetation and relief-lithology types, the study area belonged to west Žemaičiai Plateau (south taiga shrubby spruce forests, *All. Piceion abietis*) and pine forests dominated by green mosses with elements of broad-leaved forests (*All. Dicrano-Pinion*, *All. Carpinion betuli*, *All. Alnion incanae*) [7]. To indicate the area of meadow communities the mapping and research data were digitized by computer program *ArcView GIS 3.0a* (Division of Cartography of the Landscape Geography and Cartography of the Institute of Geography of Lithuania).

There are two study objects, i.e. two meadows managed at different intensity and differing in ecological conditions.

Table 1. Agrochemical characteristics of the soil of meadows. Klaipėda, 2003-04, 2006.

Agrochemical parameters	Meadow of the Minija mid-river banks			Veiviržas floodplain meadow		
	Experimental year					
	2003	2004	2006	2003	2004	2006
pH <sub>KCl</sub>	5.4	6.0	5.4	6.7	6.9	6.9
P <sub>2</sub> O <sub>5</sub> (mg/kg)	57	37	35	98	102	99
K <sub>2</sub> O (mg/kg)	111	87	80	141	139	140
N <sub>total</sub> (%)	0.14	0.16	0.13	0.18	0.17	0.18

The first object was the floodplain meadow in the reserve of the Minija river valley (central coordinates: 55°73'33N; 21°43'11E). The following management practices are applied in this meadow: one grazing and one cutting per season annually. The meadow was managed more intensively until 1991: annually one grazing and two cuttings per season. The flooding effect manifests itself only in spring, continental features are specific to a meadow's grass cover. The area of the meadow is 1.82 ha. The soil (pH<sub>KCl</sub>) is somewhat acidic, with low phosphorus and potassium status. Moreover, a reduction in the contents of the main macro-elements were noted during the test period (Table 1).

The second study object was the conservation area of the Veiviržas River landscape in a meadow of 1.96 ha in size (central coordinates: 55°60'55N; 21°59'43E). Part of the meadow is regularly flooded in spring and autumn (flooding continuation is usually more than one-two weeks), the other part only in spring. However, during the dry period the soil dries off quickly, and the plant habitat is sunny and protected from winds. Ten years before the launch of the study and during the experimental period, no regular management activities were done on the meadow, the processes of naturalization are obvious here. Management of the meadow was regular until 1993: it was mown and hay removed. The reaction (pH<sub>KCl</sub>) of meadow soil is close to neutral, the soil is moderate in phosphorus and potassium contents and no marked variations in agrochemical characteristics were identified during the test period (Table 1).

The soil in both territories – *Endohypergleyi-Eutric Fluvisols (FLe-gln-h)*. Soil analyses were done using the following methods: pH<sub>KCl</sub> potentiometrically, available phosphorus and potassium by A-L technique, hydrolytic acidity after Kappen, total nitrogen – after Kjeldahl. Soil samples were taken from plant habitats' rhizosphere up to 20 cm depth and were analyzed at the Lithuanian Research Centre for Agriculture and Forestry Agrochemical Research Laboratory.

### Climatic Conditions

Mean air temperature during the intensive plant growth period (June, July and August 2003) was 16.9°C. However, in 2004 the mean air temperature for the same months was

15.8°C. 2004 saw 136.3 mm more rainfall than in 2003. During the most luxuriant growing of plants the mean amount of rainfall in 2003 was 79.1 mm, in 2004 61.9 mm. In 2006, high air temperature and a low amount of rainfall were recorded: during the plant growing season the mean air temperature exceeded the long-term mean by 0.4 to 3.5°C, and the amount of rainfall was markedly lower than the long-term mean. July was especially dry with a rate of rainfall as low as 4.3 mm. The weather conditions were described based on the data obtained from the Vėžaičiai weather station (Klaipėda district, Western Lithuania).

### Experimental Methods

The abundance of species of meadow communities and herb layer coverage were evaluated according to the J. Braun-Blanquet (1964) scale on the test plots [13]. The stability (frequency) of each species was expressed by a percentage of test plots. Five presence classes were distinguished:

- I – the species occurs in 1-20% of the plots tested,
- II – the species occurs in 21-40% of plots
- III – the species occurs in 41-60% of plots
- IV – the species occurs in 61-80% of plots
- V – the species occurs in 81-100% of plots

While making phytocenotic descriptions, the abundance of species and projective cover were assessed in experimental sites 1×1 m in size. In each meadow, 100 phytocenotic descriptions were made annually. Flora composition of the communities were registered in July. Plant ecological groups, depending on the demand for soil moisture, acidity, and nutrients were distinguished according to Ellenberg's scale [14].

Coefficient of dominance (CDD), which is inversely proportional to the number of species identified, is provided [15].

The following additional calculations were made to estimate the changes in the structure of meadow phytocenoses [2]:

Shannon-Wiener Index:

$$H' = -\sum (P_i \times \ln P_i) \quad (1)$$

$P_i$  – proportional abundance of the  $i$ -th taxa

Evenness:

$$J = H / \ln S \quad (2)$$

$S$  – number of species

Number of equally common species:

$$N_1 = 2^H \quad (3)$$

To estimate plant species changes according to different ecological factors we calculated the Fisher  $\alpha$  index:

$$N/S = (e^{S/\alpha} - 1) \times (S/\alpha) \quad (4)$$

$N$  – number of individuals,  $S$  – number of species.

The experimental data were processed by ANOVA and correlation-regression analysis methods [16]. The symbols

used in the paper: \* significant at  $P < 0.05$ , and \*\* significant at  $P < 0.01$ .

## Results and Discussion

### Plant Species Diversity and Distribution

The experimental evidence suggests that the meadows managed at various intensities and characterized by different ecological conditions had a diverse structure of phytocenoses and different frequency and stability of species, although a similar number of vascular plant species composing phytocenoses was recorded. In total, we identified 39 herbaceous plant species in the meadow of the Minija mid-river banks. The species diversity is greater there compared with hilly regions' meadows. In Slovakia, the tests were done annually in a similar meadow (*Festuco-Cynosuretum* association) and managed at a medium intensity during the period 1993 to 2002 showed that there were identified on average 25 vascular plant species, with *Dactylis glomerata* L. being the dominant one [1]. An average species richness in differently managed floodplain meadows in southwestern Estonia (in Soomaa National Park) varied between 28 and 36 species. The Estonian researchers observed a significant overall change in richness over the years ( $P=0.009$ ), and a significant interaction between the year and the treatment ( $P=0.0012$ ). Species richness fluctuated in unmanaged plots, while all cut plots saw a significant increase in species richness [12]. We observed changes in plant richness over the years too. The largest number of species – 33 – was identified in the meadow of the Minija mid-river banks in 2006. It is noteworthy that during the experimental period we did not find any common for the whole association dominant or subdominant, only minor species. An especially low projective cover (“r”; “+”; “1” according to the Braun-Blanquet scale) was recorded for all species, as well as other indicators on which community stability depends (Table 2). *Achillea millefolium* L., *Anthoxanthum odoratum* L., *Briza media* L., *Dactylis glomerata* L., *Festuca pratensis* Huds., and *Leucanthemum vulgare* Lam. can be partly considered as species forming the phytocenose. The distribution of these herbaceous plant species in the phytocenoses did not vary during the test period. Having determined floristic composition of this habitat and having identified diagnostic species, we could distinguish *Achillea millefolium* + *Anthoxanthum odoratum* + *Agrostis stolonifera* association. Our experimental evidence indicates a low species stability in the phytocenose: on average 90% of all species were attributed to stability class I, i.e. they were found in not more than 20% of the plots tested. Moreover, reduction of frequency and stability of the species *Achillea millefolium* L., *Agrostis stolonifera*, *Anthoxanthum odoratum* L., *Briza media* L., and *Dactylis glomerata* L. was recorded during the test period (Table 2). Intensity of meadow succession depends on the character of grassland management. Positive correlation between the number of vascular plant species and meadow age revealed that botanical diversity in

Table 2. Species diversity and distribution in the meadow of the Miniņa mid-river banks. Klaipėda, 2003-04, 2006.

No.	Plant species	Abundance (coverage according to Braun-Blanquet scale)			Frequency, %			Presence class		
		Experiment year								
		2003	2004	2006	2003	2004	2006	2003	2004	2006
1.	<i>Achillea millefolium</i> L.	1	1	1	70	40	25	IV	II	II
2.	<i>Agrostis canina</i> L.	1		1	35		10	II		I
3.	<i>Agrostis stolonifera</i> L.		1	1		35	10		II	I
4.	<i>Agrostis tenuis</i> Sibth.			+			5			I
5.	<i>Alchemilla xanthochlora</i> Rothm.	r	+	+	5	5	5	I	I	I
6.	<i>Alopecurus pratensis</i> L.		1	1		10	15		I	I
7.	<i>Anthoxanthum odoratum</i> L.	1	1	1	40	30	15	II	II	I
8.	<i>Anthylis vulneraria</i> L.		+	1		5	15		I	I
9.	<i>Briza media</i> L.	1	1	1	30	20	15	II	I	I
10.	<i>Campanula rotundifolia</i> L.		1			10			I	
11.	<i>Carex disticha</i> Huds.			+			5			I
12.	<i>Cerastium holosteoides</i> Fr.				5			I		
13.	<i>Cirsium arvense</i> (L.) Scop.	r			5			I		
14.	<i>Cynosurus cristatus</i> L.			r			5			I
15.	<i>Dactylis glomerata</i> L.	1	1	1	25	10	20	II	I	I
16.	<i>Deschampsia cespitosa</i> (L.) P. Beauv.	+	1	1	10	10	25	I	I	II
17.	<i>Elytrigia repens</i> (L.) Nevski		+	1		5	20		I	I
18.	<i>Equisetum arvense</i> L.	+		+	10		5	I		I
19.	<i>Festuca pratensis</i> Huds.	1	1	1	40	10	15	II	I	I
20.	<i>Galium mollugo</i> L.	1	1	+	25	10	5	II	I	I
21.	<i>Helictotrichon pubescens</i> (Huds.) Pilg.	1	+	+	20	5	5	I	I	I
22.	<i>Lathyrus pratensis</i> L.	r	1	+	10	10	5	I	I	I
23.	<i>Leontodon autumnalis</i> L.		1	+		25	5		II	I
24.	<i>Leucanthemum vulgare</i> Lam.	1	1	1	15	20	10	I	I	I
25.	<i>Lychnis flos-cuculi</i> L.		+			5			I	
26.	<i>Medicago falcata</i> L.			+			5			I
27.	<i>Phleum pratense</i> L.	1	1	+	25	15	5	II	I	I
28.	<i>Plantago lanceolata</i> L.		1	1		10	10		I	I
29.	<i>Poa palustris</i> L.	+			10			I		
30.	<i>Poa pratensis</i> L.	1		1	15		20	I		I
31.	<i>Potentilla anserina</i> L.			+			5			I
32.	<i>Ranunculus acris</i> L.	+	1	+	10	15	5	I	I	I
33.	<i>Rumex acetosella</i> L.	1	1		40	15		II	I	
34.	<i>Taraxacum officinale</i> F. H. Wigg.	+	1	1	10	25	10	I	II	I
35.	<i>Trifolium dubium</i> Sibth.			1			15			I
36.	<i>Trifolium pratense</i> L.			1			10			I
37.	<i>Trifolium repens</i> L.	r	1	1	5	15	15	I	I	I
38.	<i>Veronica chamaedrys</i> L.	1	1	+	45	15	5	III	I	I
39.	<i>Vicia cracca</i> L.		1	+		10	5		I	I

extensively used grassland restores much faster than under intensive management conditions [8].

In the Veiviržas floodplain meadow, in unmanaged sites, we inventoried 37 vascular plant species during the test period (2003-04, 2006), i.e. a little less than in the managed meadow of the Minija mid-river banks. However, Finnish researchers observed, that the number of plant species and seedlings per plot were smaller in grazed sites than in ungrazed or in meadows without any management [17]. In this phytocenose, like in the meadow of the Minija mid-river banks, we recorded an increase in the number of species annually: in 2003 27, in 2004 32, and in 2006 35 herbaceous vascular plant species. The plants belonging to the *Asteraceae* and *Poaceae* families prevailed. Unlike in the above-described phytocenose, in the Veiviržas floodplain meadow there were distinguished phytocenose-forming dominant species: *Dactylis glomerata* L., *Galium rivale* (Sibth. et Sm.) Griseb., *Agrostis tenuis* Sibth., *Calamagrostis epigeios* (L.) Roth., and *Vicia cracca* L. Similar dominant species were identified in 2001 during monitoring of meadow vegetation: in most sites of the Nemunas floodplain meadows in Central Lithuania, where ecological conditions were similar to those recorded in the meadow investigated by us (but with a more intensive management), the group of abundantly growing species was composed of *Galium rivale* (Sibth. et Sm.) Griseb., *Poa pratensis* L., *Vicia cracca* L., *Deschampsia cespitosa* (L.) P. Beauv., *Carex disticha* Huds., *Festuca pratensis* L., and others [8, 17]. *Dactylis glomerata* L. was a differential species distinguishing the phytocenose of the Veiviržas floodplain meadow. This species was moderately frequently found also in the meadow of the Minija mid-river banks. Having assessed the abundance of plant species in the Veiviržas floodplain meadow and having established their diagnostic groups, we can distinguish *Dactylium glomeratum* fac. *Galium rivale* phytocenose. In this phytocenose, *Galium rivale* (Sibth. et Sm.) Griseb., together with *Vicia cracca* L. forms a uniform, dense sward. The community type in which not one or two but many dominating species are encountered, which was the case in the meadow of Veiviržas landscape reserve, is specific to *Helictotricho pubescentis-filipenduletum vulgare* community. It is a community that is common on the higher levels of floodplains. In Lithuania they are most common in the Western part – in the Minija and Venta floodplains. The communities are related to steppe *Festuco-Brometea* class meadows. The group of accompanying species is rather large, *Achillea millefolium* L., *Briza media* L., *Leucanthemum vulgare* Lam., *Knautia arvensis* (L.) Coult., *Rumex acetosella* L. are more abundant and stable [17]. *Peucedanum oreoselinum* (L.) Moench grows abundantly in summer. These communities are interesting from the environmental protection viewpoint, some of the species found in them are included into the Red Book of the Republic of Lithuania. One of the distinctive features of a phytocenose is the stability of different species in it [8]. The estimated plant species frequency and stability classes showed that in both meadows tested the prevailing species were those belonging to stability class I (Tables 2, 3). These species do not have any special significance for quantitative

structure but community diversity depends on them. While estimating species stability, we did not consider whether there were many individuals of the species or few. Having estimated species stability there were distinguished species dividing groups of plots. The highest stability classes – III, IV – during the experimental period were recorded only for the species dominating the phytocenoses (Table 3).

In the meadow of the Minija mid-river banks the average dominance coefficient of plant species (CDD) was 0.9, whereas in the Veiviržas floodplain meadow the number was 1.24. The number of species and coefficient of dominance (CDD) show the general level of intensification. The coefficient of dominance is higher where there are one or two main species. The high diversity of plant species of natural meadows and low coefficient of dominance suggests that meadows are used extensively [18].

Community stability results show that in the Veiviržas floodplain meadow the stability of the sward declines annually. Low-value plants (*Urtica dioica* L., *Lysimachia nummularia* L., *Leucanthemum vulgare* Lam., and other species) increasingly being established in the sward indicate the beginning of sward degradation. However, various successions and fluctuations are characteristic for the populations. There may be five-fold plant population abundance dynamics:

- 1) the abundance of populations declines annually and reaches a critical limit
- 2) the abundance of populations declines for several years then stabilizes, and then declines again
- 3) the abundance of populations pulsates – increases, declines, etc.
- 4) the abundance of populations increases due to intensive particulation, then sharply declines and remains such for many years
- 5) the abundance of populations varies only insignificantly for many years [2, 8, 19, 20].

Under normal conditions, all populations are subject to some fluctuation, which affects stability variation, and rapid successions are specific only to the populations in stressful situations or peculiar ecological conditions [21, 22]. Insufficient management in the meadow was responsible for more rapid sward variations. Similarly to Liira et al. [12], we realized that changes in plant communities after regular management were slow. Species with low canopy height (rosette species) were vulnerable to accumulation of litter on the ground. Cutting and grazing resulted in a higher proportion of grasses, while unmanagement favored more forbs.

The Shannon-Wiener Index was higher in the Veiviržas flood-meadow than in the meadow of the Minija mid-river banks as a result of increased evenness. This conclusion also is supported by higher numbers of the equally common species (Table 4).

#### Plant Species Distribution According to Soil Properties

Species of meadow grasses could grow according to their ecological properties and often they prevail not in places whose conditions are best-suited for them [20]. First of all, plants experience the effects of soil ecological factors,

Table 3. Species diversity and distribution in the Veiviržas floodplain meadow. Klaipėda, 2003-04, 2006.

No.	Plant species	Abundance (coverage according to Braun-Blanquet scale)			Frequency, %			Presence class		
		Experiment year								
		2003	2004	2006	2003	2004	2006	2003	2004	2006
1.	<i>Achillea millefolium</i> L.			r			2			I
2.	<i>Aegopodium podagraria</i> L.	3	3	3	32	34	34	II	II	II
3.	<i>Agrostis tenuis</i> Sibth.	3	3	3	41	43	40	III	III	III
4.	<i>Alchemilla acutiloba</i> Opiz.			r	7	8	1	I	I	I
5.	<i>Artemisia campestris</i> L.	3	3	3	30	31	32	II	II	II
6.	<i>Asarum europaeum</i> L.	r	r	-	2	2	1	I	I	I
7.	<i>Calamagrostis epigeios</i> (L.) Roth	4	4	4	42	43	40	III	III	III
8.	<i>Centaurea scabiosa</i> L.	r	r	r	1	1	2	I	I	I
9.	<i>Conyza canadensis</i> (L.) Cronquist	r	r		1	1		I	I	
10.	<i>Dactylis glomerata</i> L.	5	5	5	63	72	70	IV	IV	IV
11.	<i>Equisetum arvense</i> L.		+	+		4	4	-	I	I
12.	<i>Galium rivale</i> (Sibth. et Sm.) Griseb.	4	4	4	48	49	51	III	III	III
13.	<i>Glechoma hederacea</i> L.	r	r	r	24	22	9	II	II	I
14.	<i>Helichrysum arenarium</i> (L.) Moench	r	r	r	2	1	1	I	I	I
15.	<i>Knautia arvensis</i> (L.) Coult.	r	r	r	3	3	1	I	I	I
16.	<i>Leucanthemum vulgare</i> Lam.			r			1			I
17.	<i>Lychnis flos-cuculi</i> L.	3	3	3	22	23	23	II	II	II
18.	<i>Lysimachia nummularia</i> L.	+	+	r	5	5	3	I	I	I
19.	<i>Medicago falcata</i> L.		r	r		1	1		I	I
20.	<i>Melampyrum nemorosum</i> L.		r	r		2	1		I	I
21.	<i>Peucedanum oreoselinum</i> (L.) Moench	1	1	2	8	6	7	I	I	I
22.	<i>Pimpinella saxifraga</i> L.	3	3	3	25	26	29	II	II	II
23.	<i>Poa pratensis</i> L.	1	1	1	24	25	23	II	II	II
24.	<i>Polygonum persicaria</i> L.	r	r	r	1	1	1	I	I	I
25.	<i>Potentilla arenaria</i> Borkh.			r			1			I
26.	<i>Prunella vulgaris</i> L.		+	+		4	2		I	I
27.	<i>Ranunculus repens</i> L.	r	r	+	12	12	13	I	I	I
28.	<i>Rumex acetosella</i> L.			+	-	-	1	-	-	I
29.	<i>Silene dioica</i> (L.) Clairv.	r	r	r	1	1	1	I	I	I
30.	<i>Silene vulgaris</i> (Moench) Garcke	r	r	r	1	2	1	I	I	I
31.	<i>Solidago virgaurea</i> L.	r	r	r	1	1	1	I	I	I
32.	<i>Tanacetum vulgare</i> L.	r	r	r	3	3	2	I	I	I
33.	<i>Trifolium campestre</i> Schreb.			+			1			I
34.	<i>Trifolium medium</i> L.	+	+	+	4	5	6	I	I	I
35.	<i>Urtica dioica</i> L.	1	1	1	27	29	31	II	II	II
36.	<i>Vicia cracca</i> L.	3	3	2	43.	42	35	III	III	II
37.	<i>Vicia dumetorum</i> L.	r	r	r	1	2	1	I	I	I

Table 4. The variation of the main parameters of meadow phytocenoses.

Parameters	Meadow of the Minija mid-river banks			Veiviržas floodplain meadow		
	Experiment year					
	2003	2004	2006	2003	2004	2006
Total number of species	23	26	33	27	32	35
Shannon-Wiener Index $H'$	2.10	2.04	2.19	2.28	2.72	2.48
Evenness $J'$	0.74	0.69	0.70	0.75	0.88	0.76
Number of equally common species $N_1$	4.30	4.12	4.56	5.55	6.23	7.68

climate, and orographic environment. Correlations between ecological indicators and phytocenotic variability in *Molinion* meadows were evaluated in Kampinoski National Park in Poland. Unmanaged meadows were compared to meadows in which meadow conservation management practices were carried out [23]. In the meadow of the Minija mid-river banks and the Veiviržas floodplain meadow, having estimated the distribution of the inventoried vascular plants in the habitats, we determined species distribution according to the demand for moisture, soil acidity, and nutrient content. It was found that in the meadow of the Minija mid-river banks, 57-58% of all vascular plants were mesophyte species. Hygrophytes and xeromesophytes made up 15-17% and 9-13%, respectively. We identified on average 15% of plant species for which moisture is not an influencing factor. As seen from the statistical data analysis, the distribution of plant species in this phytocenoses depended on moisture conditions by 59%:

$$y = -1.7174x^2 + 21.315x - 44.809; r = 0.775^{**}, \alpha = 2.092$$

In the Veiviržas floodplain meadow mesophyte plants also prevailed (40-50%). However, and xeromesophytes accounted for a much larger share (28-38%) than in the above-discussed phytocenose, hygrophytes, xerophytes, and plant species for whom moisture is not an influencing factor were not abundant. It is noteworthy that in 2006 in this phytocenose we identified 1.3 times more xeromesophyte species, and a slight increase in xerophyte percentage share compared with the previous experimental years. This might have been influenced by the apparent shortage of moisture during the growing season in 2006. A significant relationship was established between plant species distribution and soil moisture:

$$y = 8.4236x^2 - 14.2936x + 20.412; r = 0.851^*, \alpha = 2.384$$

Hölzel and Otte showed that the majority of floodplain meadow resident species need simultaneously light and high moisture for germination and establishment [24]. Research in the grasslands in the Kulawa River valley in Poland showed that the patches growing on relatively dry, strongly decomposed peaty soil have lost the characteristics of damp meadows. Meadow species have declined there, and nitrophilous species have replaced them [25]. In respect to preferences for soil moisture, some species occurring in

fresh soils prevail [26]. The high floristic diversity of plant communities as well as the natural value of meadows in periodically excessively wet sites in Poland was achieved thanks to their extensive and sustainable utilization [27].

Most meadow grasses can normally grow in the soils having rather different pH indicators; however, the maximum number of species occurs only at optimal pH. Since soil reaction ranging from 5.0 to 7.5 is suitable for most of the grasses, their uneven distribution in the phytocenoses can be explained by the indirect soil reaction effect and resulting changes in other growing conditions, primarily nutrition [20]. For the majority of plants (64-65%) in the meadow of the Minija mid-river banks, soil acidity was a non-influencing factor, 22-31% of plant species were attributed to a neutrophilic plant group, and acidophils and basophils were identified in small numbers. However, in the Veiviržas floodplain meadow neutrophils were the prevalent group, and the number of plant species attributed to this ecological group did not change during the experimental period. A large part of plant species are attributed to the group of plants indifferent to soil acidity. A moderately strong correlation  $r = 0.455^{**}$  was found between the occurrence of plant species and soil acidity ( $\alpha = 1.646$ ).

Biodiversity of meadows and sward productivity are highly dependent on the content of mineral nutrients in the habitat too [1, 20]. In English Environmentally Sensitive Areas, species-rich grassland was overwhelmingly found on soil with an available phosphorus status that is low to very low by agricultural standards [28]. Our experimental evidence suggests that both meadows were dominated by plants indicating moderate soil productivity, i.e. mesotrophs. Together with mesooligotrophs they accounted for on average 37% of the inventoried plant species in the meadow of the Minija mid-river banks and for 52% in the Veiviržas flood-meadow. During the test period the number of these plant groups slightly declined, but the number of other plant groups increased. A strong correlation was established between the number of plant species in the meadow of the Minija mid-river banks and in the Veiviržas flood-meadow and nutrient content in the soil:

$$y = -12.250x + 52.428; r = 0.676^{**}, \alpha = 2.055$$

and

$$y = 3.67 - 0.05x_1 + 0.04x_2 + 0.0001x_3^2; r = 0.625^{**}, \alpha = 1.988,$$

respectively.

In summary, we can assert that quantitative and qualitative parameters of meadow phytocenoses are determined by the species composition of the sward, meteorological conditions, and edaphic and moisture conditions of the habitats [8]. Herbaceous vegetation is one of the most sensitive indicators of landscape changes [17, 29]. Species especially susceptible to the anthropogenic effect become extinct as well as those adapted to growing in the ecological conditions of a narrow range. In the differently managed meadows, plants adjust to the method of management. Late-flowering weeds propagating by seed are disappearing from cut meadows. Favorable conditions are created for growth of all grasses and legumes that suppress the short-growing plants. When the meadow is regularly cut, early-maturing plant species (*Rhinanthus*, *Ranunculus*, and others) can spread during the flowering of the main grasses, or late, maturing in the autumn after cutting (*Geranium*, *Odontites*, *Centaurea*). In grazed meadows, grasses are often cropped, trampled, and damaged. The content of tall-growing grasses and forbs that re-grow more poorly declines. Better-growing are short grasses and legumes as well as short forbs (*Taraxacum*, *Plantago*, *Achillea*). If the sward is grazed too intensively, the content of these forbs markedly increases. The obtained results are significant from the standpoint of theoretical estimation of meadow naturalization. Research data allow us to suggest autochthonous plant species for stable grassland formation corresponding to habitat diversity in protected areas.

### Conclusions

Development of meadow communities depends upon grassland flora composition and edaphic conditions of the habitats. In the Veiviržas floodplain meadow (no management practices applied), richer in nutrients and of lower acidity, the following diagnostic species forming phytocenose were distinguished: *Dactylis glomerata* L., *Galium rivale* (Sibth. et Sm.) Griseb., *Agrostis tenuis* Sibth., *Calamagrostis epigeios* (L.) Roth., and *Vicia cracca* L. These species were characterized by high frequency and stability in the community. However, in the soil with a lower nutrient status and higher acidity in the meadow of the Minija mid-river banks (management practices applied), only minor and rare species characterized by low frequency and stability were identified.

During the experimental period, in the Veiviržas floodplain meadow there were recorded low-value by agricultural standards but ecologically rather significant indicators of community naturalness – an increase in herbaceous plant species. No such changes were identified in the meadow of the Minija mid-river banks.

Mesophytes accounted for about 50% of all vascular plant species in the communities. A significant correlation was determined between the distribution of plant species and soil moisture in the meadow of the Minija mid-river banks and the Veiviržas floodplain meadows:  $r=0.775^{**}$  and  $r=0.851^{*}$ , respectively. In terms of soil acidity, indifferent species prevailed in the meadow of the Minija mid-

river banks, while neutrophyles indicating neutral soil prevailed in the Veiviržas floodplain meadow. Representatives from all major trophic groups were recorded in the meadows tested, although in the meadow of the Minija mid-river banks mesotrophs-mesooligotrophs and indifferent species prevailed, and in the Veiviržas floodplain meadow mesotrophs – mesooligotrophs accounted for over 50% of all plant species.

### References

- BRITAKAN N., ILAVSKA I., HANZES L., LIPTAK L. Changes in botanical composition of permanent and temporary grasslands. *Grassland Science in Europe*. **12**, 378, **2007**.
- MORAVEC J. Phytocenosis. Prague, 404, **2000** [In Czech].
- KHAJEDDIN S.J., YEGANEH H. Plant communities of the Karkas hunting-prohibited region, Isfahan-Iran. *Plant Soil Environ.*, **54**, (8), 347, **2008**.
- TILMAN D., DOWNING J. A. Biodiversity and stability in grasslands. *Nature*. **367**, 363, **1994**.
- TILMAN D., WEDLIN D., KNOPS J. Productivity and sustainability influenced in grassland ecosystems. *Nature*. **379**, 718, **1996**.
- CHAPIN F.S., WALKER B.H., HOBBS R.J., HOOPER D.U., LAWTON J.H., SALA O.E., TILMAN D. Biotic control over the functioning of ecosystems. *Science*. **277**, 500, **1997**.
- ŠIMANAUSKIENĖ R. Morphology of landscape biota territorial structure (on the example of Lithuanian territory). *The Geographical Yearbook*, **38**, (2), 24, **2005**.
- SENDŽIKAITĖ J., PAKALNIS R. Extensive use of sown meadows – a tool for restoration of botanical diversity. *Journal of Environmental Engineering and Landscape Management*. **14**, (3), 149, **2006**.
- PRAJS B., ANTKOWIAK W. Grassland ecosystems in the varied hydrological and ecological conditions of the Kulawa River valley. *Pol. J. Environ. Stud.* **19**, (1), 131, **2010**.
- VIDRIH M., ČOP J., TRDAN S., ELER K. Changes in floristic composition over three years of Ljubljana marsh grassland in relation to cutting and fertilizing management. *Acta Agriculturae Slovenica*. **93**, (2), 193, **2009**.
- LI Q., YANG X., SOININEN J., CHU C. J., ZHANG J. Q., YU K. L., WANG G. Relative importance of spatial processes and environmental factors in shaping alpine meadow communities. *Journal of Plant Ecology*. **3**, 132, **2011**.
- LIIRA J., ISSAK M., JÖGAR Ü., MÄNDAJA M., ZOBEL M. Restoration management of a floodplain meadow and its cost-effectiveness – the results of 6-year experiment. *Ann. Bot. Fennici*. **46**, 397, **2009**.
- BRAUN-BLANQUET J. Phytosociology. The study of plant communities. Wien-New York, pp. 12-28, **1964** [In German].
- ELLENBERG H. Indicator values of plant species (without *Rubus*). *Scripta Geobotanica*. **18**, 258, **1992** [In German].
- PEETERS A. Advanced technology, vegetation and the nutrition quality of grasses: investigation of interaction in grassland systems. Doctoral thesis, Catholic University of Leuven, Louvain-la-Neuve, **287**, **1989** [In French].
- CLEWER A.G., SCARISBRICK D.H. Practical statistics and experimental design for plant and crop science. New York, pp. 5-45, **2001**.
- JUTILA H. M. Germination in Baltic coastal wetland meadows: similarities and differences between vegetation and seed bank. *Plant Ecol.* **166**, (2), 275, **2003**.

18. PEETERS A., LAMBERT J. Agricultural application of a typology of intensively managed pastures. *Fourrages*. **124**, 357, **1990** [In French].
19. PANCEKAUSKIENĖ D. Longevity of perennial sown grasslands as a condition for sustainable cultivation of meadows. International conference "Sustainable development in the Information Society". Abstracts of communications, Vilnius, **62**, **2000**.
20. HOFMAN M., KOWARSCH N., BONN S., ISSELSTEIN J. Management for biodiversity and consequences for grassland productivity. *Grassland Science in Europe*. **6**, 113, **2001**.
21. KULAKOVSKAJA T., LAIDINEN G., LARIONOVA N., Stability of perennial grasses in sown swards on the ameliorated lands. *Grassland Science in Europe*. **12**, 130, **2007**.
22. LAPINS D., TURKA I. Criteria of sustainable agriculture. Scientific Aspects of Organic Farming. Proceedings of the conference held in Jelgava, Latvia, March 21-22, Jelgava, **7**, **2002**.
23. KAÇKI Z., MICHALSKA-HEJDUK D. Assessment of biodiversity in *Molinia* Meadows in Kampinoski national park based on biocenotic indicators. *Pol. J. Environ. Stud.* **19**, (2), 351, **2010**.
24. HÖLZEL N., OTTE A. Ecological significance of seed germination characteristics in flood-meadow species. *Flora*. **199**, 24, **2004**.
25. PRAJS B., ROGALSKI M., SOTEK Z., STASIŃSKA M. Xerothermic Grassland Communities of the Alliance *Cirsio-Brachypodium pinnati* Hadac et Klika 1944 em. Krausch 1961 in Northwestern Poland. *Pol. J. Environ. Stud.* **19**, (1), 141, **2010**.
26. STEPIEŃ E. Changes of meadow flora species in area of Cedyński landscape park. *Pol. J. Environ. Stud.* **18**, (6), **2009**.
27. KRYSZAK A., KRYSZAK J. Utilization of excessively wet meadows and protection of their diversity. *Grassland Science in Europe*. **11**, 481, **2006**.
28. CRITCHLEY C. N. R., CHAMBERS B. J., FOWBERT J. A., BHOGAL A., ROSE S. C., SANDERSON R. A. Plant species richness, functional type and soil properties of grasslands and allied vegetation in English Environmentally Sensitive Areas. *Grass and Forage Science*. **57**, 82, **2002**.
29. SUSAN F., ZILIOTTO U. Estimating floristic richness of pastures using indicator species: a study case in the Dolomitic area. *Grassland Science in Europe*. **11**, 805, **2006**.

