Acta Agrobotanica

DOI: 10.5586/aa.1689

Publication history
Received: 2015-11-26
Accepted: 2016-08-20
Published: 2016-11-15

Handling editor
Piotr Sugier, Faculty of Biology and Biotechnology, Maria Curie-Skłodowska University, Poland

Authors' contributions
MK, RB: idea of the study; MK, RB, MW: writing the manuscript; MK, RB, ESK: field research; MK: statistical analysis; MK: improving the final version of the manuscript

Funding
Research supported by the Ministry of Science and Higher Education of Poland as a part of the statutory activities of the Department of Grassland and Landscape Forming, University of Life Sciences in Lublin.

Competing interests
No competing interests have been declared.

Citation
Kulik M, Baryła R, Warda M, Stamirowska-Krzaczek E. Vegetation changes of the *Molinio-Arrhenatheretea* class in the Bystra valley, eastern Poland. Acta Agrobot. 2016;69(4):1689. http://dx.doi.org/10.5586/aa.1689

ORIGINAL RESEARCH PAPER

Vegetation changes of the *Molinio-Arrhenatheretea* class in the Bystra valley, eastern Poland

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Abstract
The study objective was to analyze and assess the vegetation changes of the meadows (*Molinio-Arrhenatheretea* class) located in the valley of the Bystra River in eastern Poland after a period of 38 years, and to identify the direction of plant communities succession. The studies were conducted in the years 1973 and 2011 on grasslands belonging to farmers. The floristic diversity was identified based on the phytosociological structure and mean number of species calculated based on the number of species in the particular relevés of the phytocenosis under study. The highest frequency of occurrence was demonstrated by the *Poa pratensis-Festuca rubra* community within which more than half of the patches persisted over the 38-year period. New communities (*Scirpetum sylvatici*, *Alopecuretum pratensis*, *Lythro-Filipenduletum*) appeared after the withdrawal of habitats of the *Phragmitetea* class, due to the lowering of the groundwater level. A portion of the meadows and pastures were transformed into arable fields, gardens or building plots. Among ecological indicators, the greatest differences were observed in the mean soil moisture values between the two years compared, both for all meadows and the predominant community, which indicates an increase in habitat humidity.

Keywords
Bystra valley; *Molinio-Arrhenatheretea*; meadow; vegetation changes

Introduction

The valleys of rivers and smaller streams are an integral feature of agricultural landscape. They are characterized by varied habitat conditions both in terms of water content and fertility of the soil, which is reflected in the diversity of semi-natural communities occurring there. Most of them were or still are used agriculturally, mainly by cutting and, to a lesser extent, grazing of animals. Besides the habitat conditions, both the manner and intensity of land use have an impact on the persistency and floristic diversity of these communities. Interference with the habitat conditions – through regulating the hydrologic regime, limiting the intensity of use or its abandonment – leads to changes in the species composition and size of the area covered by plant communities [1–3]. Modern agricultural trends result in increasing the area of land excluded from use, including grassland [4]. The discontinuation of the use of meadow communities leads to their fast degradation [5] and frequently irreversible habitat changes [6–8]. Due to draining and land use changes, many habitats situated in river valleys in Poland have been subject to considerable transformation resulting in the extinction of certain plant species and disappearance of the previously occurring plant communities [9,10]. Development of meadow communities depends upon

flora composition and edaphic conditions of the habitat [2]. Herbaceous vegetation is also one of the most sensitive indicators of landscape changes [11]. One of the areas subjected to various changes is the valley of the Bystra River, a right-hand tributary of the Vistula, flowing across the Lublin Upland in eastern Poland and emptying into the Małopolska Vistula Gap at Bochotnica [12]. The aim of the study was to (***i***) analyze the vegetation changes of the *Molinio-Arrhenatheretea* class in the valley of the Bystra River in eastern Poland after a period of 38 years and to (***ii***) identify the direction of plant communities succession.

Material and methods

Characteristics of the Bystra catchment

The Bystra River starts in Czesławice (vicinity of Nałęczów) and flows from the east to the west, emptying into the Vistula at Bochotnica (downstream from Kazimierz Dolny) in eastern Poland (Fig. 1). It is fed by several streams, the largest of which is the Czerka River. The Bystra catchment, covering about 299 km^2, encompasses the eastern part of the Kazimierz Plateau composed of Cretaceous rocks covered by post-glacial materials (sands and gravels as well as layered clays) of varying thickness, overlain by a loess layer [13]. The thickness of the loess cover depends on the intensity of erosion that commonly occurs in the Bystra catchment [14]. A large network of gullies dissecting both sides of the Bystra valley are a characteristic feature of the catchment [13].

Most of this area is used agriculturally (about 90%, including 1.6% of grasslands), while the remainder is covered by forests and shrubbery. Erosion causes the accumulation and sedimentation of soil material, which results in the formation of alluvial soils. Alluvial fans develop at the mouths of the gullies (the sediment layer is up to 100 cm thick) and, in some places, constitute a barrier along the river channel, thus restricting the free drainage of flood waters, which causes the periodic or permanent paludification of the valley below them. The hydrologic regime in the valley is also shaped by processes of bottom and riverbank erosion. The Bystra has high gradients (up to 3%) in its upper and lower reaches and a lower gradient (1%) in its middle reaches where engineering works were carried out (mainly straightening of the river channel) aimed at accelerating the drainage of flood waters. This has resulted in increased intensity of river bottom erosion, controlled by damming facilities that were damaged by flood waters [13,14]. The biological structure in the form of *Salix* species occurs along most stretches of the river, which considerably reduces bottom erosion, particularly along the previously straightened stretches of the river channel [15]. The course of the river and layout of the valley bottom are characteristic of typical lowland rivers. The meadows in this valley are frequently flooded both during spring thaw and after heavy rainfall in the summer. The groundwater level varies, which has an impact on the plant communities.

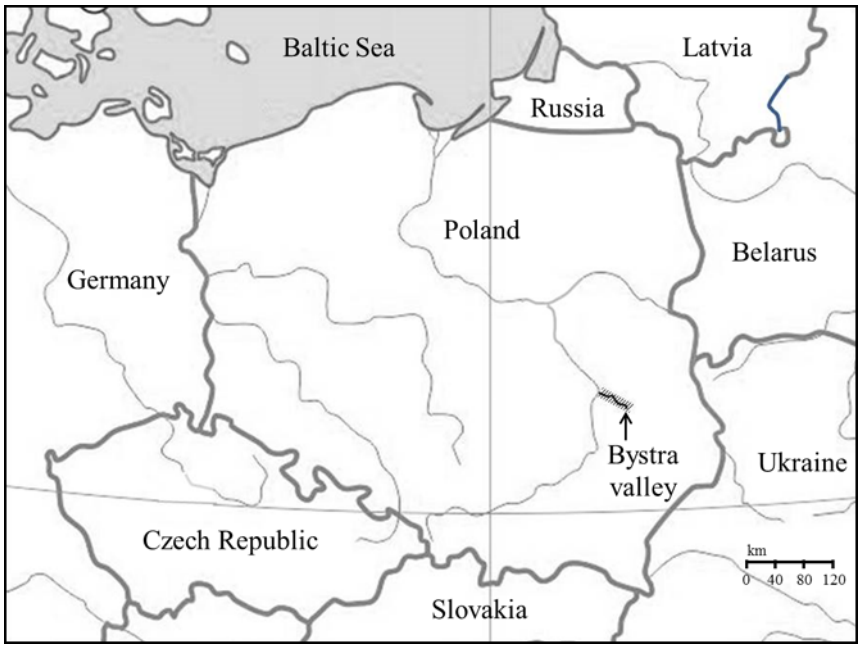

Fig. 1 Study area.

Field study

The studies were conducted in the years 1973 and 2011 in the valley of the Bystra River, on grasslands with an area of approx. 20 ha belonging to farmers from the following localities: Nałęczów (2.45 ha), Łąki (2.66 ha), Wąwolnica (4.90 ha), Mareczki (3.04 ha), Rogalów (2.33 ha), Zawada (1.55 ha), and Bartłomiejowice (3.31 ha). Twenty-nine phytosociological relevés were performed in 1973 and 38 in 2011 according to the Braun-Blanquet [16] method. All relevés presented in this study were assigned to plant communities of the *Molinio-Arrhenatheretea* class. The same area of grassland was taken into account in both years. In 2011, several mosaic alliances were observed and relevés were performed for the most distinct patches covering a minimum of 25 m^2; the patches were marked with letters (a, b, c, etc.). The floristic diversity after a period of 38 years was identified based on the phytosociological structure and mean number of species calculated based on the number of species in the particular relevés of the phytocoenosis under study. Owing to the large number of relevés, the predominant *Poa pratensis-Festuca rubra* community was presented in Tab. 1 and Tab. 2, using degrees of constancy (S) and cover-abundance (D) scales.

Data analysis

Changes of the edaphic conditions were assessed using ecological indicator (F – moisture, R – acidity, and N – nitrogen content) values by Ellenberg et al. [17]. This study presents the range (minimum and maximum) of ecological indicator values and the mean values for all relevés and for the predominant *Poa pratensis-Festuca rubra* community. The pragmaTax (Cortex Nova, Bydgoszcz, Poland) program was used to carry out the numerical classification for all relevés based on the quantitative share of species. The weighted pair group method of arithmetic averages (WPGMA) was used. A comparison of the dendrograms obtained in the classification made it possible to include groups of relevés at alfa scale 0.5 – similar in terms of community species composition – in the phytosociological tables. The qualitative similarity between the vegetation after a period of 38 years at the level of class (ChCl.) and order (ChO.) was calculated using Jaccard's index [18]. Phytosociological taxonomy is based on Matuszkiewicz [19], and the species names are provided according to Mirek et al. [20].

Results

Phytosociological studies conducted in the Bystra valley in 2011 revealed changes in the species composition and plant communities in comparison with 1973. Based on the analysis of phytosociological relevés, a total of 12 plant communities of the *Molinio-Arrhenatheretea* R. Tx. 1937 class were distinguished (in brackets are the years of their occurrence):

order *Molinietalia caeruleae* W. Koch 1926
- alliance *Filipendulion ulmariae* Segal 1966
  - *Lythro-Filipenduletum ulmariae* Hadač et all. 1997 (year 2011)
- alliance *Calthion palustris* R. Tx. 1936 em. Oberd. 1957
  - community *Polygonum bistorta* (year 1973)
  - *Cirsietum rivularis* Nowiński 1927 (year 2011)
  - *Scirpetum sylvatici* Ralski 1931 (year 2011)
  - community *Deschampsia caespitosa* (*Deschampsietum caespitosae* Horvatić 1930) (year 2011)
- alliance *Alopecurion pratensis* Pass. 1964
  - *Alopecuretum pratensis* (Regel 1925) Steffen 1931 (year 2011)
  - community *Holcus lanatus* [*Holcetum lanati* (Issler 1936) em. Passarge 1964] (year 2011)

order *Arrhenatheretalia elatioris* Pawł. 1928
- alliance *Arrhenatherion elatioris* (Br.-Bl. 1925) Koch 1926
  - *Arrhenatheretum elatioris* Br.-Bl. ex Scherr. 1925 (year 1973)

community *Poa pratensis-Festuca rubra* (*Poo-Festucetum rubrae* Fijałk. 1962) (years 1973 and 2011)
community *Dactylis glomerata* (year 2011)
community *Phleum pratense* (years 1973 and 2011)
alliance *Cynosurion* R. Tx. 1947
Lolio-Cynosuretum R. Tx. 1937 (years 1973 and 2011)

Based on the studies conducted in 1973, when 29 phytosociological relevés were performed, five phytocoenoses were distinguished: two associations (*Arrhenatheretum elatioris* and *Lolio-Cynosuretum*) as well as three communities (*Poa pratensis-Festuca rubra*, *Phleum pratense*, and *Polygonum bistorta*) (Tab. 1, Fig. 2). In the Bystra valley, the *Poa pratensis-Festuca rubra* community was recorded most frequently; it was represented by 19 phytosociological relevés. In 1973, this community showed a high degree of constancy and cover-abundance for *P. pratensis* and *F. rubra*; it was lower for the other differential species: *Alopecurus pratensis* and *Holcus lanatus*. Species characteristic of the *Arrhenatheretalia* order (nine species) were also recorded in this community: *Heracleum sphondylium* and *Leucanthemum vulgare* occurred most frequently. Species characteristic of the *Arrhenatherion* alliance occurred rarely and with low cover-abundance (Tab. 1). The most numerous group was constituted by species characteristic of the class (15 species), among which *Festuca pratensis* stood out with its high degree of constancy and considerable cover-abundance. Constant components of the meadow (S = V) were also: *Ranunculus acris*, *Trifolium pratense*, *Rumex acetosa*, and *Lathyrus pratensis* as well as *Cerastium holosteoides*, *P. pratense*, and *Plantago lanceolata* (S = IV). *Lychnis flos-cuculi* was recorded most often among the seven species characteristic of the *Molinietalia* order.

The other communities identified were represented by a small number of phytosociological relevés (Tab. 1, Fig. 2). The *Lolio-Cynosuretum* association was identified based on four relevés where *Trifolium repens* predominated. The share of other species characteristic of this association (*Bellis perennis* and *Leontodon autumnalis*) was small. No species characteristic of the *Arrhenatherion* alliance and a few taxa of the *Arrhenatheretalia* order were found in this community. The *Arrhenatheretum elatioris* association was distinguished by the presence of *Arrhenatherum elatius* and *Geranium pratense* (Tab. 1). Characteristic species of the *Arrhenatherion* alliance (*Galium mollugo*, *Crepis biennis*, *Knautia arvensis*) and the *Arrhenatheretalia* order (*H. sphondylium*, *L. vulgare*, *Taraxacum officinale*, *Lotus corniculatus*, *Daucus carota*, *Bromus hordeaceus*, *Dactylis glomerata*, and *Rhinanthus alectorolophus*) were also recorded in this community. Species characteristic of the *Molinio-Arrhenatheretea* class were also highly represented (14 species). The association colonized the driest parts of the valley, i.e., typical dry grasslands, in contrast to the community *Polygonum bistorta* that occupied the most humid habitats, at the boundary with communities of the *Phragmitetea* class. This community was characterized by high abundance of *P. bistorta* and occurrence of *Cirsium rivulare* (Tab. 1). One patch (Relevé 50) was a transitional community corresponding to hay meadows as evidenced by the high cover-abundance of *P. pratensis* and species characteristic of the order (six species), particularly *H. sphondylium* (Fig. 2, Tab. 1).

Based on the studies conducted in 2011, when 38 phytosociological relevés were performed, 10 plant communities were distinguished within two orders: five associations (*Lythro-Filipenduletum ulmariae*, *Cirsietum rivularis*, *Scirpetum sylvatici*, *Alopecuretum pratensis*, and *Lolio-Cynosuretum*) as well as five communities (*Poa pratensis-Festuca rubra*, *Deschampsia caespitosa*, *P. pratense*, *H. lanatus*, and *D. glomerata*) (Tab. 2, Fig. 3).

Communities of the *Arrhenatheretalia* order were characterized by a considerably greater diversity (mean number of species in relevé – 26) in comparison with *Molinietalia* (18). They were distinguished by a larger share of species characteristic of the *Arrhenatheretalia* order with higher degrees of constancy on the one hand and, on the other hand, by a smaller share of taxa of the *Calthion* alliance and *Molinietalia* order and lower degrees of constancy. These communities were also dominated by species characteristic of the class, with high cover-abundance and a high degree of constancy in comparison with communities of the *Molinietalia* order (Tab. 2).

Tab. 1 Floristic composition of plant communities in 1973.

Relevé number	*Poa pratensis-Festuca rubra* com.		*Lolio-Cynosuretum*				*Arr ela*		*Pp*	*Pb*	
			2	4	16	34	20	48	31	50	51
Number of species	**mean 25**		**20**	**18**	**15**	**22**	**26**	**40**	**22**	**28**	**20**
	S	**D**									
ChAss. *Lolio-Cynosuretum*											
Trifolium repens	III	15	3	3	3	3	+	+	.	+	.
Bellis perennis	I	5	+	+	+	+	.	.	.	.	.
Leontodon autumnalis	I	3	+	+	.	+	.	+	.	.	.
Lolium perenne (D)	.	.	+	2	+	.	.	.	.	.	.
ChAss. *Arrhenatheretum elatioris*											
Arrhenatherum elatius	I	78	.	.	.	.	2	2	.	+	.
Geranium pratense	I	20	.	.	.	.	.	+	.	.	.
Community *Poa pratensis-Festuca rubra*											
Poa pratensis	V	2850	2	2	2	2	2	2	2	2	2
Festuca rubra	V	858	+	+	+	1	+	+	+	+	+
Alopecurus pratensis	III	30	+	.	.	.	+	+	2	+	.
Holcus lanatus	I	83	.	.	.	.	2	+	.	.	.
ChAll. *Arrhenatherion*											
Campanula patula	II	18	.	.	.	.	.	.	.	.	.
Galium mollugo	II	13	.	.	.	.	.	+	.	.	.
Crepis biennis	I	3	.	.	.	.	.	+	.	.	.
Tragopogon pratensis	I	3	.	.	.	.	.	.	.	.	.
Knautia arvensis	.	.	.	.	.	.	.	+	.	.	.
ChO. *Arrhenatheretalia*											
Heracleum sphondylium	V	220	.	.	.	.	+	+	+	2	+
Leucanthemum vulgare	V	43	.	.	.	+	1	+	+	+	+
Taraxacum officinale	IV	40	+	+	+	2	.	+	.	+	.
Lotus corniculatus	III	103	.	.	.	.	+	+	+	.	.
Daucus carota	III	28	.	.	.	.	.	+	.	.	.
Dactylis glomerata	II	98	.	.	.	.	.	+	.	+	.
Bromus hordeaceus	II	15	.	.	.	.	+	+	.	+	.
Achillea millefolium	I	8	+	.	.	.	.	.	.	+	.
Rhinanthus alectorolophus	I	3	.	.	.	.	.	+	.	.	.
ChAll. *Calthion*											
Cirsium rivulare	II	98	.	.	.	.	+	.	+	+	2
Polygonum bistorta	I	5	.	.	.	.	.	.	.	3	3
Trifolium hybridum	I	5	.	.	.	.	.	.	.	.	+

Tab. 1 Continued

Relevé number	*Poa pratensis-Festuca rubra* com.		*Lolio-Cynosuretum*				*Arr ela*		*Pp*	*Pb*	
			2	4	16	34	20	48	31	50	51
Number of species	**mean 25**		**20**	**18**	**15**	**22**	**26**	**40**	**22**	**28**	**20**
	S	**D**									
Myosotis palustris	I	3	.	.	.	.	.	.	.	.	+
Caltha palustris	I	3	.	.	.	.	.	.	.	.	.
Juncus effusus	I	3	.	.	.	.	.	.	.	.	.
Geum rivale (D)	I	3	.	.	.	.	.	.	.	.	.
Juncus conglomeratus	.	.	.	.	.	.	+	.	.	.	.
ChO. *Molinietalia*											
Lychnis flos-cuculi	IV	40	.	.	.	+	+	+	+	+	+
Deschampsia caespitosa	III	113	.	.	.	+	+	+	+	.	.
Equisetum palustre	III	25	.	.	.	.	+	.	+	.	+
Filipendula ulmaria	II	30	.	.	.	.	.	+	+	.	+
Briza media (D)	II	13	.	.	.	.	+	+	.	.	+
Sanguisorba officinalis	II	13	.	.	.	.	.	+	.	.	.
Lythrum salicaria	I	3	.	.	.	.	.	.	.	.	+
Lysimachia vulgaris	I	3	.	.	.	.	.	.	.	.	.
ChCl. *Molinio-Arrhenatheretea*											
Festuca pratensis	V	1815	+	+	+	2	2	2	2	2	+
Lathyrus pratensis	V	373	.	.	.	.	.	+	1	1	+
Trifolium pratense	V	48	.	.	.	+	+	.	+	+	.
Ranunculus acris	V	45	+	+	.	+	+	+	+	.	+
Rumex acetosa	V	43	+	.	.	.	+	+	+	+	.
Phleum pratense	IV	403	.	.	.	+	.	+	3	+	.
Plantago lanceolata	IV	128	+	+	+	+	2	+	+	.	.
Cerastium holosteoides	IV	40	.	+	+	+	+	+	+	.	.
Avenula pubescens	III	33	.	.	.	.	.	+	.	.	.
Poa trivialis	III	33	+	+	.	.	+	.	.	+	+
Ranunculus repens	III	23	+	+	.	+	.	.	+	+	.
Agrostis gigantea	II	20	+	+	2	+	.	.	.	.	.
Carex hirta	II	13	+	+	.	+	.	.	.	+	.
Centaurea jacea	II	13	.	.	.	+	+	+	.	.	.
Prunella vulgaris	II	13	.	.	+	.	.	.	.	.	.
Leontodon hispidus	I	10	.	.	.	.	.	.	.	.	.
Vicia cracca	I	8	.	.	.	.	.	.	.	.	.
Cardamine pratensis	I	3	.	.	.	.	.	.	.	.	.

Tab. 1 Continued

Relevé number	*Poa pratensis-Festuca rubra* com.		*Lolio-Cynosuretum*				*Arr ela*		*Pp*	*Pb*	
			2	4	16	34	20	48	31	50	51
Number of species	**mean 25**		**20**	**18**	**15**	**22**	**26**	**40**	**22**	**28**	**20**
	S	**D**									
Companions species											
Anthoxanthum odoratum	III	38	.	.	.	.	+	+	.	+	.
Medicago lupulina	II	25	.	+	.	+	+	+	.	+	+
Carex gracilis	II	23	.	.	.	.	.	.	+	.	2
Galium verum	II	13	.	.	.	.	.	.	.	.	.

Sporadic species: *Alchemilla monticola* + (13, 39, 48); *Carex pairae* + (33–35, 40, 50); *Cirsium vulgare* + (16); *Elymus repens* + (46); *Equisetum arvense* + (46, 48–50); *Galium aparine* + (50); *G. boreale* + (40); *G. verum* + (33, 38, 40, 46, 47); *Glechoma hederacea* + (7, 51); *Juncus articulatus* + (20); *Luzula campestris* + (46, 48); *Lysimachia nummularia* + (8, 22, 48, 50); *Mentha arvensis* + (2); *Phragmites australis* + (7); *Plantago major* + (2, 16); *P. media* + (35, 39); *Poa annua* + (16); *Polygonum persicaria* + (29, 31, 40); *Potentilla anserina* + (2, 4, 18, 46); *P. reptans* + (7); *Rumex crispus* + (39); *Symphytum officinale* + (7, 18, 28); *Veronica chamaedrys* + (7, 8, 11, 48).

Explanations: *Arr ela* – *Arrhenatheretum elatioris*; *Pp* – community *Phleum pratense*; *Pb* – community *Polygonum bistorta*.

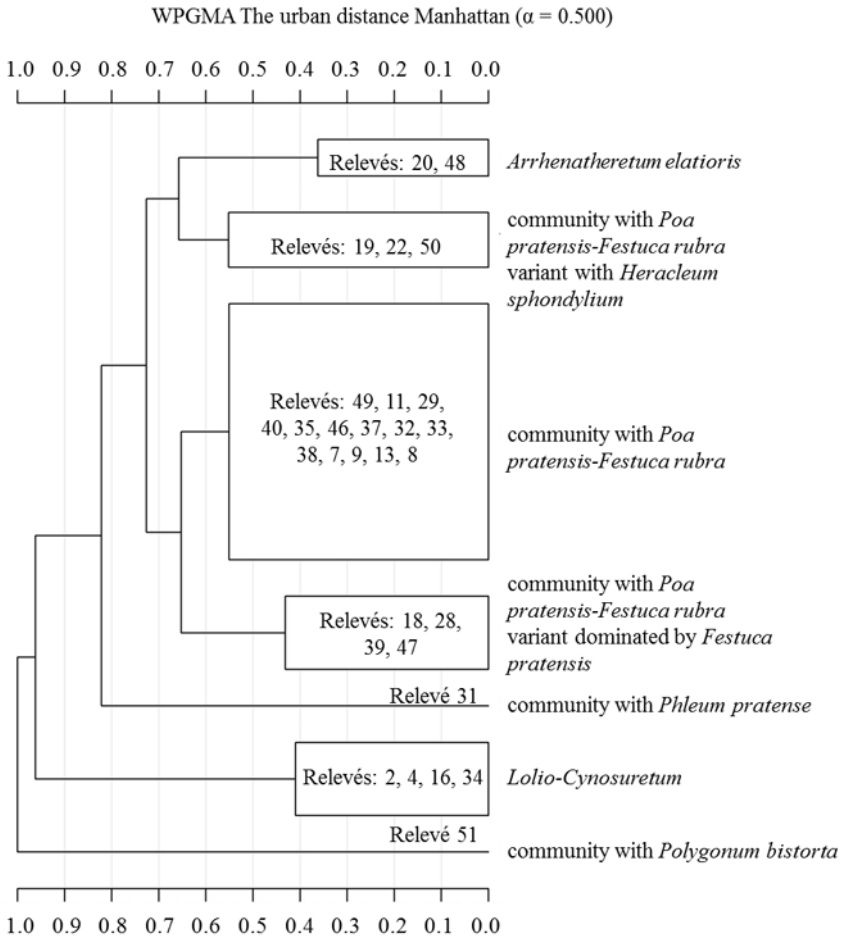

Fig. 2 Classification of the plant communities of *Molinio-Arrhenatheretea* class (1973).

Tab. 2 Floristic composition of plant communities in 2011.

Relevé number	*Poa pratensis-Festuca rubra* com.		*L-C*	*Pp*	*Dg*	*Alo pra*				*Hl*		*Lyt-Fil*		*Dc*			*Cir riv*			*Sci syl*	
			2	31	33	26	3e	15b	25	47a	105a	30b	42	47c	47b	47d	32a	40	51	15	3b
Number of species	**mean 25**		**28**	**24**	**32**	**25**	**14**	**15**	**25**	**11**	**25**	**17**	**24**	**16**	**16**	**18**	**14**	**14**	**24**	**22**	**12**
	S	D																			
ChAss. *Lolio-Cynosuretum*																					
Trifolium repens	III	37	2	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lolium perenne	II	45	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bellis perennis	I	18	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ChAll. *Arrhenatherion*																					
Geranium pratense	III	53	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Galium mollugo	I	26	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Tragopogon pratensis	I	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arrhenatherum elatius	I	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ChO. *Arrhenatheretalia*																					
Heracleum sphondylium	IV	174	.	.	.	+	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.
Leucanthemum vulgare	III	311	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dactylis glomerata	III	232	+	.	3	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Taraxacum officinale	III	87	1	+	1	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Daucus carota	II	113	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lotus corniculatus	II	58	1	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bromus hordeaceus	II	21	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Achillea millefolium	I	26	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
D community *Poa pratensis-Festuca rubra*																					
Poa pratensis	V	1108	1	2	1	1	1	1	+	2	1	2	2	1	1	+	.	.	1	1	+

Tab. 2 Continued

Relevé number	*Poa pratensis-Festuca rubra* com.		*L-C*	*Pp*	*Dg*	*Alo pra*				*Hl*		*Lyt-Fil*		*Dc*			*Cir riv*			*Sci syl*	
			2	31	33	26	3e	15b	25	47a	105a	30b	42	47c	47b	47d	32a	40	51	15	3b
Number of species	**mean 25**		**28**	**24**	**32**	**25**	**14**	**15**	**25**	**11**	**25**	**17**	**24**	**16**	**16**	**18**	**14**	**14**	**24**	**22**	**12**
	S	**D**																			
Holcus lanatus	IV	834	.	.	2	.	.	1	.	3	3	.	.	2	1	+	.	.	2	+	.
Festuca rubra	III	158	1	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
ChAll *Alopecurion*																					
Alopecurus pratensis	IV	374	.	1	.	2	4	4	3	2	1	.	1	.	.	.	+	.	1	1	.
Symphytum officinale (D)	III	211	.	.	.	1	1	1	1	1	+	.	.	1	.	1	.	2	2	1	1
ChAss. *Scirpetum sylvatici*																					
Scirpus sylvaticus	I	5	.	.	.	.	1	+	.	.	+	.	.	.	.	.	2	.	.	4	4
ChAss. *Cirsietum rivularis*																					
Cirsium rivulare	III	58	.	+	.	+	1	+	+	.	1	1	2	1	+	1	3	3	3	1	1
ChAll. *Calthion*																					
Trifolium hybridum	II	39	1	1	.	1	1	.	1	.	1	1	.	.	.	.	.	.	+	1	.
Caltha palustris	II	24	.	.	.	.	.	.	.	.	.	2	.	+	.	.	1	.	.	1	1
Polygonum bistorta	I	16	.	.	.	.	.	.	.	+	.	.	.	.	2	.	.	.	+	.	.
Myosotis palustris	I	5	.	+	.	.	+	.	+	.	.	1	.	.	.	.	+	.	.	.	.
Geum rivale	I	3	.	.	.	.	.	.	.	1	.	.	.	+	1	1	.	.	.	.	.
Juncus conglomeratus	I	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus effusus	I	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium oleraceum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Lathyrus palustris	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
ChO *Molinietalia*																					

Tab. 2 Continued

Relevé number	*Poa pratensis-Festuca rubra* com.		*L-C*	*Pp*	*Dg*	*Alo pra*				*Hl*		*Lyt-Fil*		*Dc*			*Cir riv*			*Sci syl*	
			2	31	33	26	3e	15b	25	47a	105a	30b	42	47c	47b	47d	32a	40	51	15	3b
Number of species	**mean 25**		**28**	**24**	**32**	**25**	**14**	**15**	**25**	**11**	**25**	**17**	**24**	**16**	**16**	**18**	**14**	**14**	**24**	**22**	**12**
	S	**D**																			
Deschampsia caespitosa	IV	289	+	1	+	1	1	1	.	.	2	.	2	3	3	4	.	.	.	+	.
Lychnis flos-cuculi	III	97	.	1	+	1	.	.	.	.	.	2	1	.	2	1	1	1	+	.	.
Equisetum palustre	III	45	.	+	.	.	1	1	+	.	+	1	1	1	1	.	1	1	1	1	1
Sanguisorba officinalis	II	132	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.
Filipendula ulmaria	II	61	.	+	+	+	.	.	2	2	1	3	3	2	2	1	+	2	2	.	1
Rhinanthus angustifolius	II	21	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Lythrum salicaria	II	11	.	+	.	+	.	.	1	.	1	2	1	.	.	1	.	.	+	.	1
Briza media (D)	I	39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex panicea (D)	I	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Angelica sylvestris	.	.	.	.	.	.	.	.	+	.	.	.	1	.	.	.	.	.	+	.	.
Galium uliginosum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	+	+	.
Lysimachia vulgaris	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+		+	.	+	.	1
ChCl. *Molinio-Arrhenatheretea*																					
Festuca pratensis	V	2224	2		1	1	.	1	1	1	+	1	1	+		+	+	1	+	.	.
Ranunculus acris	V	608	+	1	+	1	1	1	.	1	1	1	1	+	1	1	1	1	1	+	+
Trifolium pratense	V	521	+	1	+	1	.	1	+	.	+	.	.	.	.	.	.	.	+	.	.
Phleum pratense	IV	529	1	3	1	+	.	.	+	1	.	+	1	.	.	.	.	1	+	.	.
Plantago lanceolata	IV	174	+	1	+	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	.
Ranunculus repens	IV	42	1	+	2	1	.	.	+	1	+	.	.	.	.	2	.	.	.	.	.
Agrostis gigantea	III	245	.	2	1	3	.	.	1	.	.	.	.	1	.	.	.	+	.	.	.

Tab. 2 Continued

Relevé number	*Poa pratensis-Festuca rubra* com.		*L-C*	*Pp*	*Dg*	*Alo pra*				*Hl*		*Lyt-Fil*		*Dc*			*Cir riv*			*Sci syl*	
			2	31	33	26	3e	15b	25	47a	105a	30b	42	47c	47b	47d	32a	40	51	15	3b
Number of species	**mean 25**		**28**	**24**	**32**	**25**	**14**	**15**	**25**	**11**	**25**	**17**	**24**	**16**	**16**	**18**	**14**	**14**	**24**	**22**	**12**
	S	D																			
Lathyrus pratensis	III	134	.	.	+	2	.	.	+	.	.	1	.	+	.	.	+	+	+	.	.
Cerastium holosteoides	III	50	+	.	+	.	.	.	+	.	.	+	.	.	+	+	.	.	.	.	.
Carex hirta	III	42	1	.	.	.	+	.	.	.	.	.	1	.	1	.	.	.	.	.	.
Rumex acetosa	II	147	.	.	+	+	.	.	+	.	.	.	1	.	.	+	.	.	1	.	.
Avenula pubescens	II	134	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Poa trivialis	II	71	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.
Centaurea jacea	I	16	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leontodon hispidus	I	5	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Vicia cracca	I	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Companions species																					
Carex gracilis	IV	108	.	+	.	.	1	+	.	.	1	1	1	2	1	.	3	+	.	+	
Phalaris arundinacea	III	74	.	+	.	2	.	+	1	.	1	.	.	.	.	.	.	.	.	1	
Anthoxanthum odoratum	III	66	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	

Sporadic species: *Aegopodium podagraria* + (2), 1 (3e); *Alchemilla monticola* + (7, 39); *Artemisia vulgaris* + (2); *Carex disticha* + (2, 40a); *C. leporina* + (33); *C. pairae* + (39); *C. vulpina* + (39), 1 (47c), 2 (40); *Cirsium arvense* + (30); *Dactylorhiza majalis* 1 (35); *Dianthus carthusianorum* + (33); *Eleocharis palustris* + (37); *Elymus repens* + (2, 18, 19); *Equisetum arvense* + (2, 7, 7a, 8, 32); *Erigeron annuus* + (15, 25); *Festuca arundinacea* + (32), 1 (105a); *Galium aparine* + (8, 15, 15b, 47, 47b); *G. palustre* + (19a, 25, 26, 28, 31, 37, 39); *G. verum* + (32, 33, 40a), 1 (35, 39); *Glyceria fluitans* + (15); *G. maxima* 1 (15); *Hieracium caespitosum* + (33); *H. pilosella* + (8, 9, 13, 32), 1 (18); *Juncus articulatus* + (19a); *Lolium multiflorum* 3 (22a); *Lysimachia nummularia* + (7, 7a, 8, 13, 30b, 37); *Medicago lupulina* + (2, 8, 9), 1 (19, 32, 47); *Mentha longifolia* + (105a); *Peucedanum palustre* 1 (30); *Phragmites australis* 1 (3e, 105a); *Plantago major* + (2, 8); *Polygonum persicaria* + (8, 9, 19, 26, 27, 33); *Potentilla anserina* + (2, 8, 30), 1 (7b, 39); *Rumex crispus* + (2, 18, 28, 47), 1 (22), 2 (25); *Scrophularia nodosa* + (51); *Scutellaria galericulata* + (15); *Stachys palustris* + (105a); *Stellaria graminea* + (30, 32, 40a); *Urtica dioica* + (2, 25, 47d, 105a).

Explanations: *L-C* – *Lolio-Cynosuretum*; *Pp* – community *Phleum pratense*; *Dg* – community *Dactylis glomerata*; *Alo pra* – *Alopecuretum pratensis*; *Hl* – community *Holcus lanatus*; *Lyt-Fil* – *Lythro-Filipenduletum ulmariae*; *Dc* – community *Deschampsia caespitosa*; *Cir riv* – *Cirsietum rivularis*; *Sci syl* – *Scirpetum sylvatici*.

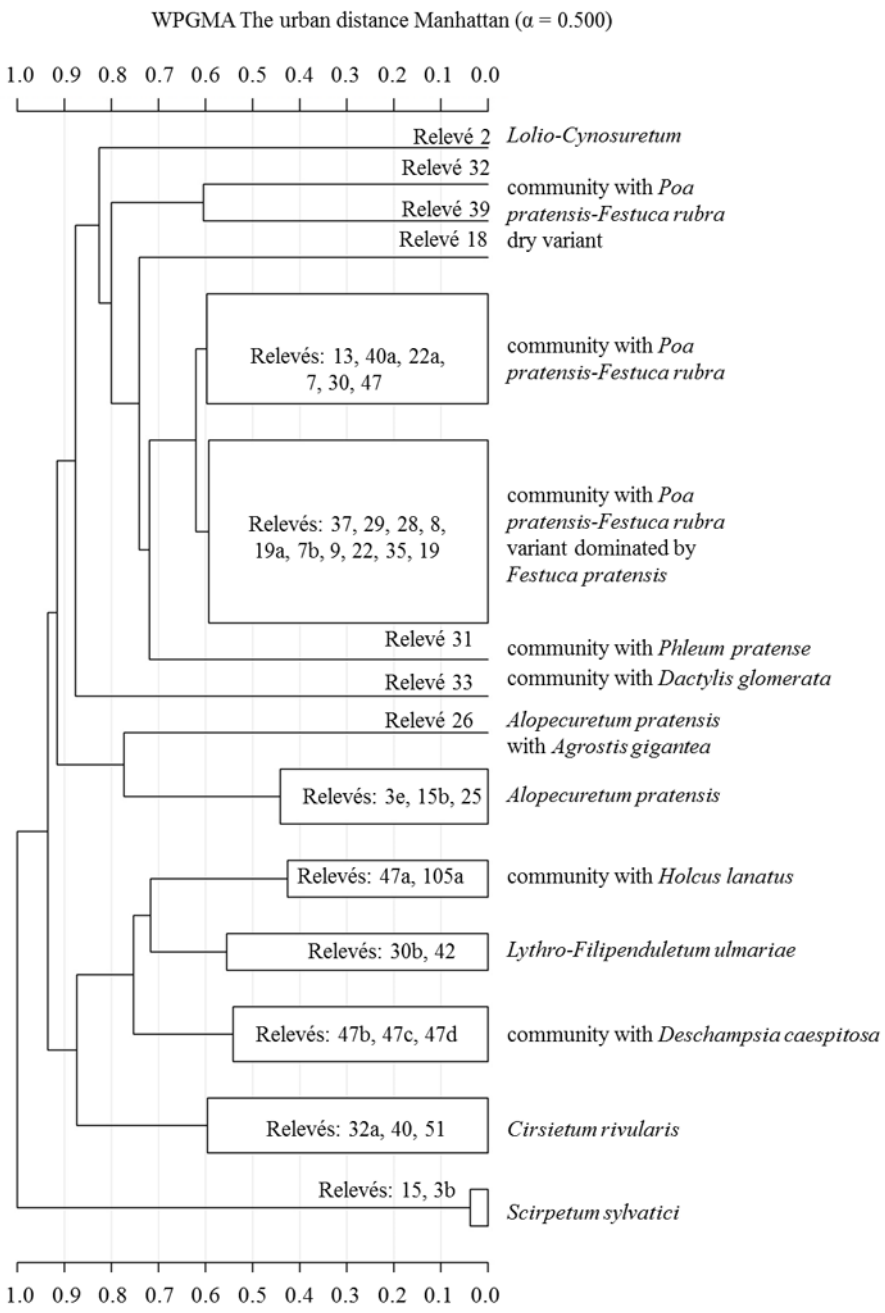

Fig. 3 Classification of the plant communities of *Molinio-Arrhenatheretea* class (2011).

Within the class discussed, the *Poa pratensis-Festuca rubra* community, occupying large areas in the Bystra valley – mainly in its middle reaches – was the most numerous. This community was distinguished by a high degree of constancy and cover-abundance of *P. pratensis* and other distinguishing species: *H. lanatus*, *A. pratensis*, and *F. rubra*. Species characteristic of the *Arrhenatherion* (four species) and *Cynosurion alliance* (three species) were found in the meadows. The *Arrhenatheretalia* order was represented by eight species, among which *H. sphondylium*, *T. officinale*, *D. glomerata*, and *L. vulgare* were the most frequently recorded. The most numerous group comprised species characteristic of the *Molinio-Arrhenatheretea* class (14 species), among which *Festuca pratensis* was the most frequently recorded. Following species, *R. acris*, *T. pratense*, *P. pratense*, and *P. lanceolata* occurred often, too. The *Molinietalia* order (16 species), including nine characteristic species of the *Calthion* alliance, was also highly represented. The most frequently recorded were *D. caespitosa*, *L. flos-cuculi*, *Equisetum palustre*, and *C. rivulare*. It is worth noting the occurrence of species of the *Phragmitetea* class, namely *Carex gracilis* and *Phalaris arundinacea*, which indicates

periodically greater humidity of a portion of the habitat. In addition, two communities with a predominance of *D. glomerata* and *P. pratense* were also found within the *Arrhenatherion* alliance. The first community corresponded to hay meadows with a large share of species characteristic of the *Arrhenatheretalia* order (six species) and *Molinio-Arrhenatheretea* class (11 species). The community with *Phleum pratense* occurred in a periodically humid habitat, which was indicated by the occurrence of species characteristic for the *Molinietalia* order as well as a small number of humid habitat species, such as *C. gracilis* and *P. arundinacea* (Tab. 2). The community remained very much the same over the years and its species composition was similar to that in 1973. The last community of this alliance was the *Lolio-Cynosuretum* association that, in comparison with 1973, survived as a single patch where traditional goat grazing had been conducted. This association was characterized by a predominance of *Lolium perenne* and *T. repens* and a considerably smaller share of *B. perennis*.

In 2011, a considerably greater number of communities of the *Molinietalia* order was recorded. One of them was the *Lythro-Filipenduletum ulmariae* association, characterized by a predominance of *F. ulmaria* and *L. salicaria* and high cover-abundance of species characteristic of the *Filipendulion* alliance and the order (Fig. 3, Tab. 2). Besides the predominant species mentioned above, *L. flos-cuculi* and *Lysimachia vulgaris* also occurred frequently. Within the *Calthion* alliance, the *Cirsietum rivularis* association was distinguished; it was characterized by a predominance of the characteristic species and considerable cover-abundance of species of the order (nine species) and class (eight species). *Scirpus sylvaticus* and *Symphytum officinale* were also found to have high cover-abundance. The *Scirpetum sylvatici* was characterized by the predominance of the characteristic species and occurrence of the *Calthion* alliance species (Tab. 2). Within the alliance, the *D. caespitosa* community was also distinguished, characterized by the predominance of that species and high cover-abundance of the species characteristic of the *Molinietalia* order (seven species).

Within the *Alopecurion* alliance, the *Alopecuretum pratensis* association was distinguished, with the predominance of *A. pratensis* and a certain share of *S. officinale*. Species characteristic of the *Molinietalia* order (six species) and *Molinio-Arrhenatheretea* class (eight species) were also recorded in the sward of these meadows. The community *H. lanatus* also showed similar characteristics. This community is distinguished by high cover-abundance of *H. lanatus* and species characteristic of the *Molinietalia* order. High cover-abundance was characteristic for *F. ulmaria*, while *D. caespitosa* and *L. salicaria* had low cover-abundance. No species characteristic of the *Arrhenatherion* alliance and *Arrhenatheretalia* order (except *Achillea millefolium*) were found.

The phytosociological studies conducted in the valley of the Bystra River in 2011 showed a greater diversity of the species composition of communities of the *Molinio-Arrhenatheretea* class in comparison with 1973. The number of communities within this class in the study area rose from 5 (1973) to 10 (2011). The *Poa pratensis-Festuca rubra* community occurred most frequently in both years (58% of relevés). More than half of the patches of this community persisted for the 38-year period with few changes in their species composition. The cover-abundance of the two differential species for this community, i.e., *P. pratensis* and *F. rubra*, decreased, while the cover-abundance of *A. pratensis* and *H. lanatus* increased. Furthermore, there was a considerable increase in the cover-abundance of *Festuca pratensis*, which became a dominant species in this community, and of other species characteristic of the *Molinio-Arrhenatheretea* class. Patches of the *Lolio-Cynosuretum* association and community with *Phleum pratense* also persisted (Tab. 2, Tab. 3). Some phytocenoses of the *Poa pratensis-Festuca rubra* community changed into mosaic complexes where the analyzed community was accompanied by patches (over 100 m^2) with *H. lanatus* and *D. caespitosa* or, in a local depression, the *Cirsietum rivularis* association. Some communities changed and showed considerable syntaxonomic similarity: the *Poa pratensis-Festuca rubra* community changed into the community with *D. glomerata*, which may have resulted from the use of resowing; *Arrhenatheretum elatioris* changed into the *Poa pratensis-Festuca rubra* community, while a community with *Polygonum bistorta* changed into the *Cirsietum rivularis* association characterized by similar species composition (Tab. 3). The *Arrhenatheretum elatioris* association was not recorded in 2011. Most of the new communities recorded in 2011, belonging mostly to the *Molinietalia* order, also appeared in habitats after the withdrawal of communities of the *Phragmitetea* class, due to the

Tab. 3 Directions of changes in plant communities of *Molinio-Arrhenatheretea* class.

Name of the community in particular years (relevé number)	
1973	**2011**
Communities that have not changed over time	
Community with *Poa pratensis-Festuca rubra* (8, 9, 13, 18, 19, 22, 28, 29, 37, 39)	Community with *Poa pratensis-Festuca rubra* (8, 9, 13, 18, 19, 22, 28, 29, 37, 39)
Lolio-Cynosuretum (2)	*Lolio-Cynosuretum* (2)
Community with *Phleum pratense* (31)	Community with *Phleum pratense* (31)
Communities that have changed in the mosaic of different communities	
Community with *Poa pratensis-Festuca rubra* (7, 32, 40)	*Cirsietum rivularis* (7b, 32a, 40); community with *Poa pratensis-Festuca rubra* (7, 32, 40a)
Community with *Poa pratensis-Festuca rubra* (47)	Community with *Poa pratensis-Festuca rubra* (47); community with *Holcus lanatus* (47a); community with *Deschampsia caespitosa* (47b–d)
Communities that have changed within the *Molinio-Arrhenatheretea* class	
Community with *Poa pratensis-Festuca rubra* (33)	Community with *Dactylis glomerata* (33)
Arrhenatheretum elatioris (20)	Community with *Poa pratensis-Festuca rubra* (20)
Community with *Polygonum bistorta* (51)	*Cirsietum rivularis* (51)
Communities that have changed as a result of the reduction of soil moisture	
Communities of the *Phragmitetea* class	*Scirpetum sylvatici* (3b, 15); *Alopecuretum pratensis* (3e, 15b, 25, 26)
	Community with *Poa pratensis-Festuca rubra* (30); *Lythro-Filipenduletum ulmariae* (30b, 42)
	Community with *Holcus lanatus* (105a)
Other changes	
Lolio-Cynosuretum (4, 16, 34)	Arable fields, gardens
Community *Poa pratensis-Festuca rubra* (11, 38, 46)	Arable fields, gardens
Arrhenatheretum elatioris (48, 49)	Building plots
Community with *Polygonum bistorta* (50)	Building plots

lowering of the groundwater level. Some meadows and pastures were changed into arable fields, gardens or building plots (Tab. 3).

An important indicator of changes in communities was the total number of species in the study area, number of species characteristic of the particular syntaxonomic units, and the degree of their constancy. Within the *Molinio-Arrhenatheretea* class, 85 herbaceous species were recorded in 1973 and 100 in 2011. However, the average number of species per relevé was higher in 1973 (24) than in 2011 (23). In 2011, communities of the *Arrhenatheretalia* order showed greater species richness in comparison with the *Molinietalia* order, within which communities of the *Calthion alliance*, particularly *Scirpetum sylvatici*, had the poorest species richness (Tab. 1, Tab. 2). In comparison with 1973, the constancy and number of species characteristic of the *Arrhenatheretalia* order and its alliances decreased in 2011, but increased in the case of the *Molinietalia* order and *Calthion* alliance (Tab. 4). The most numerous group comprised species characteristic of the class. In 1973, a greater number of these species showed the degree of constancy IV and V. In 2011, species characteristic of the *Phragmitetea* class, particularly *C. gracilis* and *P. arundinacea*, were recorded in the meadow. Due to decreased humidity, communities of this class partially transformed

Tab. 4 Changes in the number of characteristic species and their constancy degree.

Phytosociological status	Jaccard's index mean and range	1973	2011
		Number of species (S – constancy)	
ChAll. *Arrhenatherion*		2 (II); 5 (I)	1 (II); 3 (I)
ChAll. *Cynosurion*		2 (III); 2 (I)	1 (III); 1 (II); 1 (I)
ChO. *Arrhenatheretalia*	$\bar{y}$ = 0.26 (0.0 – 0.43)	3 (IV); 2 (III); 2 (II); 2 (I)	1 (IV); 3 (III); 3 (II); 1 (I)
ChAll. *Calthion*		1 (II); 7 (I)	1 (IV); 1 (III); 2 (II); 7 (I)
ChO. *Molinietalia*	$\bar{y}$ = 0.34 (0.0 – 1.0)	1 (IV); 3 (III); 1 (II); 2 (I)	2 (IV); 2 (III); 4 (II); 2 (I)
ChCl. *Molinio-Arrhenatheretea*	$\bar{y}$ = 0.54 (0.29 – 0.69)	4 (V); 6 (IV); 3 (III); 3 (II); 3 (I)	3 (V); 4 (IV); 3 (III); 4 (II); 4 (I)
ChCl. *Phragmitetea*		1 (II); 1 (I)	1 (IV); 1 (II); 5 (I)
Number of communities		5	10
Mean number of species (min–max)		24 (15–40)	23 (11–32)

into communities of the *Molinietalia* order. Jaccard's indices revealed remarkable changes in the species composition after a period of 38 years, especially at the level of the order *Arrhenatheretalia* (J = 0.26) and *Molinietalia* (J = 0.34). A larger similarity at the level of the class (J = 0.54) was observed (Tab. 4).

These habitat changes are also confirmed by the ecological index numbers [17]. The paper does not include climatic indicators because they are usually subject to the smallest fluctuation. Edaphic indicators, particularly the moisture index (mean F = 5.5 for year 1973, mean F = 6.3 for 2011), showed greater changes. The habitats of communities of the *Molinietalia* order (*Cirsietum rivularis* F = 7.3–7.9 and *Scirpetum sylvatici* F = 7.8–8.0) had the highest humidity index. However, changes in the moisture index were also observed within *Poa pratensis-Festuca rubra* communities (5.5 for year 1973, 5.9 for 2011), which resulted from the appearance of humid habitat species (Tab. 1, Tab. 2). The mean values of acidity indicator decreased only slightly. On the other hand, the nitrogen content index decreased (5.8 for year 1973, 5.3 for 2011), which may have resulted from the gradual impoverishment of the habitat (Tab. 5). The decrease in the values of this indicator also applies to the *Poa pratensis-Festuca rubra* communities (5.8 for year 1973, 5.5 for 2011).

Discussion

The plant communities of the *Molinio-Arrhenatheretea* class described in this study are typical of valleys of smaller and larger rivers in Poland [21–26]. In the Bystra valley, the *Poa pratensis-Festuca rubra* community was recorded most frequently, which resulted from the systematic cutting of meadows, frequently accompanied by fertilization, as indicated by the considerable cover-abundance of agriculturally valuable plant species (*F. pratensis*, *P. pratensis*, *P. pratense*, and *Trifolium pratense*). This vegetation grew mostly in habitats of flood-meadows subjected to periodic short-lasting flooding, as evidenced by the presence of humid (*Molinietalia* order) and wet habitat species such as *Carex gracilis* (*Phragmitetea* class) which belongs to flood-tolerant species and has a wide range of plasticity to adjust its physiology resulting in metabolic, morphological, and anatomical acclimation [27]. The consequence of waterlogging is usually anoxia and wetland species characterized by tolerance to this phenomenon [28]. On the other hand, *Poa pratensis-Festuca rubra* meadows are Natura 2000 habitats (6510-2) but, according to Korzeniak [29], these habitats only include floristically rich meadows whose species composition is similar to psammophilous grassland. However, cultivated meadows, with a predominance of grasses with a high fodder

Tab. 5 Changes in the values of edaphic indicators [17].

	Poa pratensis-Festuca rubra community						All relevés					
	1973			2011			1973			2011		
Indicator	min	max	mean	min	max	mean	min	max	mean	min	max	mean
F	5.2	6.2	5.5	4.9	7.2	5.9	5.1	6.6	5.5	4.9	8.0	6.3
R	6.1	6.6	6.2	6.1	6.7	6.2	5.8	6.6	6.2	4.7	6.9	6.1
N	4.9	6.3	5.8	4.8	6.2	5.5	4.7	6.3	5.8	3.6	6.5	5.3

Edaphic indicators: F – moisture; R – acidity; N – nitrogen content.

value, may not be included in this habitat. Typical meadows with a large share of grasses, especially *F. pratensis*, *P. pratensis*, *Anthoxanthum odoratum*, *D. caespitosa*, *F. rubra*, or *Agrostis gigantean*, and a small share of dicotyledons develop in more humid habitats [30]. An analogous community, with a very similar species composition, was described in another river valley in the Lublin Upland [31–34].

The *Lolio-Cynosuretum* association was recorded in dry grasslands formed at the mouths of the gullies, along which sediment-carrying water flowed from the adjoining areas into the valley [14]. These phytocoenoses have developed under the influence of intensive grazing, in this case – goat grazing, in contrast to the other association *Arrhenatheretum elatioris* which is mainly based on cutting.

In 2011, a considerably greater number of communities of the *Molinietalia* order was recorded. One of them was the *Lythro-Filipenduletum ulmariae* association. Meadows of this type are anthropogenic or partially natural herbaceous communities occurring along streams [19]. The existence of *Molinietalia* meadows depends on the water regime of river valleys [1]. They are characterized by the colorful aspect of blooming plants. The *Scirpetum sylvatici* association developed as an ecotone within some associations of the *Phragmitetea* class. It usually occupies small areas in local depressions, often in places fed by seeping water. According to Kucharski [21], the other meadow association, *Alopecuretum pratensis*, is one of the most agriculturally important types of wet meadows in Poland, maintained thanks to adequate fertilization and cutting. Neglecting such measures causes the degradation of these meadows, which was observed in the studies. Many *Alopecurus* meadows transformed into *Deschampsia* ones. Meadows with the predominance of *D. caespitosa* develop due to the lack of proper maintenance on humid grasslands and are characterized by poor fodder value [19]. These grasslands are characterized by low biodiversity, but tussocks of *D. caespitosa* are reservoirs of meadow species even at advanced successional stages and may play a significant role in the process of long-term species turnover [35]. The other type of degraded meadow is the *Holcus lanatus* community, regarded by Matuszkiewicz [19] as a degenerative phase caused by the excessive drying of the upper soil layers or the abandonment of fertilization, which is suggested by the occurrence of *A. pratensis* (Tab. 2). These patches corresponded to the humid meadow variants occurring in Poland, as described by other authors [22,36,37].

In 2011, a greater diversity of the species composition of communities of the *Molinio-Arrhenatheretea* class in comparison with 1973 was noted (Tab. 3). The number of communities within this class in the study area increased from 5 (1973) to 10 (2011), but the *Poa pratensis-Festuca rubra* community was the predominant in both years.

The *Arrhenatheretum elatioris* association was not recorded in 2011, as it is locally threatened with extinction due to its strong dependence on appropriate grassland management [21,38,39]. One of the reasons is also the gradual disappearance of characteristic species due to the land management changes [1]. The differences in the species diversity of communities from the *Arrhenatheretalia* and *Molinietalia* order are confirmed by the results of studies by other authors [38].

Habitat changes are also confirmed by the greater changes in ecological indicator values [17]. Ecological indicators perform a very important role in assessing changes

of the vegetation cover and habitat conditions occurring in several homologous communities replacing one another in the course of ecological succession. Phytocoenoses include sets of species which are relatively uniform, relatively constant and instantly recognizable, which can be helpful in attempting an assessment of vegetation transformations [40,41]. Moisture conditions are the most various indicators on the grassland sites [42]. Changes in moisture conditions influence the changes in the vegetation and even cause the formation of new plant communities (Tab. 3). Vegetation changes in flooded meadows in rivers valley also depend on flooding duration and alluvial processes which cause changes in the soil seed bank [43], which is considered an important factor influencing plant community changes. The reserve of propagules in the soil facilitates regeneration of plant communities [44]. At the level of succession changes of plant communities within different phytosociological classes, the soil humidity index has a medium indicative strength. Among the plant communities analyzed in this study, communities of the *Arrhenatherion elatioris* alliance occur in the driest habitats, while those of the *Filipendulion ulmariae*, *Calthion palustris*, and *Alopecurion pratensis* alliance – in the most humid [41]. It should also be noted that in meadows of the *Molinio-Arrhenatheretea* class, indicator-species of humid and wet habitats predominate [17], which has an impact on the succession changes of grasslands [40]. On the other hand, a gradual impoverishment of the habitat in the study area was observed as shown by the decreasing values of the nitrogen content indicators (Tab. 5). A reduced nitrogen content in the soil was observed not only for all communities but also within the dominant *Poa pratensis-Festuca rubra* community, which resulted from the changes in species composition, the appearance of indicator species with a lower value of that indicator, and a decreasing share of indicator species with a higher value. It should be noted that communities of the *Arrhenatherion* alliance are among the most fertile in the class [41]. This phenomenon is also observed within the same plant communities, which shows a considerable reduction in application of mineral fertilizers by farmers or their abandonment [4,5].

Changes in the vegetation of grasslands in the Bystra valley were primarily caused by the extensification of management, including reduced mowing and absence or reduction of mineral fertilization. The vegetation transformation also resulted from the changes in land use. Furthermore, the directions of grassland succession were caused by the changes in the soil environment, particularly increased humidity and decreased fertility of habitats. Succession resulting from decreased humidity (drying) was also observed in a few cases.

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Zmiany zbiorowisk roślinnych z klasy *Molinio-Arrhenatheretea* w dolinie Bystrej we wschodniej Polsce

Streszczenie

Celem pracy była analiza i ocena zmian zbiorowisk roślinnych z klasy *Molinio-Arrhenatheretea* występujących w dolinie Bystrej we wschodniej Polsce na przestrzeni 38 lat oraz określenie kierunku sukcesji. Badania przeprowadzono w latach 1973 i 2011 na użytkach zielonych należących do rolników. Zmienność florystyczną określono na podstawie struktury fitosocjologicznej i średniej liczby gatunków w poszczególnych zdjęciach badanej fitocenozy. Największą częstością występowania w obu okresach wyróżniało się zbiorowisko *Poa pratensis-Festuca rubra*, którego ponad połowa płatów przetrwała przez okres 38 lat. Nowe zbiorowiska (*Scirpetum silvatici*, *Alopecuretum pratensis*, *Lythro-Filipenduletum*) pojawiły się w siedliskach po ustępujących zbiorowiskach z klasy *Phragmitetea*, w wyniku obniżenia poziomu wody gruntowej. Część powierzchni łąk i pastwisk została przekształcona w pola uprawne, ogrody lub działki budowlane. Wśród wskaźników ekologicznych największe różnice zanotowano w średnich wartościach wskaźnika wilgotności gleby pomiędzy latami, zarówno dla wszystkich analizowanych łąk, jak i dominującego zbiorowiska, co wskazuje na zwiększenie wilgotności siedlisk.