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Floristic diversity and utilization value of the semi-natural grassland in the lower section of the Bug River Valley

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Abstract. Both, floristic diversity and utilization value of the semi-natural grasslands located in the lower section of the Bug River Valley spread from the Długie Kamieńskie to Kossaki were analyzed based on the Braun-Blanquet method and using chosen ecological indicators. In the study area occurred 15 phytocoenoses from the 4 phytosociological classes: *Phragmitetea*, *Molinio-Arrhenatheretea*, *Koelerio glaucae-Corynephoretea canescentis*, *Epilobietea angustifolii*. With the highest frequency (60.6%) appeared patches represented *Molinio-Arrhenatheretea* class and among them the most common were patches of *Alopecuretum pratensis* and *Arrhenatheretum elatioris*. In the same time, these associations presented the most favorable relationship between floristic diversity and the utilization value.

Keywords: utilization value of sward, biodiversity indices, syntaxonomical structure.

1. Introduction

Semi-natural grassland phytocoenoses of the Bug River Valley are among the most valuable plant communities in Poland. In the same time they are poorly recognized. The recent widespread studies had been carried out by Fijłkowski (1966; 1967), Fijłakowski and Chojnacka-Fijałkowska (1990), Fijałkowski and Romer (1999) in the second half of the 20th century. Some elaboration were prepared also by other authors (among others Głowacki, 1988; Głowacki et al., 2002; 2003; Święs and Łuczycka-Popiel, 1999; Sienkiewicz-Paderewska, 2008; 2010; Sienkiewicz-Paderewska and Paderewski, 2011; Kulik et al., 2013; Warda et al., 2015). The analyses of phytosociological materials collected in that area showed a great variety of well-shaped and relatively well-preserved patches of semi-natural grassland plant communities, which represented a wide spectrum of phytocoenoses belonging to different phytosociological classes. Among them were: xerothermic swards of *Festuco-Brometea*, psammophilous – from *Koelerio glaucae-Corynephoretea canescentis*, *Nardo-Callunetea* swards, afterwards, meadows and

pastures of damp and fresh habitats from the *Molinio-Arrhenatheretea*, peatland communities belonging to the *Scheuchzerio-Caricetea nigrae* and finally, communities of tall sedges and grasses from the *Phragmiteteta*. This differentiation results from the features of the geographical and climatic traits of this region and also from the traditional extensive grassland management that still exists in this territory.

Therefore, the purpose of the present elaboration was the determination of the natural and utilization value of the semi-natural grassland phytocoenoses placed in the lower section of the Bug River Valley spread from Długie Kamieńskie to Kossaki.

2. Study area

The study area is placed in the northeast Poland along the left bank of the Bug River Valley from Długie Kamieńskie (52° 40' 24" N, 22° 15' 43 " E) to Kossaki (52° 38' 43" N, 22° 21' 28" E) in the Ceranów gmina. According to the Warsaw Statistical Office (2012), 80.0–89.9 % of the total area of Ceranów gmina is under legal protection due to nature conservation. The investigated area belongs

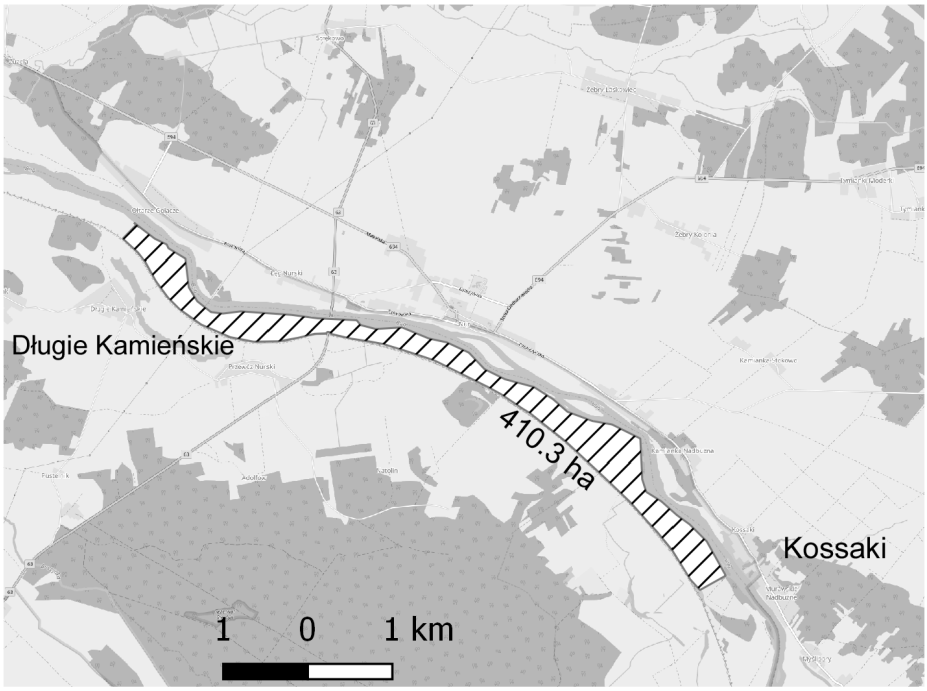

Figure 1. The study area

to the 'Nadburzański Landscape Park' as the Special Area of Conservation and Special Protection Area 'Dolina Dolnego Bugu'. The major part of this surface is covered with permanent grasslands that are either extensively mowed (usually 2 cuts per year) or pastured. The mowing management due to higher humidity prevails from the bridge in Nur towards Kossaki, while pasturing dominates from the bridge towards Długie Kamieńskie (Fig. 1).

According to the physico-geographical regionalization of Poland the investigated area belongs to the mezoregion Dolina Dolnego Bugu (Kondracki, 2002) and is located in the mazowiecko-podlaski climatic region (Okołowicz, 1965) with a predominant influence of the continental climate. The average annual precipitation in this area is 550 mm, snow cover duration varies from 90 to 110 days, and vegetation period lasts on average 210 days. Average annual air temperature is 7.4ºC (Ceranów, 2011).

The study area includes permanent grassland located from the left part of the river bed to the anti-flooding embankment of the river bed. The area is flat with local drains and shelterbelts. The soil moisture conditions are changeable and vary from dry to wet places, locally with stagnant water. Through all the study area the spring flooding of the Bug River was observed.

3. Methods

The research was carried out in the 2011 from the 4 of June to the end of July. Along to the river bed were designated three transects. The 99 phytosociological relevés were recorded on the permanent grasslands in each transect every 100 m (excluding groups of trees, shrubs or local dips) with the use of the Braun-Blanquet (1964) method. The plant species were named according to Mirek et al. (2002). The cover abundance of each species was recorded using the Braun-Blanquet scale (r,+, 1, 2, 3, 4, 5). The mean cover from the cover-abundance scale was transformed as follows: r = 0.1%, + = 0.5%, 1 = 5.0%, 2 = 17.5%, 3 = 37.5%, 4 = 62.5%, 5 = 87.5%. The location of relevés was described using GPSMAP 76CSx receiver. In each relevé the sod cover and the height of the sward were measured in triplicate using a centimeter scale according to the Kostuch (1982) method. The classification process of the recorded phytocoenoses and the name of syntaxa were followed by Matuszkiewicz (2008) and Nowiński (1967). For each of the characterized community the following biodiversity indices were calculated: species richness (i.e. total number of species in given community), mean number of species per phytosociological relevé, the Shannon-Wiener index H'. As the indices of the utilization value were used: yield calculated using the Kostuch method and

utilization value score (UVS) according to the Filipek (1972) method. The sward quality estimated with the use of the Filipek method was considered as: very good if the UVS number ranged from 8.1 to 10.0; as a good when it ranged from 6.1–8.0; poor if it ranged from 3.1–6.0 and as a very poor when it equaled less than 3.0.

The PCA analysis was used in the aim of presentation the relationship between the utilization value score (UVS) and the factors: 'sod cover' and 'height of the sward' which influence yield (according to Kostuch method). The yield is the product of these two factors thus, higher yield results directly from the higher values of both of them. These three variables were standardized before the PCA analysis. All calculations were made using the R language (R Core Team, 2016). The standardization was done by 'scale' function, the PCA analysis and the corresponding biplot chart according Sienkiewicz-Paderewska and Paderewski (2015).

4. Results and discussion

There were described 15 plant communities (there were associations mainly) in the examined area belonging to 4 phytosociological classes: *Phragmitetea* (7), *Molinio-Arrhenatheretea* (6), *Koelerio glaucae-Corynephoretea canescentis* (1), *Epilobietea angustifolii* (1). The syntaxonomical positions of the described communities are included in the Table 1. The manner of data collection (system of the tree transects parallel to the river bed and collecting data every stable distance) allowed to estimate the frequency of the communities in the examined area. With the highest frequency appeared communities from the *Molinio-Arrhenatheretea* class (60.6%). Among them the patches of the *Arrhenatheretum elatioris* (24.2%) and *Alopecuretum pratensis* associations (17.2%) predominated. The communities from the *Phragmitetea* class constituted next 31.3% of the noted communities (22.2% records from the *Magnocaricion* and 9.1% from *Phragmition*). The domination of the communities from *Phragmitetea* and *Molinio-Arrhenatheretea* classes was expected because the investigation was conducted in the floodplain between river bed and the embankment of the river bed. Though the investigation concerned relatively small area, the examined phytocoenoses, consisted of a total of 177 species of vascular plants from 32 botanical families. The complete botanical compositions of the associations examined in the lower section of the Bug River Valley from Długie Kamieńskie to Kossaki are included in the Tables 2–4.

Table 1. The syntaxonomical position of the analyzed plant communities

Class	Order	Alliance	Association/Community
Phragmitetea R.Tx. et PRSG 1942	*Phragmitetalia* (Koch 1926)	*Phragmition* (Koch 1926)	*Acoretum calami* Kobendza 1948
			Eleocharitetum palustris Sennikow 1919
			Glycerietum maximae Hueck 1931
		Magnocaricion Koch 1926	*Caricetum gracilis* (Graeben. et Hueck 1931) R. Tx. 1937
			Caricetum vulpinae (Nowiński 1928)
			Phalaridetum arundinaceae (Koch 1926 n.n.) Libb 1931
		Sparganio-Glycerion fluitantis Br.-Bl. et Siss. inn Boer 1942	*Sparganio-Glycerietum fluitantis* Br.-Bl. 1925
Molinio-Arrhenatheretea R.Tx. 1937	*Trifolio fragiferae-Agrostietalia stoloniferae* R. Tx. 1970	*Agropyro-Rumicion crispi* Nordh. 1940 em. R. Tx. 1950	*Ranunculo-Alopecuretum geniculati* R.Tx. 1937
			Agrostis stolonifera-Potentilla anserina Oberd. 1979/1980 in Oberd. 1983
	Molinietalia caeruleae W. Koch 1926	*Calthion palustris* R. Tx. 1936 em. Oberd. 1957	*Deschampsietum caespitosae* Horvatić 1930
		Alopecurion pratensis Pass. 1964	*Alopecuretum pratensis* (Regel. 1925) Steffen 1931
	Arrhenatheretalia (Pawł. 1928)	*Arrhenatherion elatioris* (Br.-Bl. 1925) Koch 1926	*Arrhenatheretum elatioris* Br.-Bl. ex Scgerr. 1925
		Cynosurion R. Tx. 1947	*Lolio-Cynosuretum* R. Tx. 1937
Epilobietea angustifolii R. Tx. et Prsg 1950	*Atropetalia* Vlieg.1937	*Epilobion angustifolii* (Růbel 1933) Soò 1933	*Calamagrostietum epigeji* Juraszek 1928
Koelerio glaucae--Corynephoretea canescentis (Klika in Klika et Novak 1941)			

The noted associations of the *Phragmitetea* class were represented by a few to dozen patches. The communities of tall grasses and sedges are usually poor in species and it was also in that case (Tables 2, 5). On the other hand, the stated species richness of them was clearly higher that the number of species recorded in corresponding communities in the Urzędówka valley by Mosek and Miazga (2008) or in the Mogilnica valley by Kryszak et al. (2007). The communities founded during presented studies, showed in general a large share of characteristic species from *Phragmitetea* class in syntaxonomical structure (Table 5). The exceptions were *Caricetum vulpine* and *Eleocharitetum palustris* which included relatively large percentage of species from *Molinio-Arrhenatheretea* class. The large share of species from outside the *Phragmitetea* class in the *Caricetum vulpine* had been also stated before in other localizations by Mosek and Miazga (2008) and Sienkiewicz-Paderewska (2008). The *Eleocharitetum palustris* analyzed in the present studies included relatively large number and cover of the species from the *Trifolio fragiferae – Agrostietalia stoloniferae* (Tables 2, 5). Similar form of this association had observed Mosek and Miazga (2008) in the Urzędówka Valley.

The used biodiversity indices showed the highest values for *Alopecuretum pratensis*, *Arrhenatheretum elatioris* and *Lolio-Cynosuretum* belonging to the *Molinio-Arrhenatheretea* class. It is well-known that a large number of species in the floristic composition of syntaxon should not reflect a good ecological shape. Often, it is typical for the initial or transitory stages of secondary succession (Kryszak and Kryszak, 2005) and only careful analysis of botanical composition and syntaxonomical structure of the association helps to identify of reasons. The *Alopecuretum pratensis* presented the highest values of the biodiversity indices among described phytocoenoses and was the most abundant association among communities represented damp meadows in the examined area. In many other papers *Alopecuretum pratensis* was characterized as common but of poor biodiversity (Trąba, 1994; Ratyńska, 2001; Trąba and Wolański, 2011) while in the examined association some patches consisted of about 50 species and the species richness of this association amounted 102 (Table 5). Furthermore, the recorded species belonged mostly to the characteristic combination of *Alopecuretum pratensis* (Matuszkiewicz, 2008). In reference, it is worth underline that also *Alopecuretum pratensis* analyzed by Sienkiewicz-Paderewska and Paderewski (2011) in another part of the Bug River Valley showed high values of biodiversity indices. The reason may be traditional extensive management methods using by farmers in this region of Poland and still natural spring flooding. It can be assumed that the phytocenoses of *Alopecuretum pratensis* described in the Bug River Valley are relatively undisturbed and not changed by i.e. undersowing and drainage. The low share of synanthropic

Table 2. Phytosociological characteristic of the associations examined in the lower section of the Bug River Valley (from Długie Kamieńskie to Kossaki) belonging to the *Phragmitetea* class

Associations from the *Phragmitetea* class	*Phragmition*					*Magnocaricion*						*Sparganio-Glycerion fluitantis*	
	Ac	*Ep*		*Gm*		*Cg*		*Cv*		*Pa*		*S-Gf*	
No. of association	1	2		3		4		5		6		7	
No. of phytosociological relevés	1	2		7		12		3		4		3	
Synthetic indicators (D – mean cover, F – frequency, C – constancy)	D	D	F	D	C	D	C	D	F	D	F	D	F
ChAss. of the examined associations													
Acorus calamus	8750												
Eleocharis palustris		5130	100.0			130	II	30	66.7	10	25.0	1250	33.3
Glyceria maxima	8750			8420	V	150	II	1250	33.3				
Carex gracilis	1500			1430	IV	8580	V	1000	66.7	30	50.0	80	33.3
Carex vulpina		30	50.0	10	I	170	II	6420	100				
Phalaris arundinacea				630	II					8750	100.0		
Glyceria fluitans				250	I	750	II	500	33.3	10	25.0	8750	100.0
ChAll. *Phragmition*													
Equisetum fluviatile	3750			640	III	880	II			60	25.0		
Sium latifolium				20	II	130	II						

Table 2 – cont.

Associations from the *Phragmitetea* class	*Phragmition*					*Magnocaricion*						*Sparganio-Glycerion fluitantis*	
	Ac	*Ep*		*Gm*		*Cg*		*Cv*		*Pa*		*S-Gf*	
No. of association	*1*	*2*		*3*		*4*		*5*		*6*		*7*	
No. of phytosociological relevés	1	2		7		12		3		4		3	
Synthetic indicators (D – mean cover, F – frequency, C – constancy)	D	D	F	D	C	D	C	D	F	D	F	D	F
Alisma plantago-aquatica				20	II			20	33.3				
ChAll. *Magnocaricion*													
Iris pseudacorus				20	II	900	II	20	33.3				
Lysimachia thyrsiflora				1210	III	280	III			10	25.0		
Galium palustre		150	100.0	50	II	510	III	500	33.3	60	25.0	500	33.3
Carex vesicaria				10	I	330	I	30	66.7	10	25.0	1270	66.7
Poa palustris		30	50.0			330	I	30	66.7	80	50.0		
ChCl. *Scheuchzerio-Caricetea nigrae*													
Juncus articulatus	50	30	50.0			150	I	30	66.7				
Stellaria palustris								500	33.3				
Veronica scutellata								80	33.3				
Carex nigra						<1	I	20	33.3				

ChCl. ***Molinio-Arrhenatheretea***													
Cardamine pratensis		30	50.0	1130	I	10	II					20	33.3
Cerastium holosteoides						320	I			10	25.0		
Poa pratensis		1880	50.0					20	33.3				
Festuca pratensis										380	25.0	20	33.3
Rumex acetosa						10	II			60	25.0		
Ranunculus acris				10	I	20	I						
Agrostis gigantea				40	I			20	33.3				
Lathyrus pratensis				40	I								
Vicia cracca				10	I	<1	I	20	33.3	10	25.0		
Plantago lanceolata		30	50.0										
Poa trivialis						<1	I						
Phleum pratense										0.0	25.0		
ChO. ***Molinietalia***													
Alopecurus pratensis				10	I	<1	I	1000	66.7	380	25.0		
Caltha palustris				10	I	330	II	20	33.3				
Deschampsia caespitosa		130	50.0	250	I	10	II	100	66.7			520	66.7
Myosotis palustris		50	100.0	101	I	130	II					30	66.7
Galium boreale						30	I	80	33.3	10	25.0		
Filipendula ulmaria						30	II	80	33.3				
Equisetum palustre		30	50.0			30	II						
Cnidium dubium								80	33.3				
Lathyrus palustris								20	33.3				
Taraxacum palustre								20	33.3				
Gratiola officinalis								20	33.3				

Table 2 – cont.

Associations from the *Phragmitetea* class	*Phragmition*					*Magnocaricion*						*Sparganio-Glycerion fluitantis*	
	Ac	*Ep*		*Gm*		*Cg*		*Cv*		*Pa*		*S-Gf*	
No. of association	1	2		3		4		5		6		7	
No. of phytosociological relevés	1	2		7		12		3		4		3	
Synthetic indicators (D – mean cover, F – frequency, C – constancy)	D	D	F	D	C	D	C	D	F	D	F	D	F
ChO. *Plantaginetalia majoris*													
Poa annua								20	33.3				
Plantago major		10	50.0										
ChO. *Trifolio fragiferae-Agrostietalia stoloniferae*													
Potentilla anserina		7750	100.0			880	III	500	33.3	10	25.0	170	66.7
Ranunculus repens		50	100.0			490	III	5750	100			20	33.3
Agrostis stolonifera								2250	33.3			2250	33.3
Trifolium fragiferum		2000	100.0			<1	I						
Alopecurus geniculatus												1250	33.3
Lysimachia nummularia				270	III	80	III	180	100	10	25.0	20	33.3
Carex hirta		50	100.0	40	I	<1	I			90	75.0	20	33.3
Inula britannica		30	50.0										
Rumex crispus												20	33.3
Carex cuprina												20	33.3

Others													
Mentha aquatica		6250	100.0	630	I	40	III	30	66.7			100	66.7
Carex praecox								80	33.3	2190	25.0		
Thalictrum aquilegii-folium						570	I						
Stellaria graminea				10	I	130	I						
Rumex hydrolapathum				30	III	30	I						
Potentilla erecta		30	50.0			10	I	30	66.7	10	25.0		
Equisetum arvense		30	50.0					20	33.3				
Carex ovalis		30	50.0					20	33.3				
Symphytum officinale						10	I						
Selinum carvifolia								20	33.3				
Senecio congestus						<1	I						
Rumex confertus										10	25.0		

Ac – Acoretum calami, *Ep – Eleocharitetum palustris*, *Gm – Glycerietum maximae*, *Cg – Caricetum gracilis*, *Cv – Caricetum vulpine*, *Pa – Phalaridetum arundinaceae*, *S-Gf – Sparganio-Glycerietum fluitantis*

Sporadic species: **ChAll**. ***Phragmition***: *Rorippa amphibia* (*3*, *4*); *Phragmites australis* (*3*); **ChAll**. ***Magnocaricion***: *Carex appropinquata* – (*4*), *Carex rostrata* – (*3*); **ChAll**. ***Sparganio-Glycerion fluitantis***:*Veronica beccabunga* (*3*); **ChCl**. ***Scheuchzerio-Caricetea nigrae***: *Comarum palustre* (*4*); **ChCl**. ***Molinio-Arrhenathereteа***: *Ranunculus acris* – (*3*,*4*), *Lathyrus pratensis* – (*3*), *Poa trivialis* – (*4*); *ChO*. *Molinietalia*: *Juncus effusus* – (*2*), *Lysimachia vulgaris* – (*1*,*3*,*4*), *Galium uliginosum* – (*3*,*4*); **ChO**. ***Trifolio fragiferae-Agrostietalia stoloniferae***: *Agropyron repens* – (*4*), *Festuca arundinacea* – (*4*); **Others**: *Thalictrum aquilegifolium* – (*4*), *Stellaria graminea* – (*3*,*4*), *Symphytum officinale* – (*4*), *Senecio congestus* – (*4*).

Table 3. Phytosociological characteristic of the associations examined in the lower section of the Bug River Valley (from Długie Kamieńskie to Kossaki) belonging to the *Molinio-Arrhenatheretea* class

Associations from the *Molinio-Arrhenatheretea* class	*Trifolio fragiferae-Agrostietalia stoloniferae*			*Molinietalia*				*Arrhenatheretalia*			
	R-Agen		*AsPa*	*Dc*		*Ap*		*Ae*		*LC*	
No. of the association	1		2	3		4		5		6	
No. of phytosociological relevés	3		1	9		17		24		6	
Synthetic indicators (D – mean cover, F – frequency, C – constancy)	D	F	D	D	C	D	C	D	C	D	C
ChAss., DAss. of examined associations											
Alopecurus pratensis			3750	2678	V	4679	V	484	III		
Glechoma hederacea				39	II	544	III	221	III		
Deschampsia caespitosa	500	33.3		6194	V	982	IV	175	II	300	III
Arrhenatherum elatius						53	II	5838	V	42	I
Pastinaca sativa	33	66.7									
Bellis perennis						3	I				
Leontodon autumnalis						15	II	50	II	550	IV
Trifolium repens				883	IV	156	III	96	II	3467	V
Lolium perenne						35	II	4	I	67	IV
Potentilla anserina	250	100.0	1500	44	III	3	I			292	II
Alopecurus geniculatus	6417	100.0									
Potentilla reptans			50			3	I	2	I		
Agropyron repens	17	33.3		6	I	6	I				

ChO. *Trifolio fragiferae -Agrostietalia stoloniferae*											
Ranunculus repens	50	100.0	50	3506	V	1082	IV	167	II	875	II
Carex hirta	50	100.0		783	III	371	IV	44	IV	83	V
Lysimachia nummularia			1500	350	III	318	III	190	II		
Agrostis stolonifera			3750					10	I	50	II
Trifolium fragiferum	100	66.7								258	II
Festuca arundinacea						18	I			50	II
Inula britannica	17	33.3				6	I	2	I	8	I
Carex cuprina										8	I
Juncus compressus	17	33.3									
ChO. *Molinietalia*											
Galium boreale			50	794	IV	1382	IV	1683	IV	258	II
Polygonum bistorta				11	II	1024	III	15	I		
Juncus effusus	2267	66.7									
Lychnis flos-cuculi				56	IV	106	III	73	II	8	I
Bromus racemosus				11	II	106	I	4	I		
Equisetum palustre	17	33.3		33	II	21	I				
Cirsium palustre						24	II				
Filipendula ulmaria				11	II	9	II				
Myosotis palustris	33	66.7				3	I				
Betonica officinalis						4	I	2	I		
Lotus uliginosus						3	I	2	I		
Geranium palustre	17	33.3									
Crepis paludosa	17	33.3									

Table 3 – cont.

Associations from the *Molinio-Arrhenatheretea* class	*Trifolio fragiferae-Agrostietalia stoloniferae*			*Molinietalia*				*Arrhenatheretalia*			
	R-Agen		*AsPa*	*Dc*		*Ap*		*Ae*		*LC*	
No. of the association	1		2	3		4		5		6	
No. of phytosociological relevés	3		1	9		17		24		6	
Synthetic indicators (D – mean cover, F – frequency, C – constancy)	D	F	D	D	C	D	C	D	C	D	C
ChO. *Arrhenatheretalia*											
Achillea millefolium				33	II	326	IV	817	IV	83	V
Dactylis glomerata						32	I	778	IV		
Trisetum flavescens						21	I	750	III	2	I
Leucanthemum vulgare				22	III	50	III	406	IV	8	I
Galium mollugo						3	I	10	I	1125	I
Taraxacum officinale				22	III	21	III	85	II	33	IV
Lotus corniculatus						18	I	21	II	25	III
Veronica serpyllifolia				11	II	30	III	6	I	8	I
Campanula patula						12	II	21	III	8	I
ChCl. *Molinio-Arrhenatheretea*											
Holcus lanatus				17		1024	III	2700	V	625	I
Rumex acetosa				528	V	1621	V	1396	V	25	III
Plantago lanceolata				1094	IV	503	V	1517	V	1850	V
Ranunculus acris				683	V	1988	V	471	V	308	IV
Phleum pratense				2067	IV	1009	IV	381	II	1167	II
Poa pratensis				261	IV	1368	V	517	IV	1750	III

Festuca pratensis	500	33.3		628	IV	1788	IV	248	II	25	III
Vicia cracca				22	III	344	III	706	II	8	I
Trifolium pratense				17	II	262	IV	469	III	67	IV
Prunella vulgaris						18	I			650	IV
Festuca rubra				167	I	53	II	65	I	8	I
Centaurea jacea				11	II	26	II	40	III	250	I
Cardamine pratensis	17	33.3		172	II	29	II	2	I	50	II
Lathyrus pratensis				6	I	12	II	75	I	8	I
Poa trivialis				6	I	115	II	2	I		
Cerastium holosteoides				17	II	3	I	33	II	33	IV
Agrostis gigantea				17	II	3	I	6	I		
Euphrasia rostkoviana										17	II
ChCl. *Phragmitetea*											
Galium palustre	50	100.0		6	I	3	I	2	I	1133	II
Glyceria fluitans	2250	33.3									
Lysimachia thyrsiflora						397	I				
Poa palustris	500	33.3				94	I				
Carex gracilis			50	200	II	9	I	2	I		
Eleocharis palustris	583	66.7									
Carex vulpina			50	6	I	12	II			8	I
ChCl. *Scheuchzerio-Caricetea nigrae*											
Carex nigra	2250	33.3						3	I	8	I
Juncus articulatus	517	66.7								83	II
ChCl. *Nardo-Callunetea*											
Potentilla erecta	83	33.3		367	III	32	I	13	II		
Luzula campestris						112	II	73	II	17	II

Table 3 – cont.

Associations from the *Molinio-Arrhenatheretea* class	*Trifolio fragiferae-Agrostietalia stoloniferae*			*Molinietalia*				*Arrhenatheretalia*			
	R-Agen		*AsPa*	*Dc*		*Ap*		*Ae*		*LC*	
No. of the association	1		2	3		4		5		6	
No. of phytosociological relevés	3		1	9		17		24		6	
Synthetic indicators (D – mean cover, F – frequency, C – constancy)	D	F	D	D	C	D	C	D	C	D	C
ChCl. *Koelerio glaucae-Corynephoretea canescentis*											
Galium verum				339	II	509	III	992	IV		
Cerastium arvense						3	I	33	II		
ChCl. *Festuco-Brometea*											
Carex praecox				61	II	121	II	21	II	8	I
ChCl. *Agropyretea*											
Equisetum arvense				6	I	94	I	21	II	42	V
Others											
Stellaria graminea	17	33.3		1544	V	1353	V	1396	V	667	II
Anthoxanthum odoratum				44	III	529	III	2246	V	258	II
Veronica chamaedrys				6	I	350	III	1942	V	42	I
Agrostis capillaris				1000	II	91	I	381	II	1725	IV
Mentha aquatica	3500	100.0				6	I				
Carex ovalis			8750			6	I	6	I	8	I
Rumex confertus						521	III	6	I		
Trifolium dubium						224	I	31	II	8	I
Rhinanthus minor				178	II	3	I	25	II	8	I

Mentha arvensis						3	I			258	II
Geum rivale				11	II	9	I	2	I		
Rorippa palustris	17	33.3									
Achillea salicifolia	17	33.3									
Polygonum persicaria	17	33.3									

R–Agen – Ranunculo-Alopecuretum geniculati; *AsPa* – zb. *Agrostis stolonifera-Potentilla anserina*; *Dc -Deschampsietum caespitosae*; *Ap – Alopecuretum pratensis*;, *Ae – Arrhenatheretum elatioris*; *LC – Lolio-Cynosuretum*

Sporadic species: **ChO**. ***Plantaginetalia***: *Plantago major* (*3*,*6*), *Poa annua* (*6*); **ChO**. ***Molinietalia***: *Cirsium oleraceum* (*5*), *Ononis arvensis* (*6*), *Taraxacum palustre* (*3*,*4*), *Carex hartmanii* (*3*); **ChO**. ***Arrhenatheretalia***: *Cynosurus cristatus* (*4*,*6*), *Crepis biennis* (*4*,*5*), *Heracleum sphondylium* (*4*,*5*), *Saxifraga granulata* (*4*); **ChCl**. ***Molinio-Arrhenatheretea***: *Leontodon hispidus* (*4*,*5*), *Avenula pubescens* (*5*); *Rorippa amphibia* (*3*,*4*), *Phalaris arundinacea* (*2*,*3*,*4*), *Iris pseudacorus* (*4*), *Veronica beccabunga* (*4*), *Carex rostrata* (*3*); **ChCl**. ***Nardo-Callunetea***: *Hieracium pilosella* (*4*,*5*,*6*); **ChCl**. ***Koelerio glaucae-Corynephoretea canescentis***: *Cerastium semidecandrum* (*4*,*5*,*6*), *Dianthus deltoides* (*5*), *Armeria maritima* (*5*), *Hypochoeris radicata* (*4*,*5*,*6*), *Sedum acre* (*6*), *Vicia lathyroides* (*4*), *Spergula morisonii* (*6*); **ChCl**. ***Festuco-Brometea***: *Filipendula vulgaris* (*4*); **ChCl**. ***Stellarietea mediae***: *Vicia angustifolia* (*4*); **ChCl**. ***Epilobietea angustifolii***: *Fragaria vesca* (*4*,*5*), *Calamagrostis epigejos* (*6*); **ChCl**. ***Artemisietea vulgaris***: *Urtica dioica* (*4*,*5*), *Cirsium arvense* (*4*), *Galium aparine* (*4*), *Rumex obtusifolius* (*4*), *Linaria vulgaris* (*4*); **ChCl**. ***Agropyretea***: *Poa angustifolia* (*4*); **Others**: *Rubus idaeus* (*4*,*5*), *Symphytum officinale* (*5*), *Briza media* (*5*), *Thalitrum aquilegiifolium* (*3*,*4*), *Pimpinella saxifraga* (*5*), *Quercus robur* (*4*,*5*), *Plantago media* (*5*), *Polygonum hydropipper* (*4*), *Tilia cordata* (*5*), *Ranunculus bulbosus* (*5*), *Frangula alnus* (*5*), *Medicago lupulina* (*6*), *Veronica arvensis* (*5*), *Capsella bursa-pastoris* (*3*), *Salix repens subspec. rosmarinifolia* (*5*), *Gallopia convolvulus* (*5*), *Rumex hydrolaphatum* (*5*), *Chenopodium album* (*4*).

species confirms this hypothesis. For these reasons the *Alopecuretum* described in the Bug River Valley should be treated as the example of this associations being in a good ecological shape and in such form is worth of monitoring and protection. As focused Trąba and Wolański (2011) well-shaped *Alopecuretum pratensis* naturally occurring in the floodplains becoming less and less frequent in Poland.

Arrhenatheretalia communities were represented by the *Arrhenatheretum elatioris* and *Lolio-Cynosuretum cristati* associations in the surveyed area. The patches of *A. elatioris* have been appeared with the highest frequency there. The *A. elatioris* is still widespread in Poland and is also internally highly differentiated which manifests itself in the occurrence of a large number of sub-associations and variants (Trąba et al., 2003; Kryszak et al., 2012). In the analyzed association was clearly marked the share of *Holcus lanatus* and *Anthoxanthum odoratum*, with stable persistency and relatively large mean cover of *Galium boreale*, *Galium verum*, *Rumex acetosa* and *Plantago lanceolata* (Table 3). Thus, the character of the described *A. elatirois* remind its sub-variant with *Holcus lanatus* denoted by Brągiel et al. (2016) in the area of Bukowskie Foothils. The botanical composition of this association indicates extensive grassland management in the examined localization.

The patches of the *Lolio-Cynosuretum* were not frequent in the studied part of the Bug River Valley (9.1%) and did not present its well-developed form which is usually a little bit more diverse and of much higher utilization value (Trąba et al., 2008). In the eastern part the Bug River Valley the *Lolio-Cynosuretum* had presented much higher biodiversity (H' amounted 3.44, the total number of species was 123) and a greater variety of the characteristic species (Sienkiewicz-Paderewska, 2008). Similarly, in the San River Valley Trąba et al. (2008) founded well-developed form of *Lolio-Cynosuretum* represented by five sub-associations. However, the number of relevés collected between Długie Kamieńskie and Kossaki was limited.

The *Deschampsietum caespitosae* probably evolved on the basis of meadow communities that previously were utilized more intensively. The observed form of this association seems to be a combined effect of improper land management and the expansive character of *Deschampsia caepitosa* (Kryszak et al., 2009).

The patches of the low trampled swards belonging to the *Trifolio fragiferae-Agrostietalia stoloniferae* occurred marginally, in places with water stagnating for a long time during vegetation period. In their composition dominated creeping species like *Alopecurus geniculatus*, *Agrostis stolonifera*, *Lysimachia nummularia* and also *Carex ovalis* (Table 3).

Table 4. Phytosociological characteristic of the associations examined in the lower section of the Bug River Valley (from Długie Kamieńskie to Kossaki) belonging to the *Epilobietea angustifolii* and *Koelerio glaucae-Corynephoretea canescentis* class

Communities from the *Epilobietea angustifolii* and *Koelerio glaucae-Corynephoretea canescentis* class	*Calamagrostietum epigeji*	*Koelerio glaucae-Corynephoretea canescentis*	
No. of phytosociological relevés	1	7	
Synthetic indicators (D – mean cover, F – frequency, C – constancy)	D	D	C
ChAss. ***Calamagrostietum epigeji***			
Calamagrostis epigejos	6750		
ChCl. ***Koelerio glaucae-Corynephoretea canescentis***			
Sedum acre	3750	2614	III
Festuca ovina	250	2221	II
Corynephorus canescens		1207	III
Potentilla collina	150		
Thymus serpyllum	50	29	II
Plantago arenaria		21	II
ChCl. ***Nardo-Callunetea***			
Hieracium pilosella	250	36	II
ChCl. ***Molinio-Arrhenatheretea***			
Rumex acetosa	3750		
Plantago lanceolata	50	50	II
ChO. ***Arrhenatheretalia***			
Lotus corniculatus	50		
Others			
Helichrysum arenarium		1950	II
Erigeron acris	50	764	II

Sporadic species: **ChCl**. ***Koelerio glaucae-Corynephoretea canescentis***: *Trifolium arvense* (*2*), *Cerastium semidecandrum* (*2*), *Spergula morisonii* (*2*), *Jasione montana* (*2*), *Potentilla argentea* (*2*), *Rumex acetosella* (*2*), *Galium verum* (*2*); **ChCl**. ***Festuco-Brometea***: *Potentilla arenaria* (*2*); **ChCl**. ***Molinio--Arrhenatheretea***: *Cerastium holosteoides* (*2*), *Phleum pratense* (*2*); **ChO**. ***Trifolio fragiferae-Agrostietalia stoloniferae***: *Carex hirta* (*1*,*2*); **ChO**. ***Arrhenatheretalia***: *Achillea millefolium* (*1*,*2*); **Others**: *Equisetum arvense* (*1*,*2*), *Trifolium dubium* (*1*), *Veronica dillenii* (*1*), *Myosotis stricta* (*2*).

The communities belonging to the *Koelerio glaucae-Corynephoretea canescentis* class were less frequent in the studied area and were represented by the small patches of 10–25 m^2. However, it was rather expectable, because the research was conducted close to the river bed, in the floodplain. It is worth men-

Table 5. Syntaxonomical structure and biodiversity indices of the associations examined in the lower section of the Bug River Valley (from Długie Kamieńskie to Kossaki)

Syntaxons	The share of the characteristic species for classes (%)					*Synanthropization	Biodiversity indices			Utilization value	
	Ph	*MA*	*Kg Cc*	*Ea*	others		species richness	mean number of species per relevé	H'	UVS	yield of hay t ha^{-1}
Phragmitetea*, *Phragmition											
Acoretum calami	93.6	6.2	0.0	0.0	0.2	0.0	6	6.0	1.38	1.7	2.4
Eleocharitetum palustris	22.4	51.0	0.0	0.0	26.7	<1.0	22	15.0	1.66	2.1	1.8
Glycerietum maximae	83.7	12.0	0.0	0.0	4.3	0.0	32	8.3	1.71	3.6	3.8
Magnocaricion											
Caricetum gracilis	79.5	15.0	0.0	0.0	5.5	0.0	47	9.1	2.17	0.6	4.3
Caricetum vulpine	47.1	48.9	0.0	0.0	4.0	<1.0	37	17.3	2.10	2.2	2.8
Phalaridetum arundinaceae	74.0	7.9	0.0	0.0	18.1	0.0	22	7.5	1.00	6.9	2.7
Sparganio-Glycerietum fluitantis	72.8	26.6	0.0	0.0	0.6	0.0	18	6.0	1.58	4.0	2.0
Molinio-Arrhenatheretea											
Trifolio fragiferae-Agrostietalia stoloniferae*, *Agropyro-Rumicion crispi											
Ranunculo-Alopecuretum geniculati	16.8	51.3	0.0	0.0	31.9	0.0	29	15.7	2.11	3.2	2.2
Agrostis stolonifera--Potentilla anserina	0.8	54.5	0.0	0.0	44.8	0.0	11	11.0	1.48	3.9	2.1

Molinietalia*, *Calthion											
Deschampsietum caespitosae	1.0	84.8	1.4	0.0	12.9	0.0	56	21.2	2.65	3.7	4.5
Molinietalia*, *Alopecurion											
Alopecuretum pratensis	2.0	81.0	2.0	0.0	15.0	1.3	102	27.7	3.24	5.4	3.8
Arrhenatheretalia*, *Arrhenatherion											
Arrhenatheretum elatioris	0.0	73.7	3.8	0.2	22.2	0.4	87	24.3	3.00	5.6	4.6
Arrhenatheretalia*, *Cynosurion											
Lolio-Cynosuretum	5.8	77.3	0.3	0.2	16.3	0.4	65	22.8	3.00	4.9	2.3
Epilobietea angustifolii											
Calamagrostietum epigeji	0.0	27.5	28.5	34.4	9.7	42.0	16	16.0	1.82	1.5	0.7
Koelerio glaucae-Corynephoretea canescentis	0.0	0.9	68.4	0.0	30.7	0.2	23	20.0	1.70	1.0	0.4

Ph – Phragmitetea; MA – *Molinio-Arrhenatheretea*; KgCc – *Koelerio glaucae-Corynephoretea canescentis*; *Ea – Epilobietea angustifolii*

* Synanthropisation means sum of the percentage share of the species belonging to the following classes: *Stellarietea mediae*, *Agropyretea intermedio-repentis*, *Epilobietea angustifolii*, *Artemisietea vulgaris*, H' – Shannon-Wiener index, UVS – Utilization Value Score.

tioning that in the Bug River valley can be easily found psammophilous swards enormously naturally valuable, extremely floristically interested and represented by well-shaped patches covering large surfaces (Głowacki, 1988; Sienkiewicz-Paderewska, 2010).

The *Calamagrostietum epigeji* was represented by the one patch only and reflected the process of colonization of the low psammophilous sward by *Calamagrostis epigejos* (Table 4).

The analysis of the syntaxonomical structure of the associations examined in the Bug River Valley from Długie Kamieńskie to Kossaki showed that the associations from the *Phragmitetea* class as well as from the *Molinietalia* and *Arrhenatheretalia* orders had high percentage of species representing characteristic combinations (>70%) which indicates a relatively good ecological shape of these phytocoenoses.

The obtained values of UVS ranged from 0.6 for *Caricetum gracilis* to 6.9 for *Phalaridetum arundinaceae* (Table 5), though in most cases the sward quality of the examined communities has been defined as a poor. The *Alopecuretum pratensis* and *Arrhenatheretum elatioris* associations showed relatively good relation between their utilization and natural value.

Based on the constructed biplot (Fig. 2), it was stated that higher values of sod cover were usually not accompanied by the greater height of the sward (the arrows form an obtuse angle in the biplot). Therefore, the higher yield was usually obtained either by higher sward or by higher sod cover of the sward. The common occurrence of both these parameters was limited.

In details, there was found that the *Lolio-Cynosuretum* demonstrated the largest values of the sod cover and, in the same time the relatively high UVS were retained despite the shorter sward (Fig. 2). The relatively high yield of the *Arrhenatheretum elatioris* resulted either from the large sod cover or great height of the sward. Although, the higher yield was caused rather by greater height of the sward than by higher sod cover. Similarly, the *Phalaridetum arundinaceae* had rather greater height and worse sod cover but with maintaining relatively high UVS. The patches of the *Deschampsietum caespitosae* demonstrated larger values of sod cover. However, lower sward resulted sometimes in lower yield and thus, the UVS varied across the patches. On the contrary, the *Caricetum gracilis* patches were characterized in some cases by the relatively higher sward, but it was connected with lower sod cover, and thus, relatively low UVS were denoted for all patches of this association. In the *Glycerietum maximae* the higher UVS resulted from the larger height of the sward. As expected, the patches represented the *Koelerio glaucae-Corynephoretea canescentis* class, achieved extremely low UVS.

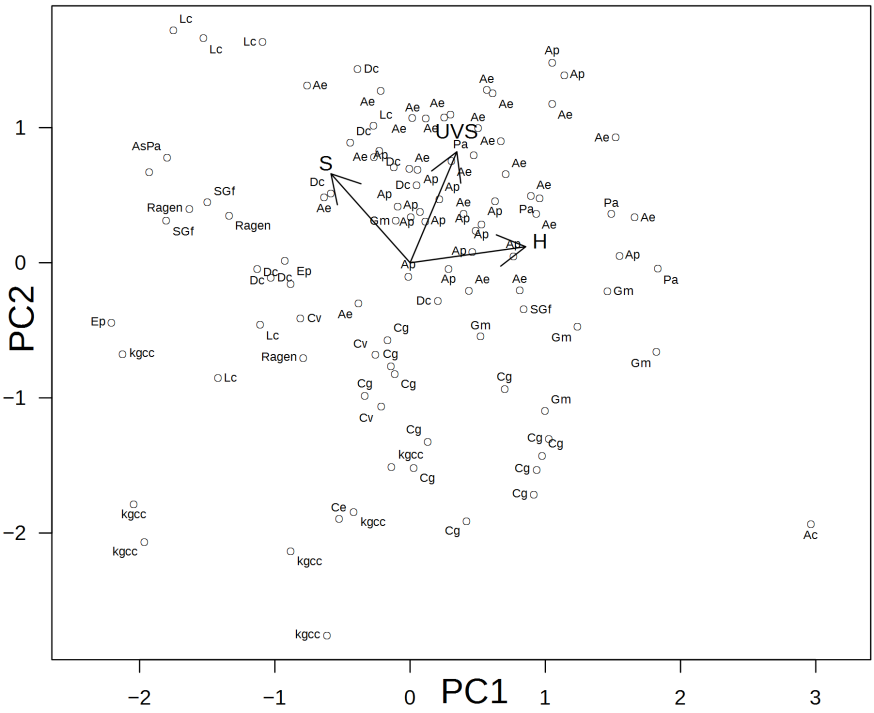

Figure 2. The PCA biplot for the standardized utilization value score, sod cover and height of the sward of the examined patches belonging to different communities
Ac – Acoretum calami; *Ep – Eleocharitetum palustris*; *Gm – Glycerietum maximae*; *Cg – Caricetum gracilis*; *Cv – Caricetum vulpine*; *Pa – Phalaridetum arundinaceae*; *SGf – Sparganio-Glycerietum fluitantis*; *Ragen – Ranunculo-Alopecuretum geniculati*; *AsPa* – community with *Agrostis stolonifera-Potentilla anserina*; *Dc -Deschampsietum caespitosae*; *Ap – Alopecuretum pratensis*; *Ae – Arrhenatheretum elatioris*; *Lc – Lolio--Cynosuretum*; *Ce – Calamagrostietum epigeji*; *Kgcc – Koelerio glaucae-Corynephoretea canescentis*. The first principal component retains 40% of the variability of the three traits, whereas the second principal component – 38%. The traits were denoted by arrows (H – height of the sward, S – sod cover, UVS – utilization value score). The points represent the patches assigned to the appropriate association.

4. Conclusions

- Along the described section of the Bug River Valley the most abundant were phytocoenoses of the *Molinio-Arrhenatheretea* class. Among them the most common were *Alopecuretum pratensis* and *Arrhenatheretum elatioris* communities.

- Floristic diversity of the examined phytocoenoses greatly varied but in general was the lowest in the *Phragmitetea* class and the highest – in the *Molinio-Arrhenatheretea* class. The highest species richness, mean number of species per recorded relevé as well as the value of Shannon-Wiener H' indicator were stated for the *Alopecuretum pratensis* association.
- Sward quality of the examined communities was mostly classified as a poor. The highest estimated yield had the *Arrhenatheretum elatioris*, *Deschampsietum caespitosae* and *Caricetum gracilis*.
- Both the *Alopecuretum pratensis* and the *Arrhenatheretum elatioris* associations presented the most favorable relationship between floristic diversity and the utilization value.

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Różnorodność florystyczna i wartość rolnicza półnaturalnych zbiorowisk trawiastych występujących w Dolinie Dolnego Bugu

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Streszczenie

W pracy przedstawiono charakterystykę roślinności półnaturalnych zbiorowisk trawiastych występujących w Dolinie Dolnego Bugu na odcinku Długie Kamieńskie-Kossaki. Badania terenowe wykonano metodą Braun-Blanqueta w 2011 roku. Analizą objęto 99 zdjęć fitosocjologicznych. Pozwoliła ona na opisanie zróżnicowania florystycznego badanych zbiorowisk (bogactwo gatunkowe, całkowita liczba gatunków w zbiorowisku, wskaźnik Shanona-Wienera H') oraz charakterystykę wartości użytkowej (z wykorzystaniem systemu liczb użytkowych Filipka i metody szacunkowo-pomiarowej Kostucha).

Opisane fitocenozy reprezentowały cztery klasy fitosocjologiczne. Stwierdzono występowanie: zbiorowisk szuwarowych z klasy *Phragmitetea* (z przewagą zbiorowisk ze związku *Magnocaricion*), zbiorowisk z klasy *Molinio-Arrhenatheretea*, reprezentujących zarówno fitocenozy łąk wilgotnych ze związku *Alopecurion*, jak i fitocenozy świeżych łąk i pastwisk ze związków *Arrhenatherion* i *Cynosurion*. Pojedyncze płaty zakwalifikowano do klas *Koelerio glaucae-Corynephoretea canescetis* oraz *Epilobietea angustifolii*.

Na badanym obszarze z najwyższą frekwencją występowały fitocenozy należące do klasy *Molinio-Arrhenatheretea* (60,6%), a wśród nich zespoły: *Arrhenatheretum elatioris* i *Alopecuretum pratensis*. Stwierdzono znaczący udział gatunków charakterystycznych w strukturze syntaksonomicznej większości zespołów szuwarowych oraz zespołów z rzędów *Arrhenatheretalia* i *Molinietalia*. Wynosił on nie mniej niż 70%, co świadczy o dobrej kondycji ekologicznej tych zbiorowisk.

Najbardziej bogate gatunkowo były zespoły z klasy *Molinio-Arrhenatheretea*, a wśród nich zespół *Alopecuretum pratensis*. Najmniej różnorodne pod tym względem były zespoły należące do klasy *Phragmitetea*. Najwartościowszą przyrodniczo fitocenozą na badanym obszarze był zespół *Alopecuretum pratensis*, co jest zgodne z wcześniejszymi wynikami dotyczącymi tego zespołu w dolinie Bugu.

Średnia wartość liczb wartości użytkowej wahała się od 0,6 (*Caricetum gracilis*) do 6,9 (*Phalaridetum arundinaceae*), jednak w większości przypadków szacowana jakość uzyskiwanej paszy była mierna. Najwyższej plonowały fitocenozy *Arrhenatheretum elatioris*, *Deschampsietum caespitosae* i *Caricetum gracilis*.

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