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LAND USE IMPACT ON THE DIVERSITY OF RUSH AND MEADOW VEGETATION OF A SMALL RIVER VALLEY IN CENTRAL POLAND

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ABSTRACT. The results of phytosociological studies on the diversity of rush and meadow vegetation in a small-size valley of Moszczenica river are presented. There is a great variety of water-courses in central Poland but small-size valleys have not been surveyed widely. The research supports new data on the variety of rush and meadow communities in this type of valley and reveals the relationship of vegetation diversity with the type of land use. According to 68 phytosociological relevés 18 plant associations and communities were distinguished in the investigated area. These are communities of the classes *Phragmitetea*, *Molinio-Arrhenatheretea* and *Koelerio-Corynephoretea*. Parts of the valley with agricultural and recreational use of land are dominated by meadow communities and parts with no present land use are dominated by rush communities. Diversity of communities is generally higher in the used parts than in the non-used areas.

KEY WORDS: vegetation diversity, rush and meadow communities, small-size river valleys, Moszczenica river, central Poland

INTRODUCTION

Natural and semi natural river valleys are rare elements of the landscape in today's world. Most of them have been heavily transformed by anthropopressure for a long time. The main reasons for this transformation are: regulation of rivers, building of dams and changes in traditional agricultural use of land (Perzanowska and Mróz 2003, Zając 2003). It is generally known that these ecosystems are very complex, dynamic and have a high biological diversity. Moreover, a pattern of communities following laterally can be described in many river valleys (Herbich 1994, Zając 2003, Gielniak and Wolski 2007). There are rush communities close to river beds which are regularly flooded. Places situated higher in valleys, which are less frequently flooded, are occupied by carr communities. These have been common in the landscape of river valleys but, nowadays, their area is declining. Valley-sides are characteristic for dry-ground forests. Moreover, steppe and xeric grasslands are met in specific habitat conditions (Zając 2003, Gielniak and Wolski 2007). Nowadays, a large part of the area in river valleys is covered by meadow communities due to human activity.

Different investigations have been taken to study the diversity of rush and meadow vegetation in river valleys of Poland (Urban and Grzywna 2003, Kryszak et al. 2006, Mosek and Miazga 2006, Trąba et al. 2006, Grzelak et al. 2008, Grzywna and Urban 2008). This vegetation has been researched in the valleys of central Poland as well (Fagasiewicz 1963, Hereźniak 1972, Osuchowska 1995, Kucharski 1999, Drzażdżyńska 2003). However, the greatest part of the studies has been located in larger river valleys such as Warta or Pilica, and small river valleys were investigated rarely.

The valley of the Moszczenica river is an example of a small-size valley with a naturally meandering river. It has been used for agricultural purposes and, therefore, its vegetation has been transformed antropogenically. A part of the valley that has not been studied earlier was chosen in the research. The aim of the study is to investigate the variety of rush and meadow vegetation in the Moszczenica valley and the relationship of vegetation diversity with the land use.

STUDY AREA AND METHODS

The Moszczenica river is situated in central Poland. It is a right-side tributary of the Bzura river which springs about 10 km north-east from Łódź (Fig. 1). The research has taken place in the 5 km long part of the valley which is located near Zgierz. The river flows north-west in this location. This part of the Moszczenica valley was chosen for the research because of the great variety of rush and meadow vegetation and diversified use of land.

The phytosociological material was obtained in the years 2006-2007. The research followed the generally accepted method of Braun-Blanquet (1964). The area of standardized plot was 25 m^2, both for rush and meadow communities (Chytrý and Otýpková 2003, Dzwonko 2007). Exceptionally, the area of 4-24 m^2 was used in the case of very small patches or irregular shape of the plant

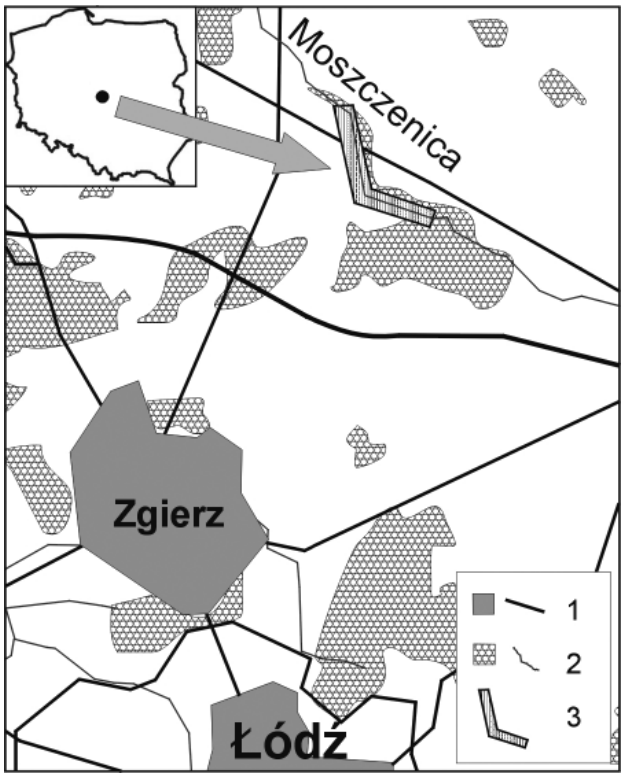

Fig. 1. Localization of the study area in central Poland: 1 – cities and roads, 2 – forests and rivers, 3 – the researched area

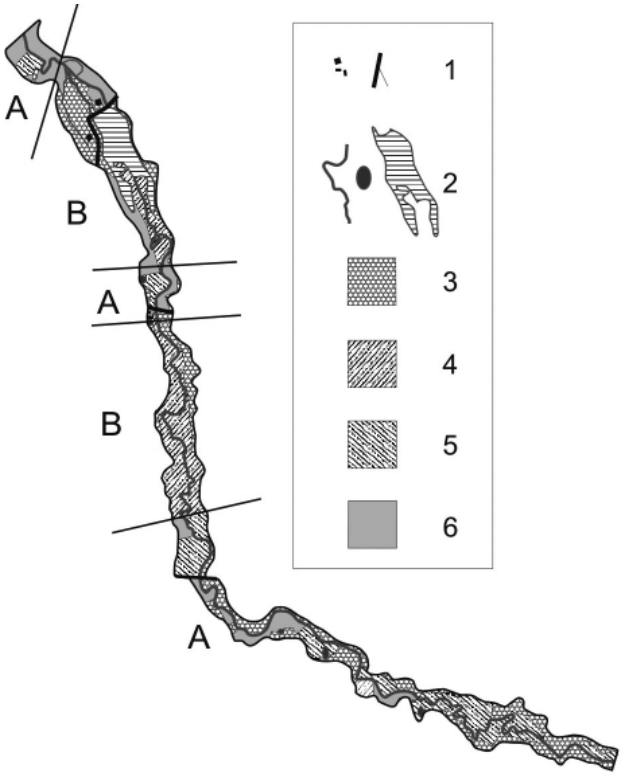

Fig. 2. The researched part of the valley divided into two land use types: A – parts of the valley with agricultural and recreational use of land, B – parts of the valley with no present land use; 1 – buildings and roads, 2 – river, water bodies and abandoned fishing ponds, 3 – forests, 4 – rushes, 5 – meadows, 6 – farm land

association. The largest possible number of phytosociological relevés was made in all distinguished rush and meadow phytocenoses which covered the whole variety of rush and meadow vegetation in the valley. Totally, 68 phytosociological relevés were made in the researched part of the Moszczenica valley with 159 vascular plant species described.

The phytosociological material underwent, in first, the conventional analysis of phytosociological data. Furthermore, the numerical analysis was applied (Dzwonko 2007). All relevés were analysed twice by taking into consideration the presence of species and their abundance. Firstly, the Jaccard's Coefficient was used and, secondly, the Squared Euclidean index was adopted. Both dendrograms were constructed with the unweighted pair group method using arithmetic averages (UPGMA). The numerical analysis was undertaken with the MVSP programme. The results of these two analysis were compared in order to distinguish similar groups of the phytosociological relevés. The identification of syntaxonomic affiliation of these groups was based on the Matuszkiewicz system (2001).

The researched part of the valley was divided into two land use types: parts of the valley with agricultural and recreational use of land (A) and, on the other hand, parts of the valley with no present land use (B) (Fig. 2). The aim of this division is to investigate if there is a relationship of vegetation diversity with the land use and to compare the diversity of rush and meadow vegetation between different land use types. The average values of soil moisture gradients according to Zarzycki et al. (2002) were estimated for the distinguished plant communities in both land use types. The diversity of communities was analysed with the use of Shannon's diversity index (Shannon and Weaver 1963) and Pielou's evenness index (Pielou 1975).

RESULTS

On the basis of the analysis of phytosociological data, 18 plant associations and communities have been distinguished (Table 1). There are eight identities in the class *Phragmitetea*, one in the class *Koelerio-Corynephoretea* and nine in the class *Molinio-Arrhenatheretea*. Among all of them, 10 have been classified to generally known syntaxonomic plant associations (Matuszkiewicz 2001). The others have been classified as communities on the level of classes, orders and alliances.

The list of distinguished plant associations and communities and occurrence of the syntaxons in parts of the valley with agricultural and recreational use of land (A) and in parts with no present land use (B)

PHRAGMITETEA R.Tx. et Prsg 1942
Phragmitetalia Koch 1926
Phragmition Koch 1926
1. *Equisetetum fluviatilis* Steffen 1931 – B
2. *Typhetum latifoliae* Soó 1927 – B
3. *Glycerietum maximae* Hueck 1931 – B
Magnocaricion Koch 1926
4. *Iridetum pseudacori* Eggler 1933 – B
5. *Caricetum acutiformis* Sauer 1937 – A, B

TABLE 1. Synoptic table of the phytosociological data. The plant associations and communities are numbered as in the list of the distinguished syntaxons. I-V – constancy classes (according to five or more phytosociological relevés), 1 – species occur in one relevé, 2 – species occur in two relevés, 3 – species occur in three relevés (according to communities distinguished by 1-3 relevés)

Plant association, community	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Number of relevés	1	1	12	3	10	3	2	2	2	1	2	17	2	3	3	1	2	1
Ch. *Equisetetum fluviatilis*																		
Equisetum fluviatile	1^{4}	1^{+}	.	1^{2}	I^{+}	.	.	.	.	.	.	.	.	1^{+}	.	1^{+}	.	.
Ch. *Typhetum latifoliae*																		
Typha latifolia	.	1^{5}	.	1^{+}	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.
Ch. *Glycerietum maximae*																		
Glyceria maxima	1^{+}	1^{1}	V^{3-5}	3^{+-1}	II^{+-1}	.	.	.	.	.	.	.	.	.	3^{+}	1^{+}	.	.
Ch. *Iridetum pseudacori*																		
Iris pseudoacorus	1^{+}	1^{+}	I^{+}	3^{4-5}	II^{+-1}	.	1^{+}	1^{+}	.	.	.	.	.	.	1^{+}	.	.	.
Ch. *Caricetum acutiformis*																		
Carex acutiformis	.	.	I^{+-1}	1^{1}	V^{3-5}	.	.	1^{+}	.	.	.	I^{1}	.	1^{2}	.	.	.	.
Ch. *Caricetum gracilis*																		
Carex gracilis	.	.	.	.	.	3^{3-5}	.	1^{1}	.	.	.	II^{+-1}	.	.	.	.	.	.
Ch. *Phalaridetum arundinaceae*																		
Phalaris arundinacea	.	.	.	.	I^{+}	.	2^{5}	.	.	.	.	.	.	.	.	.	.	.
Community with *Glyceria fluitans*																		
Glyceria fluitans	.	.	.	.	I^{+-1}	.	.	2^{4-5}	.	.	.	I^{2}	.	2^{1-2}	.	.	.	.
Ch. *Phragmitetea* (*Magnocaricion)**																		
*Galium palustre**	.	.	I^{+}	.	II^{+-1}	1^{+}.	.	1^{+}	.	.	.	I^{1}	.	1^{1}	2^{+}	.	.	.
Alisma plantago-aquatica	.	.	I^{3}	1^{+}	I^{1}	.	.	.	.	.	.	.	.	1^{+}	1^{+}	.	.	.
*Scutellaria galericulata**	.	.	I^{1}	.	II^{1-2}	.	1^{1}	.	.	.	.	.	1^{+}	.	.	.	.	.
Rumex hydrolapathum	.	.	.	.	II^{+-1}	1^{+}	.	.	.	.	.	.	1^{+}	.	1^{+}	.	.	.
Scrophularia umbrosa	.	.	I^{1}	.	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.

Species which occur only in community no. 3: *Veronica beccabunga* – 2^{+}; 6: *Carex rostrata** – 2^{+}, *Poa palustris** – 1^{+}, *Carex vesicaria** – 1^{1}; *Peucedanum palustre** – 1^{+}; 14: *Eleocharis palustris* – 1^{2}, *Carex pseudocyperus* – 2^{+}

TABLE 1 – cont.

Plant association, community	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Community with *Rumex acetosella*																		
Rumex acetosella	.	.	.	.	.	.	.	.	2^{2-3}	.	.	.	.	.	.	.	1^{+}	.
Ch. *Koelerio-Corynephoretea*																		
Hypochoeris radicata	.	.	.	.	.	.	.	.	2^{+}	1^{2}	.	I^{+-1}	.	.	.	.	1^{2}	.
Trifolium arvense	.	.	.	.	.	.	.	.	2^{+}	1^{+}	.	.	.	.	.	.	.	.
Trifolium campestre	.	.	.	.	.	.	.	.	.	1^{+}	.	I^{+-1}	.	.	.	.	.	.
Dianthus deltoides	.	.	.	.	.	.	.	.	.	.	.	I^{+-1}	.	.	.	.	1^{+}	.
Species which occur only in community no. 9: *Helichrysum arenarium* – 1^{3}, *Cerastium semidecandrum* – 1^{1}, *Corynephorus canescens* – 1^{1}, *Filago minima* – 1^{1}, *Jasione montana* – 1^{1}, *Spergula pentandra* – 1^{1}, *Teesdalea nudicaulis* – 1^{1}, *Veronica dillenii* – 1^{+}; 12: *Armeria maritima* – I^{+}, *Rumex tenuifolius* – I^{+}																		
Community with *Agrostis capillaris*																		
Agrostis capillaris	.	.	.	.	.	.	.	.	1^{1}	1^{3}	.	II^{1}	.	.	.	.	2^{2}	.
Community with *Alopecurus pratensis*																		
Alopecurus pratensis	.	.	.	.	I^{+-1}	2^{1}	.	1^{1}	.	.	2^{1-2}	V^{+-2}	.	2^{+-1}	.	1^{+}	.	.
Community with *Holcus lanatus*																		
Holcus lanatus	.	.	.	.	.	2^{1}	.	.	.	1^{+}	.	V^{2-3}	.	3^{+-1}	1^{+}	.	1^{1}	1^{1}
Ch. *Scirpetum silvatici*																		
Scirpus sylvaticus	.	.	I^{2}	.	I^{1}	1^{1}	.	1^{+}	.	.	.	I^{1}	2^{5}	.	1^{+}	.	.	.
Ch. *Epilobio-Juncetum effusi*, Community with *Juncus effusus**																		
Juncus articulatus	.	.	.	.	.	.	.	.	.	.	.	.	.	2^{1}	.	.	.	1^{+}
Epilobium palustre	.	.	.	.	.	1^{+}	.	.	.	.	.	.	.	1^{1}	.	.	.	.
*Juncus effusus**	.	.	.	.	I^{+-1}	2^{1-2}	1^{+}	1^{+}	.	.	.	II^{+-2}	1^{+}	3^{2-3}	3^{4-5}	1^{+}	1^{+}	1^{+}
Community with *Filipendula ulmaria*																		
Filipendula ulmaria	.	.	I^{2}	.	III^{+-2}	1^{+}	.	.	.	.	.	II^{+-1}	1^{+}	1^{1}	.	1^{5}	.	.
Community with *Deschampsia caespitosa*																		
Deschampsia caespitosa	.	.	.	.	.	.	.	.	.	.	.	III^{+3}	.	2^{+-1}	.	.	2^{2}	.
Ch. *Lolio-Cynosuretum*																		
Lolium perenne	.	.	.	.	.	.	.	.	.	1^{1}	.	.	.	.	.	.	.	1^{2}

TABLE 1 – cont.

Plant association, community	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ch. *Molinietalia* (*Calthion, *Alopecurion***)**																		
Lysimachia vulgaris	.	.	III^{+1}	.	III^{+2}	1^{+}	1^{+}	.	.	.	.	.	1^{+}	2^{+}	1^{+}	.	.	.
Lychnis flos-cuculi	.	.	.	.	.	1^{+}	.	.	.	.	2^{+}	III^{+2}	.	2^{+}	.	1^{+}	.	1^{+}
Lotus uliginosus	.	.	.	.	.	2^{+}	.	.	.	1^{+}	.	III^{+2}	.	1^{1}	.	.	1^{+}	.
*Myosotis palustris**	.	.	I^{+}	1^{+}	II^{1}	.	.	1^{+}	.	.	.	.	.	1^{+}	.	.	.	.
Caltha palustris	.	.	.	.	I^{+-2}	2^{+}	.	1^{+}	.	.	.	I^{1}	.	1^{+}	.	.	.	.
Galium uliginosum	.	.	.	.	.	2^{+-1}	.	.	.	.	.	I^{2}	.	2^{1}	.	.	.	.
Species which occur only in community no. 5: *Alopecurus geniculatus*** – I^{+}																		
Ch. *Arrhenatheretalia* (*Arrhenatherion, *Cynosurion***)**																		
Achillea millefolium	.	.	.	.	.	2^{+}	.	.	2^{+-1}	1^{1}	2$^{1-3}$	V^{+-3}	.	.	.	.	2^{+}	1^{1}
Taraxacum officinale	.	.	.	.	.	.	.	.	.	.	2^{+-1}	III^{+2}	.	1^{+}	.	.	1^{+}	1^{+}
Dactylis glomerata	.	.	.	.	.	.	.	.	.	.	1^{1}	.	.	.	.	.	2^{+}	1^{1}
Species which occur only in community no. 12: *Arrhenatheretum elatius** – I^{+}; 18: *Cynosurus cristatus*** – 1^{+}																		
Ch. *Molinio-Arrhenatheretea*																		
Ranunculus repens	.	.	I^{+}	.	I^{+}	2^{+-1}	.	2^{+-1}	.	.	.	IV^{+3}	.	3$^{1-2}$	.	.	2^{+-1}	1^{2}
Lythrum salicaria	.	.	III^{+}	2^{+-1}	I^{+}	2^{+}	1^{+}	1^{+}	.	.	.	.	1^{1}	.	3^{+}	.	.	.
Rumex acetosa	.	.	.	.	.	1^{+}	.	.	2$^{1-2}$	.	2^{+}	V$^{1-3}$	.	1^{+}	.	.	2^{+-1}	1^{+}
Ranunculus acris	.	.	.	.	.	2^{+}	.	.	.	1^{+}	1^{+}	IV^{+1}	.	3+	.	.	.	1^{1}
Poa trivialis	.	.	.	.	I^{+-1}	1^{2}	.	2^{+-1}	.	.	.	III^{12}	.	1^{2}	.	1^{+}	.	.
Plantago lanceolata	.	.	.	.	.	.	.	.	1^{+}	1^{2}	2^{+-2}	III^{+2}	.	.	.	.	1^{3}	1^{+}
Poa pratensis	.	.	I^{+}	.	I^{+}	.	.	.	.	.	2$^{1-2}$	II$^{1-2}$	.	1^{+}	.	.	.	1^{1}
Cerastium holosteoides	.	.	.	.	.	1^{+}	.	.	.	1^{1}	2^{+-1}	IV^{+3}	.	.	.	.	1^{1}	.
Lysimachia nummularia	.	.	.	.	I^{+}	1^{+}	.	1^{+}	.	.	.	I$^{1-2}$	.	3^{+-1}	.	.	.	.
Potentilla anserina	.	.	.	.	.	.	.	.	.	.	2^{+-1}	III^{+2}	.	3^{+-1}	.	.	.	1^{1}
Veronica chamaedrys	.	.	.	.	.	1^{2}	.	.	.	.	2^{+}	III^{+2}	.	.	.	.	2^{+}	.
Carex hirta	.	.	.	.	.	.	.	.	.	.	2^{+-1}	III^{+2}	.	2^{1}	.	.	.	1^{1}

TABLE 1 – cont.

Plant association, community	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ranunculus flammula	.	.	I^{+}	.	.	.	.	2^{+}	.	.	.	.	.	1^{1}	.	.	.	1^{+}
Trifolium repens	.	.	.	.	.	.	.	1^{1}	.	1^{1}	.	III^{13}	.	.	.	.	.	.
Cardamine pratensis	.	.	.	.	.	.	.	1^{+}	.	1^{+}	.	III^{+1}	.	.	.	.	.	.
Lathyrus pratensis	.	.	.	.	I^{+}	2^{+}	.	.	.	.	2^{+-1}	.	.	.	.	.	.	.
Phleum pratense	.	.	.	.	.	.	.	.	.	1^{+}	.	I^{2}	.	.	.	.	.	1^{2}
Potentilla reptans	.	.	.	.	.	.	.	.	.	.	1^{3}	I^{+-1}	.	.	.	.	.	1^{+}
Agrostis gigantea	.	.	.	1^{+}	.	.	.	1^{+}	.	.	.	.	.	1^{+}	.	.	.	.
Alchemilla monticola	.	.	.	.	.	.	.	.	.	1^{+}	.	II^{+-1}	.	.	.	.	.	1^{+}
Vicia cracca	.	.	.	.	I^{1}	.	.	.	.	.	.	I^{+-1}	.	1^{+}	.	.	.	.
Climacium dendroides	.	.	.	.	.	.	.	1^{1}	.	.	1^{1}	I^{+}	.	.	.	.	.	.
Cirsium oleraceum	.	.	.	.	.	1^{+}	.	.	.	.	.	.	.	.	.	1^{+}	.	.
Cirsium palustre	.	.	I^{+}	.	.	.	.	.	.	.	.	.	.	.	1^{+}	.	.	.
Galium mollugo	.	.	.	.	.	.	.	.	.	.	.	I^{1}	.	.	.	.	1^{+}	.
Rumex crispus	.	.	.	.	I^{+}	.	.	.	.	.	1^{+}	.	.	.	.	.	.	.
Trifolium pratense	.	.	.	.	.	.	.	.	.	1^{1}	.	.	.	.	.	.	.	1^{+}
Prunella vulgaris	.	.	.	.	.	.	.	.	.	1^{+}	.	I^{+}	.	.	.	.	.	.
Campanula patula	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	.	.	.	.	1^{+}
Species which occur only in community no. 6: *Crepis paludosa* – 1^{1}; 8: *Mentha arvensis* – 1^{1}; 11: *Trifolium dubium* – 1^{+}; 12: *Festuca pratensis* – III^{1-2}, *Pimpinella major* – I^{1}, *Saxifraga granulata* – I^{1}, *Bellis perennis* – I^{+}, *Dactylorhiza majalis* – I^{+}, *Knautia arvensis* – I^{+}; 17: *Leontodon autumnalis* – 1^{2}																		
Ch. *Artemisietea vulgaris*																		
Urtica dioica	.	.	III^{+2}	1^{+}	III^{+2}	2^{+}	2^{+-1}	.	.	.	.	I^{+}	.	1^{+}	3^{+}	1^{2}	1^{+}	.
Galium aparine	.	.	I^{+-2}	.	II^{+-1}	1^{+}	.	.	.	.	1^{+}	I^{+-1}	.	.	.	1^{2}	.	.
Cirsium arvense	.	.	.	.	I^{1}	.	.	.	.	.	1^{1}	.	.	.	.	.	.	.
Calystegia sepium	.	.	I^{+-1}	.	I^{+-1}	.	.	.	.	.	.	.	.	.	.	.	.	.
Glechoma hederacea	.	.	.	.	.	1^{+}	.	.	.	.	.	I^{+-1}	.	.	.	.	.	.
Species which occur only in community no. 3: *Epilobium hirustum* – I^{+}, *Eupatorium cannabinum* – I^{+}; 5: *Galeopsis pubescens* – I^{1}; 12: *Geum urbanum* – I^{1}, *Cirsium vulgare* – I^{+}																		

TABLE 1 – cont.

Plant association, community	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ch. *Stellarietea mediae*																		
Vicia hirsute	.	.	.	.	.	.	.	.	1^{1}	1^{+}	1^{1}	I^{1}	.	.	.	.	.	.
Conyza canadensis	.	.	.	.	.	.	.	.	2^{1-2}	.	.	I^{+}	.	.	.	.	.	.
Viola arvensis	.	.	.	.	.	.	.	.	2^{+}	.	.	I^{+}	.	.	.	.	.	.
Vicia angustifolia	.	.	.	.	.	.	.	.	1^{+}	1^{+}	.	.	.	.	.	.	.	.
Species which occur only in community no. 9: *Vicia tetrasperma* – 1^{1}, *Anthemis arvensis* – 1^{+}, *Arnoseris minima* – 1^{+}; 11: *Stellaria media* – 2^{+-1}; 12: *Geranium dissectum* – I^{1}																		
Ch. *Alnetea glutinosae*																		
Lycopus europaeus	.	.	II^{+}	1^{+}	II^{+-1}	.	1^{+}	1^{+}	.	.	.	I^{+}	1^{+}	2^{+-1}	1^{+}	1^{+}	.	.
Solanum dulcamara	.	.	I^{+-1}	2^{1}	II^{+-2}	.	.	.	.	.	.	.	2^{+-1}	.	.	.	.	.
Alnus glutinosa	.	.	I^{+}	.	.	2^{1}	.	.	.	.	.	.	.	2^{+-1}	.	.	.	.
Ch. *Agropyretea*																		
Equisetum arvense	.	.	II^{+}	.	II^{+-1}	3^{+}	1^{+}	.	2^{+}	.	2^{+-1}	II^{+-2}	.	1^{+}	.	.	.	.
Elymus repens	.	.	.	.	.	.	.	.	.	.	1^{2}	I^{+}	.	.	.	.	.	.
Species which occur only in community no. 9: *Oenothera biennia* – 2^{+}, *Berteroa incana* – 1^{1}, *Convolvulus arvensis* – 1^{+}; 12: *Cerastium arvense* – I^{+}																		
Ch. *Lemnetea minoris*																		
Lemna minor	1^{1}	1^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ch. *Scheuchzerio-Caricetea nigrae*																		
Stellaria palustris	.	.	.	.	I^{1}	3^{+}	.	.	.	.	.	II^{+-2}	.	2^{+-1}	.	.	.	.
Species which occur only in community no. 5: *Comarum palustre* – I^{1}; 8: *Carex fusca* – 1^{1}; 12: *Viola palustris* – I^{2}																		
Ch. *Nardo-Callunetea*																		
Luzula campestris	.	.	.	.	.	.	.	.	.	1^{+}	.	I^{1-3}	.	.	.	.	1^{1}	.
Species which occur only in community no. 9: *Hieracium pilosella* – 2^{+-2}; 12: *Nardus stricta* – I^{1}																		
Ch. *Bidentetea*																		
Species which occur only in community no. 13: *Bidens frondosa* – 1^{+}; 15: *Polygonum minus* – 1^{+}																		
Ch. *Epilobietea angustifolii*																		
Species which occur only in community no. 12: *Populus tremula* – I^{+}																		
Ch. *Isoëto-Nanojuncetea*																		
Species which occur only in community no. 10: *Juncus bufonius* – 1^{1}																		

TABLE 1 – cont.

Plant association, community	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ch. *Montio-Cardaminetea*																		
Species which occur only in community no. 3: *Cardamine amara* – I^{+}																		
Ch. *Trifolio-Geranietea*																		
Species which occur only in community no. 12: *Galium verum* – I^{1}																		
Accompanying species																		
Rhitidiadelphus squarossus	.	.	.	.	.	.	.	.	.	1^{1}	1^{1}	II^{1-2}	.	1^{2}	.	.	2^{1}	.
Stellaria graminea	.	.	.	.	.	11	.	.	.	.	.	II^{+-2}	.	1^{+}	.	.	1^{1}	1^{+}
Humulus lupulus	.	.	II^{+}	.	I^{1}	.	1^{+}	.	.	.	.	.	.	.	1^{+}	.	.	.
Carex odalis	.	.	.	.	.	.	.	.	.	.	.	I^{+-1}	.	2^{+}	.	.	1^{+}	1^{+}
Polygonum amphibium	.	.	I^{1}	.	I^{+-1}	.	1^{+}	.	.	.	.	.	.	1^{1}	.	.	.	.
Veronica arvensis	.	.	.	.	.	.	.	.	1^{+}	1^{1}	1^{1}	I^{+}	.	.	.	.	.	.
Anthoxanthum odoratum	.	.	.	.	.	.	.	.	.	.	.	III^{13}	.	.	.	.	2^{1-3}	1^{+}
Galeopsis bifida	.	.	III^{+1}	.	II^{1}	.	1^{+}	.	.	.	.	.	.	.	.	.	.	.
Calliergonella cuspidata	.	.	.	.	.	.	.	.	.	.	1^{1}	I^{2}	.	.	.	.	.	1^{1}
Geum rivale	.	.	.	.	.	1^{+}	.	.	.	.	.	I^{+}	.	1^{+}	.	.	.	.
Brachytecium albicans	.	.	.	.	.	.	.	.	2^{2}	1^{1}	.	.	.	.	.	.	.	.
Senecio jacobea	.	.	.	.	.	.	.	.	2^{+-1}	.	.	I^{+}	.	.	.	.	.	.
Lolium multiflorum	.	.	.	.	.	.	.	.	.	1^{1}	.	.	.	.	.	.	.	1^{2}
Plantago major	.	.	.	.	.	.	.	.	.	.	.	II^{+-1}	.	.	.	.	.	1^{+}
Brachytecium retabulum	.	.	.	.	I^{1}	.	.	.	.	.	.	I^{1}	.	.	.	.	.	.
Medicago lupulina	.	.	.	.	.	.	.	.	.	.	1^{1}	.	.	.	.	.	.	1^{1}
Arenaria serpyllifolia	.	.	.	.	.	.	.	.	1^{+}	.	.	I^{+}	.	.	.	.	.	.
Rumex conglomeratus	.	.	.	.	.	.	.	1+	.	.	.	I^{+}	.	.	.	.	.	.
Species which occur only in community no. 5: *Brachytecium mildeanum* – I^{1}; 9: *Ceratodon purpureum* – 2^{2}, *Myosotis stricta* – 1^{2}, *Allium vineale* – 1^{+}; 10: *Pseudoscleropodium purum* – 1^{+}; 11: *Capsella bursa-pastoris* – 1^{+}, *Mentha* × *verticillata* – 1^{+}; 12: *Veronica serpyllifolia* – II^{1}, *Brachytecium salebrosum* – I^{2}, *Pohlia nutans* – I^{1}, *Stellaria uliginosa* – I^{+}, *Vicia dasycarpa* – I^{+}; 17: *Hypericum perforatum* – 1^{+}																		

6. *Caricetum gracilis* (Graebn. Et Hueck 1931) R.Tx. 1937 – A, B
7. *Phalaridetum arundinaceae* (Koch 1926) Libb. 1931 – B
8. Community with *Glyceria fluitans* – A, B

KOELERIO-CORYNEPHORETEA Klika in Klika et Novak 1941

9. Community with *Rumex acetosella* – A

MOLINIO-ARRHENATHERETEA R.Tx. 1937

10. Community with *Agrostis capillaris* – A
11. Community with *Alopecurus pratensis* – A

Molinietalia caeruleae W. Koch 1926

Alopecurion pratensis Pass. 1964

12. Community with *Holcus lanatus* – A

Calthion palustris R.Tx. 1936 em. 1957

13. *Scirpetum silvatici* Ralski 1931 – A, B
14. *Epilobio-Juncetum effusi* Oberd. 1957 – A, B
15. Community with *Juncus effusus* – B

Filipendulion ulmariae Segal 1966

16. Community with *Filipendula ulmaria* – B

Arrhenatheretalia Pawł. 1928

17. Community with *Deschampsia caespitosa* – A

Cynosurion R.Tx. 1947

18. *Lolio-Cynosuretum* R.Tx. 1937 – A

The numerical analysis of phytosociological relevés confirmed the identification of eight rush communities in the class *Phragmitetea* (Fig. 3). There are noticeable groups of relevés in the dendrogram constructed on the basis of species abundance. However, in the second dendrogram made with the use of species presence these groups are not so distinct because many of the species taken into account occurred in the majority of communities with a low abundance. Rush communities are mainly characterised by dominating species with significant abundance so it was the domination of a certain species that was considered in the identification of syntaxonomic affiliation of groups of relevés (Matuszkiewicz 2001).

There are noticeable groups of meadow communities in the dendrogram constructed on the basis of species abundance (Fig. 4). However, these groups are not so distinct in the dendrogram made with the use of species presence. Moreover, the identification of syntaxonomic affiliation of groups of relevés is problematic in the valley of Moszczenica. There are only three generally known plant associations in the group of 10 (Kucharski 1999, Matuszkiewicz 2001). The characteristic combination of species in these three communities is here reduced and simplified. Other communities are classified on the level of classes, orders and alliances because of the lack of characteristic species of lower syntaxons. Communities with *Alopecurus pratensis* and *Holcus lanatus* have untypical combinations of species when comparing them to generally known plant associations such as *Alopecuretum pratensis* (Regel 1925) Steffen 1931 and *Holcetum lanati* (Issler 1936) em. Pass. 1964

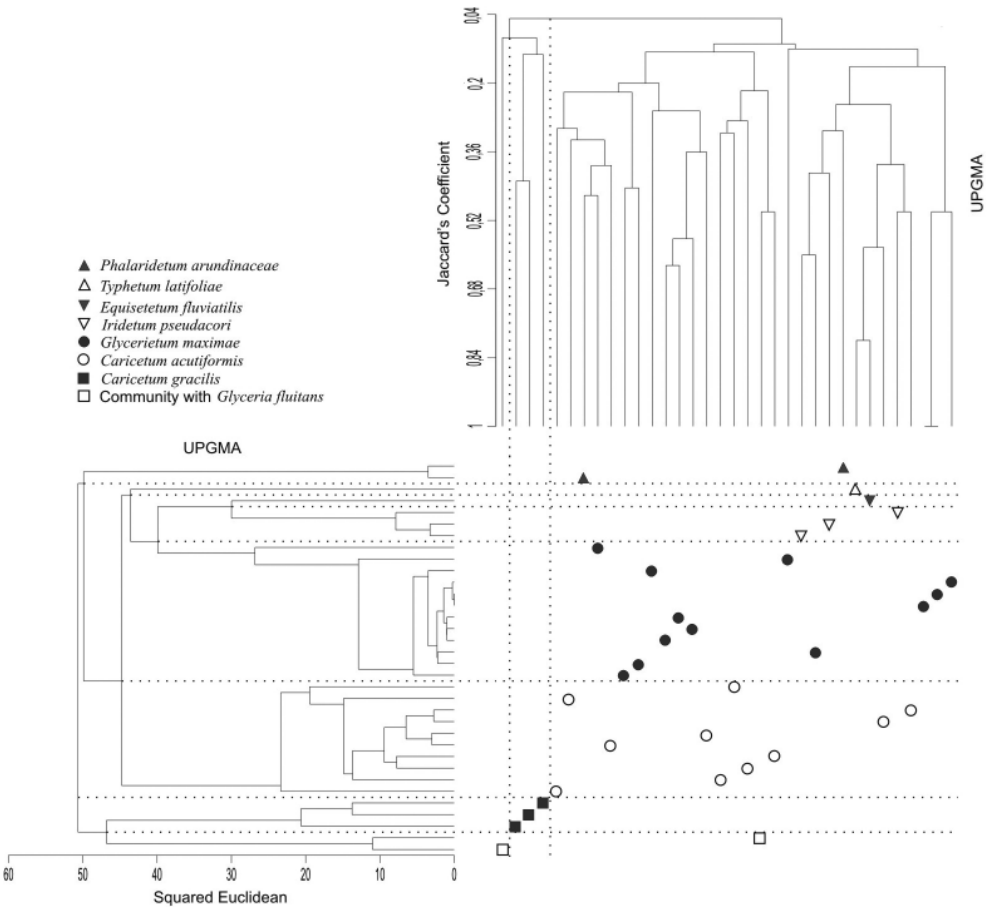

Fig. 3. Combined dendrogram for rush communities based on numerical classification. Dendrograms constructed with the use of species abundance (Squared Euclidean index) and on the basis of species presence (Jaccard's Coefficient index)

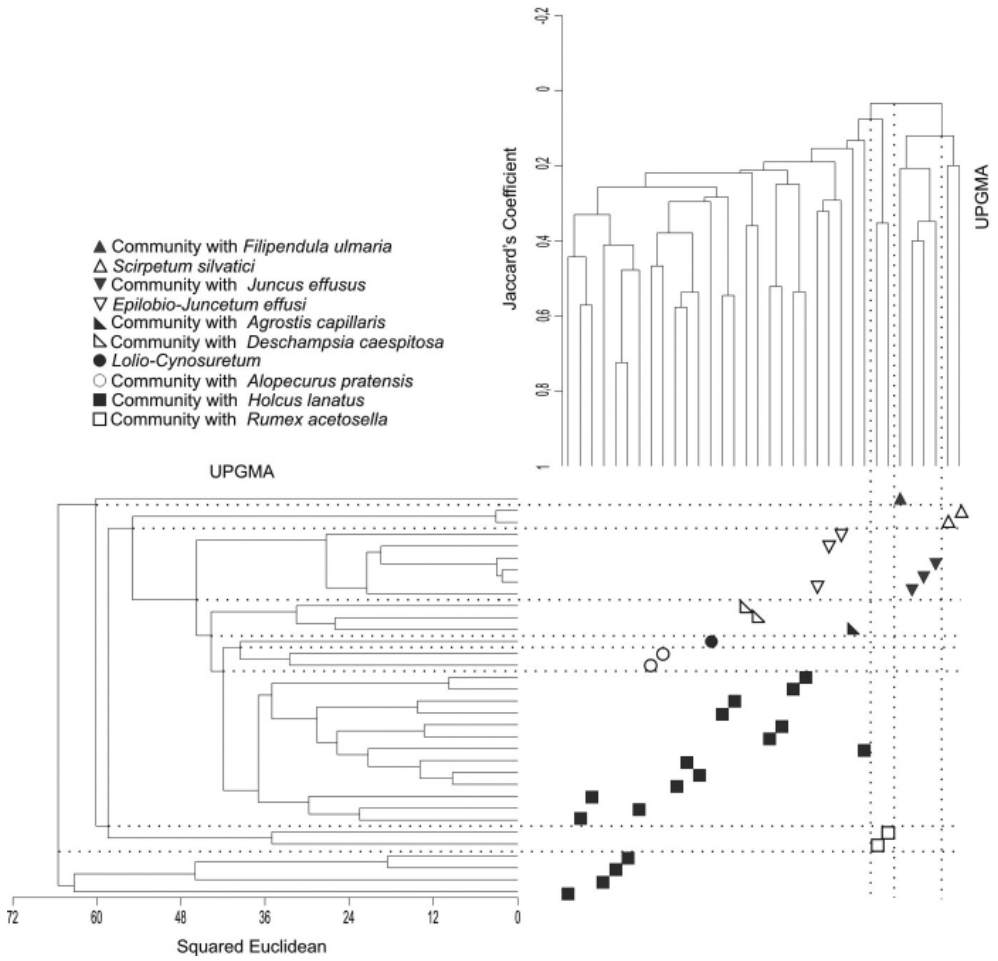

Fig. 4. Combined dendrogram for meadow communities based on numerical classification. Dendrograms constructed with the use of species abundance (Squared Euclidean index) and on the basis of species presence (Jaccard's Coefficient index)

(Kucharski 1999, Matuszkiewicz 2001). Community with *Juncus effusus* has a significantly different combination of species than *Epilobio-Juncetum effusi*, therefore these two syntaxons were characterised separately.

There are 11 plant associations and communities distinguished in parts of the valley with agricultural and recreational use of land. This land use type is dominated by meadow communities and rush communities are in minority. A similar number of 12 syntaxons occurs in parts of the valley with no land use but composition of plant associations and communities is significantly different. This land use type is dominated by rush communities and meadow communities are not common there. There are five syntaxons found both in parts with land use and with no land use. These are *Caricetum acutiformis, Caricetum gracilis, Scirpetum silvatici, Epilobio-Juncetum effusi* and community with *Glyceria fluitans*.

Distinguished plant associations and communities have been characterised with the use of soil moisture values according to Zarzycki et al. (2002) in the used and non-used parts of the valley (Table 2). Parts of the valley with agricultural and recreational use of land are dominated by fresh communities and parts with no land use are dominated by moist and wet communities. However, moist, wet and dry communities are also present in the used parts. Community with *Rumex acetosella* has the lowest soil moisture value (2.33) and occurs only in parts with agricultural and recreational use of land. On the other hand, there is only one aquatic community, *Typhetum latifoliae* (5.88), which occurs in the parts with no land use. The differences between communities occuring both in used and non-used parts according to soil moisture values are insignificant (Table 2).

Moreover, numbers of species in phytosociological relevés and diversity indexes (Shannon and Weaver 1963, Pielou 1975) were compared for the distinguished plant associations and communities in parts of the valley with agricultural and recreational use of land and with no land use (Table 3). In the used parts, *Scirpetum silvatici* has the lowest diversity indexes and *Lolio-Cynosuretum* has the highest ones. In parts of the valley with no land use, the least diversified is *Equisetetum fluviatilis* and the most various is *Epilobio-Juncetum effusi*. However, *Glycerietum maximae* has the lowest evenness index, so there is the greatest domination of single species. Comparing the syntaxons that occur both in the used and non-used parts, *Caricetum acutiformis*, *Caricetum gracilis*, community with *Glyceria fluitans* are more diversified in the first group and *Scirpetum silvatici*, *Epilobio-Juncetum effusi* in the second group.

Table 2. Groups of communities according to soil moisture values by Zarzycki et al. (2002). Communities which are found in both land use types are shadowed

Aquatic	Wet	Moist	Fresh	Dry
Parts of the valley with agricultural and recreational use of land				
	Community with *Glyceria fluitans* 4.96	*Scirpetum silvatici* 4.16	Community with *Holcus lanatus* 3.28	Community with *Rumex acetosella* 2.33
	Caricetum acutiformis 4.74	*Caricetum gracilis* 4.13	*Lolio-Cynosuretum* 2.98	
		Epilobio-Juncetum effusi 3.91	Community with *Deschampsia caespitosa* 2.93	
			Community with *Alopecurus pratensis* 2.86	
			Community with *Agrostis capillaris* 2.74	
Parts of the valley with no land use				
Typhetum latifoliae 5.88	*Glycerietum maximae* 5.28	*Caricetum gracilis* 4.45		
	Equisetetum fluviatilis 5.25	*Caricetum acutiformis* 4.44		
	Community with *Glyceria fluitans* 4.96	*Scirpetum silvatici* 4.1		
	Iridetum pseudacori 4.8	*Epilobio-Juncetum effusi* 4.09		
	Phalaridetum arundinaceae 4.58	Community with *Juncus effusus* 4.08		
		Community with *Filipendula ulmaria* 4		

Table 3. Comparison of total numbers of species in phytosociological releves, Shannon's diversity indexes (H) and Pielou's evenness indexes (J) between parts of the valley with agricultural and recreational use of land and parts with no land use. Communities which are found in both land use types are shadowed

Plant association (community)	Total number of species	H	J
1	2	3	4
Parts of the valley with agricultural and recreational use of land			
Caricetum acutiformis	15	2.12	0.9
Caricetum gracilis	35	2.95	0.92
Community with *Glyceria fluitans*	13	2.34	0.91
Community with *Rumex acetosella*	34	2.94	0.94
Community with *Agrostis capillaris*	26	3.09	0.95
Community with *Alopecurus pratensis*	30	2.92	0.94
Community with *Holcus lanatus*	86	2.84	0.95
Scirpetum silvatici	3	**0.56**	**0.51**
Epilobio-Juncetum effusi	28	2.76	0.95
Community with *Deschampsia caespitosa*	25	2.62	0.92
Lolio-Cynosuretum	29	**3.22**	**0.96**
Parts of the valley with no land use			
Equisetetum fluviatilis	4	**0.98**	0.71
Typhetum latifoliae	5	1.16	0.72
Glycerietum maximae	30	1.18	**0.63**
Iridetum pseudacori	12	1.32	0.75
Caricetum acutiformis	41	1.88	0.84
Caricetum gracilis	9	1.71	0.78
Phalaridetum arundinaceae	12	1.38	0.71
Community with *Glyceria fluitans*	15	2.22	0.82
Scirpetum silvatici	9	1.71	0.77
Epilobio-Juncetum effusi	28	**3.14**	**0.94**
Community with *Juncus effusus*	16	1.61	0.75
Community with *Filipendula ulmaria*	11	1.95	0.81

DISCUSSION

Distinguished plant associations and communities present the variety of rush and meadow vegetation in part of the small-size valley of Moszczenica. Most of the rush communities and some of the meadow communities are generally known plant associations (Matuszkiewicz 2001) which can be found in other river valleys of central Poland (Fagasiewicz 1963, Hereźniak 1972, Osuchowska 1995, Klimkiewicz 1996, Kucharski 1999, Guldzińska 2000, Kamiennik 2004), as well as in other regions of Poland (Herbich 1994, Urban and Grzywna 2003, Kryszak et al. 2005, 2006, Mosek and Miazga 2006, Trąba et al. 2006, Żyszkowska 2007, Grzelak et al. 2008, Grzywna and Urban 2008, Kryszak et al. 2009). However, the identification of syntaxonomic affiliation of other meadow communities is problematic in the valley of Moszczenica because of the lack of characteristic species. According to meadow vegetation, it is quite common situation (Urban and Grzywna 2003, Kryszak et al. 2006, Mosek and Miazga 2006, Trąba et al. 2006) as the state of meadow communities is influenced by many factors such as environmental conditions and agricultural use of land which provide a great variety of communities. Changes in environmental conditions and traditional use of land have an additional impact on the variety and state of meadow communities (Urban and Grzywna 2003, Kryszak 2004, Kryszak et al. 2005, 2008, Mosek and Miazga 2006).

Comparing the variety of rush and meadow vegetation of the Moszczenica valley with other small-size valleys in Poland we can say that it is a diversified but quite typical river valley (Hereźniak 1972, Klimkiewicz 1996, Guldzińska 2000, Urban and Grzywna 2003, Kamiennik 2004, Kryszak et al. 2005, Mosek and Miazga 2006, Żyszkowska 2007, Grzywna and Urban 2008, Kryszak et al. 2009). Moreover, the variety of the distinguished communities, as well as the variety of other small-size valleys is similar to larger river valleys (Fagasiewicz 1963, Osuchowska 1995, Kryszak et al. 2006, Trąba et al. 2006). Therefore, we can not find a pattern of communities occurring in small-size valleys but the variety of rush and meadow vegetation depends on the specific character of the valley.

By the division of the valley into two land use types: parts of the valley with agricultural and recreational use of land and with no present land use, it has been revealed that there is a relationship between vegetation diversity and land use. The overall number of plant associations and communities is similar in both land use types but the composition is different. Therefore, the land use type has a great impact on the variety of communities in the valley. Agricultural and recreational use of land increases the participation of meadow communities and, on the other hand, the lack of land use increases the participation of rush communities. However, some communities are present in both land use types and this may be connected to the variety of environmental conditions in the valley which have a strong impact on the variety of communities as well (Grzelak et al. 2008, Kamiński 2008, Kryszak et al. 2008).

Indicator numbers (Ellenberg 1992, Zarzycki et al. 2002) like soil moisture value are often used to estimate habitat conditions (Kryszak 2004, Kryszak et al. 2005, Żyszkowska 2007, Grzelak et al. 2008, Kryszak et al. 2008). The average values of soil moisture gradients according to Zarzycki et al. (2002) estimated for the distinguished plant communities in both land use types revealed some differences between the spectrums of soil moisture values (Table 2). There is a greater variety of soil moisture values in the used parts of the valley from dry to wet communities with the domination of fresh communities. On the other hand, parts of the valley with no land use have a narrower spectrum of soil moisture values from moist to aquatic communities with the domination of moist communities. Habitat conditions might have been a cause of land use concentration in some parts of the valley than in the others as fresh habitats are more suitable for agricultural and recreational use of land than inaccessible moist and wet habitats.

By comparing the numbers of species in phytosociological relevés and diversity indexes (Shannon and Weaver 1963, Pielou 1975) it has been revealed that diversity of communities is generally higher in parts with agricultural and recreational use of land than in parts with no land use. This is represented by higher numbers of species and diversity indexes of communities in the used parts. Traditional agricultural land use increases vegetation diversity but too intensive land use leads to a decrease in diversity (Kryszak et al. 2008). However, not only land use has an impact on vegetation diversity as some communities are more diverse in parts with no land use. This may be connected to environmental conditions of the site (Kryszak et al. 2006). Moreover, when comparing Shannon's diversity indexes of plant associations in the small-size valley of Moszczenica with diversity of the same syntaxons in larger valleys like these of Warta or San, we notice that it is slightly higher in the larger ones (Kryszak et al. 2006, Trąba et al. 2006).

CONCLUSIONS

1. 18 plant associations and communities have been distinguished in the researched part of the small-size valley of Moszczenica. Most of the distinguished communities are found in other small-size valleys, as well as in larger river valleys.

2. It has been revealed that there is a relationship between vegetation diversity and land use. Parts with agricultural and recreational use of land are dominated by meadow communities and parts with no land use are dominated by rush communities.

3. The average values of soil moisture gradients are more varied in the used parts of the valley from dry to wet communities. On the other hand, the parts of the valley with no land use have a narrower spectrum of mean soil moisture values from moist to aquatic communities.

4. Diversity of communities is generally higher in the parts with agricultural and recreational use of land than in the parts with no present land use.

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