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Letter to Editor

Grasses (*Poaceae*) in Riparian Vegetation of Watercourses in Agriculture Landscape

M. Szymura[1]*, T. Szymura[2], A. Dunajski[2], K. Wolski[1]

[1]Department of Grassland and Landscape Planning, University of Environmental and Life Sciences, Poland
[2]Ecological Station, Institute of Plant Biology, Wroclaw University, Poland

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Abstract

A quantitative analysis of grasses (*Poaceae* family) growing in vegetation alongside watercourses in rural regions of Poland' Odra Valley was undertaken. The quantity of a given species was calculated by multiplying the length of sections of the watercourse by the percentage coverage of this species. In total, 134 km of watercourses were analyzed. Among the 164 plant species found, 22% were grass species. Its quantitative participation was 39%. The most abundant species was *Calamgrostis epigejos* followed by *Phragmites australis*. Analysis of phytosociological affinity revealed the importance of the *Molinio-Arrhenatheretea* class and a considerable amount of species from *Querco-Fagetea*. The majority of grass species were apophytes; only 12% were antropophyte. The dominance of native species, which form specific semi-natural assemblages in human-disturbed habitat, highlighted the function of riparian vegetation in maintaining biodiversity as well as ecosystemal services in modern agricultural landscapes.

Keywords: biodiversity, *Calamagristis epigejos*, drainage channels, land reclamation system, *Phragmites australis*

Introduction

Agricultural landscape covers the largest part of Poland [1]. The industrialization of agriculture, which started during the 1950s in Western Europe [2, 3] and during the 1990s in Poland [4], caused a decrease of biodiversity and landscape dysfunction [5, 6]. The purpose of contemporary European agricultural politics is to retain these changes by promoting the non-productive function of rural areas [7].

In rural regions, watercourses and adjacent vegetation are important because of their influence on water quality, biodiversity, aesthetic values [8, 9] and function as ecological corridors [10, 11]. Riparian vegetation is also the most frequent semi-natural habitat in agricultural areas [12].

The results of analysis of riparian vegetation in agricultural landscape reveal the importance of grasses (*Poaceae* family) among other plants occurring alongside watercourses [11]. The phytocenothic significance of grasses is more important than could be expected based on the number of species occurring in Poland – over 70% of them have a diagnostic value for the classification and taxonomy of plant communities in Poland [13]. In the typology of watercourses, vegetation created for the purposes of modeling the multi-agent socio-ecological systems of valleys of large rivers (CAVES project), grass species had a strong discrimination function.

In this paper, the quantitative participation of grasses among riparian vegetation in the Odra Valley was analyzed. The influence of dominant grass species on biodiversity with respect to their connection with described phytosociological units, as well as status in Polish flora, was discussed. Due to problems separating vegetation from drainage channels into recognized plant associations [14, 15], the landscape approach suitable analysis for this kind of vegetation was applied [6, 16].

*e-mail: magdalena.szymura@up.wroc.pl

Materials and Methods

Study Site

The research was performed in a geomorphological valley of the Odra River between Brzeg Dolny and Głogów. A detailed study was undertaken at three sites that differed in respect of their drainage ditch management and land use form (Fig. 1).

Site 1 (51°28' N, 16°27' E): surveyed area ≈ 3,000 ha, total length of analyzed watercourses 77.8 km. Land use: arable land 71%, forests 9%, built-up areas and wastelands 20%. Features: an area of intensively managed large farms. The system of drainage ditches is quite well managed.

Site 2 (51°13' N, 16°25' E): surveyed area ≈ 1,600 ha, total length of analyzed watercourses 39.5 km. Land use: arable land 68%, forests 27%, built-up areas and wastelands 5%. Features: an area of small family farms run only for an additional source of income. The system of drainage ditches has been seriously neglected since the 1990s.

Site 3 (51°23' N, 16°41' E): surveyed area ≈ 500 ha, total length of analyzed watercourses: 16.8 km. Land use: arable land 54%, forests 43%, wetlands and water bodies 2%, other 1%. Features: an area of small family farms, which are the main source of household income. A substantial area is protected as a nature reserve and was re-naturalized (oxbow restoration, water outflow control) under the management of non-governmental organisations.

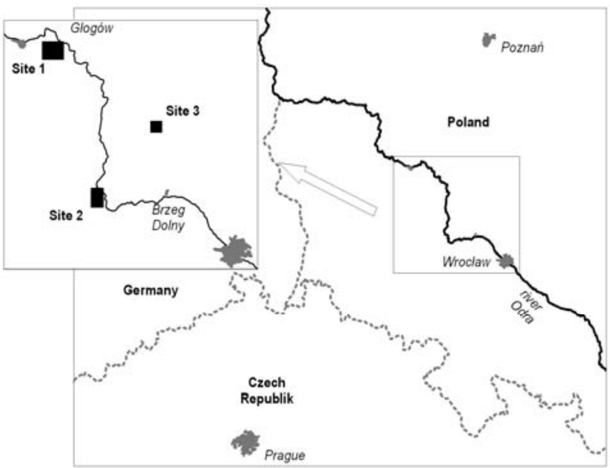

Fig. 1. The map of the study area with the three study sites marked.

The watercourses were predominantly artificial drainage channels that created a land reclamation system. The most common were ditches 0.5-1 m wide with banks 1-2 m wide. At the time of survey, water was held in 39% of ditches with a usual depth around 20 cm.

Fieldwork

The watercourses were divided into homogenous sections with respect to vegetation, channel morphology and water regime. The coverage of dominant plant species (> 5% coverage) in vegetation along the watercourse was visually assessed. Additionally, the occurrence of graminoides in aquatic vegetation was examined. The sections were mapped against a background of aerial photographs using a GPS set with ArcPad software. The adjacent land-use of each section was also recorded. All fieldwork was completed between June and September 2007.

Data Analysis

The quantitative participation of each species was counted by multiplying the length of the section by the percentage coverage of a given species. The frequency of sections with a presence of species and the median of non-zero coverage was also calculated.

Further analysis was performed using a typology of watercourse vegetation. The typology was based on the classification of riparian vegetation using the TWINSPAN procedure (Fig. 2).

The differences between sites in terms of the percentage of vegetation groups that emerged from cluster analysis were checked with the χ^2 test. The overall average percentage was used as the expected value.

The status of species in Polish flora (apophytes, antropophytes etc.) was defined according to Korniak and Urbisz [17], phytosociological affinity was defined according to Matuszkiewicz [18] and the invasiveness of species according to Tokarska-Guzik [19].

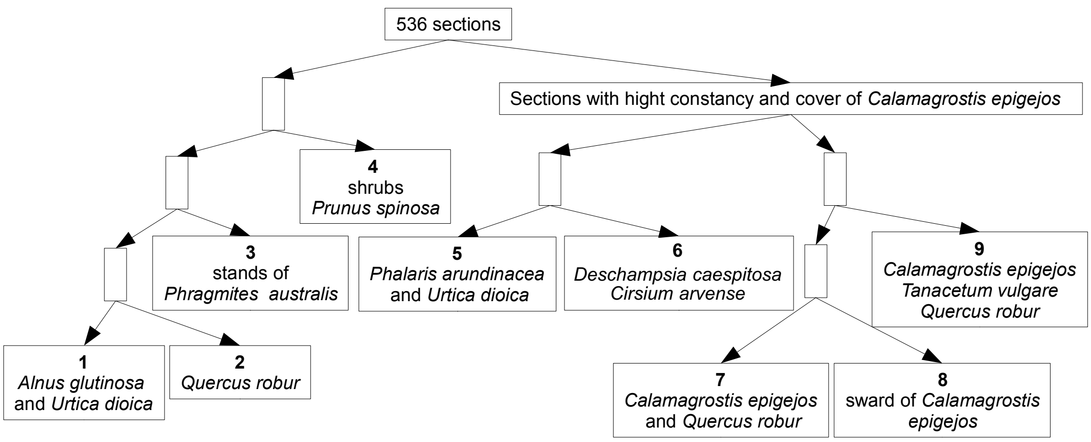

Fig. 2. The typology of watercourse vegetation. The species with the highest discriminate value are shown.

Results

The surveyed watercourses were separated into 536 sections. In the majority (69%) of aquatic vegetation consisting of 49 species, among them four grass species, was found. The dominant plant species – common reed (*Phragmites australis*) – was present in 22.1% of the lengths of sections with aquatic vegetation. There was also a considerable presence of *Glyceria maxima* (12.7%). The remaining grass species were *Glyceria fluitans* (0.8%) and *Phalaris arundinacea* (0.1%). Among non-grass species the greatest coverage was of *Iris pseudoacorus* (18.3%).

On banks, 164 plant species were recorded, among them 36 grass species (22%). However, they showed a predominantly large coverage value making its quantitative participation 39% in total. Eleven grass species could dominate vegetation (> 60% coverage) in some sections. They dominated in 27% of sections and had a considerable participation (30-59% coverage) in 37% of sections. Grasses were absent in only 12% of sections. The quantitative participation, frequency, coverage, number and percentage of sections where the species was dominant, as well as the constancy in vegetation types, are shown in Table 1. This table also shows the most important dicotyledonous species. The analysis of constancy value showed the importance of grasses in the applied typology of watercourse vegetation.

The percentage of grass species in different classes of phytocenosis and their status in flora were shown in Fig. 3. The species recognized as antropophytes belong to the archeophytes group.

The study sites differed with respect to the participation of vegetation types (Fig. 4). Site 3 (re-naturalised site) was distinguished by a high participation of woody-dominated vegetation with *Alnus glutinosa* (type 1) and an under-representation of swards of *Calamagrostis epigejos* (types 8 and 9). Such vegetation was most frequent at site 2, where the land reclamation system was neglected. In this site, the participation of watercourses with *Phalaris arundinacea* (type 5) was the lowest. The proportion of the plant community dominated by woody vegetation with *Quercus robur* (type 2), *Phragmites australis* (type 3), *Deschampsia caespitosa* and *Cirsium arvense* (type 6), and *Calamagrostis epigejos* under sparse oaks (type 9) did not differ significantly between sites.

Discussion

The most abundant species among aquatic vegetation and the second with respect to quantitative participation in riparian vegetation was *Phragmites australis*. Common reeds show a high dynamic of colonization, moving along watercourses and creating dense, single-species stands that are able to displace other rushes in suitable sites [20], and permanently arrest succession [21]. Experiments in England have revealed that it takes seven years from the end of use for drainage channels to be completely overgrown [22]. The sections dominated by *Phragmites australis* form vegetation type number 3, which characterizes a low average number of species. The common reed occurred in similar proportions in all study sites.

Among aquatic vegetation, the participation of *Glyceria maxima* is also considerable. This species occurs mainly in river valleys, where it grew with rushes, especially in flooded sites [1]. In these studies it was also most common in places where ditches were wide and shallow.

The most important species in riparian vegetation was reed grass (*Calamagrostis epigejos*). This species, along with *Elymus repens* and *Arrhenatherum elatius,* is able to

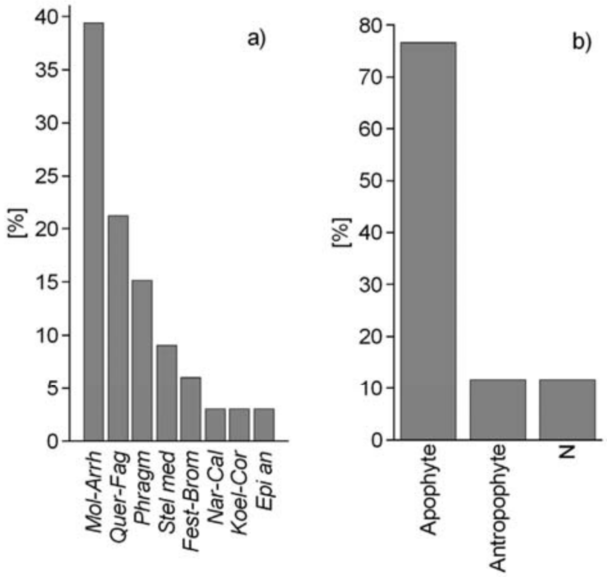

Fig. 3. Percentage of grass species in different classes of communities (a) and their status in flora (b).
Classes of communities: *Mol-Arrh: Molinio-Arrhenatheretea, Quer-Fag: Querco-Fagetea, Phragm: Phragmitetea, Stel med: Stellarietea mediae, Fest-Brom: Festuco-Brometea, Nar-Cal: Nardo-Callunetea, Koel-Cor: Koelerio glaucae-Corynephoretea, Epi an: Epilobietea angustifolii,* N: native species without apophytic tendency.

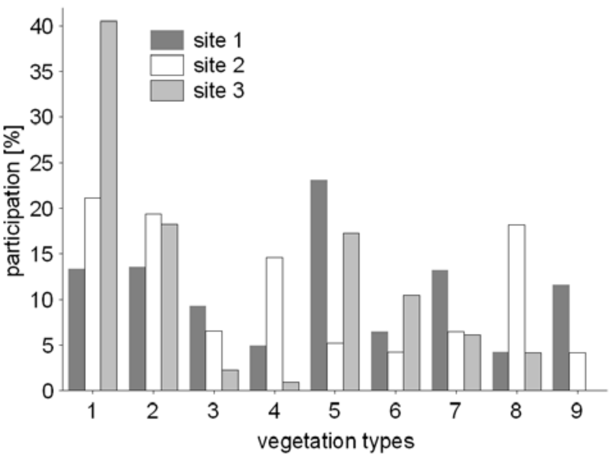

Fig. 4. The percentage share of outlined vegetation types at each study site.

Table 1. The quantitative participation (Quan.part.), frequency (Freq.), coverage, number and percentage of sections where a species was dominant (Domin.) and a constancy in used vegetation types. The constancy categories were defined in five classes: V: 100–80%, IV: 80–60%, III: 60–40%, II: 40–20%, I: 20–1%.

	Grasses	Quan. part.		Freq.		Coverage [%]			Domin.			Constancy								
		[km]	[%]	[N]	[%]	Med.	Min	Max	[N]	[%]	Type	1	2	3	4	5	6	7	8	9
1	*Calamagrostis epigejos*	34.74	13	235	43.8	30	5	90	66	12		I	I	I	I	III	II	V	V	V
2	*Phragmites australis*	18.84	7.1	120	22.4	30	5	100	41	7.6		I	I	V	I	II	I	I	I	III
3	*Phalaris arundinacea*	16.65	6.2	139	25.9	20	5	70	7	1.3		II	I	I	I	IV	II	III	I	II
4	*Dactylis glomerata*	8.55	3.2	124	23.1	10	5	60	1	0.2		I	II	I	II	II	II	II	I	I
5	*Bromus inermis*	3.91	1.5	40	7.5	20	5	60	1	0.2		I	I	I	I	I	I	I	I	II
6	*Elymus repens*	3.69	1.4	57	10.6	10	5	50	0	0		I	I	I	I	II	I	I	I	II
7	*Arrhenatherum elatius*	3.48	1.3	51	9.5	10	5	40	0	0		I	I	I	I	II	I	I	I	I
8	*Deschampsia cespitosa*	3.31	1.2	48	9	15	5	70	5	0.9		I	I	I	I	I	IV	I	I	I
9	*Dactylis aschersoniana*	2.45	0.9	15	2.8	40	10	80	6	1.1		.	I	.	.	.	.	.	.	.
10	*Poa nemoralis*	2.08	0.8	23	4.3	10	5	50	0	0		I	II	.	.	.	.	.	.	.
11	*Glyceria maxima*	1.84	0.7	34	6.3	10	5	40	0	0		I	I	.	I	I	II	.	I	I
12	*Calamagrostis arundinacea*	1.09	0.4	6	1.1	35	10	90	2	0.4		I	I	.	.	.	.	.	.	.
13	*Poa palustris*	0.6	0.2	5	0.9	10	5	40	0	0		I	I	.	.	.	.	I	.	.
14	*Deschampsia flexuosa*	0.34	0.1	1	0.2	60	60	60	1	0.2		.	I	.	.	.	.	.	.	.
15	*Festuca gigantea*	0.28	0.1	4	0.7	15	5	30	0	0		I	I	.	.	.	.	.	.	.
16	*Millium effusum*	0.26	0.1	2	0.4	33	5	60	1	0.2		I	I	.	.	.	.	.	.	.
17	*Molinia caerulea*	0.25	0.1	3	0.6	10	10	30	0	0		.	.	.	.	.	I	.	.	.
18	*Apera spica-venti*	0.22	0.1	4	0.7	20	5	30	0	0		.	.	.	.	.	.	.	I	.
19	*Alopecurus pratensis*	0.21	0.1	6	1.1	8	5	20	0	0		.	I	.	.	I	I	I	.	.
20	*Agrostis capillaris*	0.21	0.1	7	1.3	10	5	30	0	0		.	.	I	I	.	.	I	.	.
21	*Echinochloa crus-gali*	0.16	0.1	2	0.4	8	5	10	0	0		.	.	.	.	I	.	.	.	.
22	*Lolium perenne*	0.13	0.1	2	0.4	15	10	20	0	0		I	.	.	.	I	.	.	.	.
23	*Holcus lanatus*	0.13	<0.05	4	0.7	10	5	30	0	0		I	.	I	.	.	I	I	.	.
24	*Phleum pratense*	0.11	<0.05	2	0.4	5	5	5	0	0		.	.	.	.	I	.	.	.	.
25	*Setaria verticilata*	0.11	<0.05	8	1.5	5	5	10	0	0		.	.	I	I	I	I	I	I	.
26	*Elymus caninus*	0.11	<0.05	3	0.6	10	10	10	0	0		I	.	.	.	.	.	.	.	.
27	*Festuca ovina*	0.1	<0.05	2	0.4	8	5	10	0	0		.	.	.	.	I	.	I	.	.
28	*Poa pratensis*	0.08	<0.05	1	0.2	60	60	60	1	0.2		.	I	.	.	.	.	.	.	.
29	*Festuca pratensis*	0.06	<0.05	1	0.2	5	5	5	0	0		.	.	.	.	.	.	.	I	.
30	*Brachypodium pinnatum*	0.06	<0.05	1	0.2	10	10	10	0	0		.	I	.	.	.	.	.	.	.
31	*Glyceria fluitans*	0.05	<0.05	3	0.6	10	10	10	0	0		I	I	.	.	.	.	.	I	.
32	*Setaria viridis*	0.02	<0.05	1	0.2	10	10	10	0	0		.	.	.	.	I	.	.	.	.
33	*Festuca arundinacea*	0.02	<0.05	1	0.2	20	20	20	0	0		.	I	.	.	.	.	.	.	.
34	*Brachypodium sylvaticum*	0.01	<0.05	1	0.2	5	5	5	0	0		.	I	.	.	.	.	.	.	.
35	*Festuca rubra*	0.01	<0.05	2	0.4	5	5	5	0	0		.	I	.	I	.	.	.	.	.
36	*Agrostis stolonifera*	0.01	<0.05	2	0.4	5	5	5	0	0		.	I	.	I	.	.	.	.	.

Table 1. Continued.

	Major dicotyledonous	Quan. part.		Freq.		Coverage [%]			Domin.			Constancy								
		[km]	[%]	[N]	[%]	Med.	Min	Max	[N]	[%]	Type	1	2	3	4	5	6	7	8	9
1	*Urtica dioica*	25.36	9.5	241	46	20	5	90	36	6.7		V	II	III	II	III	II	II	II	II
2	*Quercus robur*	22.90	8.6	184	35	20	5	80	33	6.2		II	V	II	II	II	I	III	.	III
3	*Prunus spinosa*	23.00	8.6	131	25	30	5	100	51	9.5		I	II	II	V	I	I	III	I	II
4	*Rubus* sp.	8.85	3.3	115	22	10	5	70	4	0.7		II	III	I	I	II	I	II	I	I
5	*Alnus glutinosa*	19.66	7.4	113	22	30	5	90	28	5.2		III	II	I	I	I	I	II	.	.
6	*Cirsium arvense*	4.75	1.8	73	14	10	5	40	0	0		I	I	I	I	II	III	I	II	I
7	*Tanacetum vulgare*	4.05	1.5	73	14	10	5	40	0	0		.	I	I	I	II	I	I	I	IV

spontaneously colonize human-disturbed habitats and persist there because of its strong ability to adapt [23, 24]. Also observed was its high ability to aggressively expand into abandoned fields, following *Festuca rubra, F. ovina, Agrostis capillaris* and *Poa pratensis* [25]. It is also the dominant species in sward on the embankments of the Odra River [26, 27]. Reed grass was the most distinctive species for the group of vegetation types dominated by grasses. It occurred in dense, single-species swards with small biodiversity, especially adjacent to fallow fields (type 8), grew in human-disturbed habitats with *Tanacetum vulgare* (type 9) and formed specific assemblages with old oaks (*Quercus robur*) on banks (type 7). In this study, pure swards of reed grass (type 8) were the most frequent in site 2, where the land reclamation system was neglected. Types 7 and 9 occurred most often in site 1, where the agriculture was well developed and the land reclamation system was maintained. The abundance of type 7 was a result of specific management of ditches that allowed the growth of old large oaks on banks.

Another important grass species, *Phalaris arundinacea,* usually occupies the margins of small, often nutrient-enriched rivers or grows in wet grasslands in organic soils in large valleys [1]. Regular mowing of channels creates favourable conditions to its expansion [22]. In this study, *Phalaris arundinacea* was an indicator of mowed sections with high biodiversity, often adjacent to arable land. Thus, its frequency was the lowest in site 2. In this type of vegetation, *Phalaris arundinacea* grew in assemblages with *Calamagrostis epigejos, Dactylis glomerata, Elymus repens* and, less frequently, *Arrhenatherum elatius* and *Phragmites australis*, as well as *Urtica dioica* (type 5).

Deschampsia caespitosa is an indicator of overutilized meadows and pastures [1]. *Deschampsia caespitosa* together with *Cirsium arvense* grew in wide, wet strips along watercourses and predominantly occurred next to fallow fields in this study. The type 6 of vegetation, which gathered around the species mentioned above, was frequent in site 3. We connected it with changing water levels caused by re-naturalization.

Among the most frequent grasses was *Dactylis glomerata*, but its affinity with other vegetation types was unclear. It was among a small number of herbaceous species occurring in dense shrubs of *Prunus spinosa* (type 4).

Species such as *Dactylis aschersoniana, Calamagrostis arundinacea, Poa nemoralis, Festuca gigantea, Festuca arundinacea, Elymus caninus, Millium effusum, Deschampsia flexuosa* and *Brachypodium pinnatum* were connected to sections with wooded vegetation (types 1 and 2).

Generally, the most common group of grasses (43%) was those associated with mown meadows and pastures (*Molinio-Arrhenatheretea* class). It was a result of the most common method of maintaining a land reclamation system – mowing ditches and banks – which created a disturbance regime similar to meadows or pastures. The second largest group (23%) was grasses of broad-leaved forests (*Querco-Fagetea* class) and forest margins (*Epilobietea angustifolii* class: 3.3%). This was related to both the long-term neglect of the land reclamation system in some areas, which over time overgrew wooded vegetation, as well as the relatively high forestation of studied areas. In third place with respect to the number of species (16.7% of grasses) were rushes (*Phragmitetea* class). In this group, the major species, both in frequency and coverage, were *Phragmites australis* and *Phalaris arundinacea*, with the share of other species (*Glyceria maxima, Poa palustris* and *Glyceria fluitans*) negligible. This is related to the high variability of water level in the summer period (61% of ditches were dry). Many rush species are intolerant to drought, whereas *Phragmites australis* and *Phalaris arundinacea* are able to withstand these dry conditions [1, 23]. These two species are probably able to reciprocally replace depending on mowing intensity. The number of weeds (*Stelarietea mediae* class) was low (9.1%) despite the high share of arable land. They were recorded only in single sections typical of antropophytes: *Apera spica-venti, Echinochloa crus-gali* and *Setaria viridis*. The plant assemblages of farmlands simultaneously reflect the environmental conditions (e.g. soil properties) and farming methods [18]. Thus, the mowing of banks and ditches, as well as the considerable growth of expansive species, diminishes the presence of weeds. Only single species of grasses were affined to thermophilous, steppe grassland (*Bromus inermis,* *Brachypodium pinnatum – Festuco-Brometea* class), psammophilous grassland (*Festuca ovina – Koelerio glaucae-Corynephretea canescentis* class) as well as acidophilous heath and grassland (*Agrostis capillaris* from *Nardo-Callunetea* class).

The ratio of native grass to non-native in this study is opposite that generally reported in Poland, where 28% of grass species are apophytes and 72% are antrpophytes [17]. This study found that antropophytic grasses were archeophytes belonging to farmland weeds (*Stellarietea mediae* class). There was also a noticeable presence of species without tendencies to occur in anthropogenic habitats, and a lack of grass species invasive in Poland.

The grasses growing in ditches form specific associations based on spontaneophytes, but these assemblages (excluding sections with abundant woody vegetation, which develop into forest communities) are secondary and anthropogenic. It is similar to communities of mowing meadows [13]. However, in the case of ditches in land reclamation systems, periodic disturbances such as dragging and mowing cause continuous repetition of earlier seral stages [14] and lead to the formation of an erratic and transient mixture of species with consequent difficulty in allotting the assemblages to recognizable communities [15].

Conclusions

1. The results emphasise the quantitative dominance of grass species (*Poaceae* family) in vegetation of ditches in an agricultural landscape.
2. The vegetation of ditches in land reclamation systems consist of native species that create semi-natural assemblages important for maintaining biodiversity.
3. The most abundant and frequent species, *Calamagrostis epigejos* and *Phragmites australis,* are expansive, with a tendency to form single-species stands with low biodiversity if management of the land reclamation system is ceased.

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