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POTENTIAL TO RESTORE UTILITY VALUE OF MEADOW COMMUNITIES IN ECOLOGICAL COMPENSATION AREAS IN THE WARTA VALLEY

Summary

The study presents results of multifaceted floristic and habitat analyses in the Zagórów washland covered by the water management renaturisation programme leading to the assessment of the potential for restoration of utility value in meadow plant communities in areas, where the primary objective is to recreate their nature value. In the spring seasons of 2011-2013 geobotanical studies were conducted in the Zagórów washland along the network of culverts located in flood embankments linking the inter-embankment zone with the area behind the embankment in four transects of 77 relevés. Based on their analyses using phytoindication of their moisture content (F) and nitrogen soil content (N) were assessed using indexes according to Ellenberg et al. (1992). Utility value of swards in the identified plant communities was determined based on the structure of fodder groups, fodder value Lwu assessed according to the method proposed by Filipek (1973) and the occurrence of melliferous plants, herbs and energy materials. Renaturisation of water management facilitates not only restoration of nature value of meadow and rush plant communities, but also their utility value, mainly non-fodder. Moisture content and extensive use influences the shares of melliferous species, herbs and energy materials in the vegetation ground cover.
***Key words**: the Warta valley, utility value, melliferous plants, herbs, energy materials*

MOŻLIWOŚCI PRZYWRACANIA WARTOŚCI UŻYTKOWEJ ZBIOROWISK ŁĄKOWYCH NA TERENACH KOMPENSACJI PRZYRODNICZEJ W DOLINIE WARTY

Streszczenie

Praca przedstawia wyniki wieloaspektowych badań florystyczno-siedliskowych na polderze Zagórów objętym programem renaturyzacji gospodarki wodnej prowadzących do oceny możliwości przywracania wartości użytkowej zbiorowisk łąkowych na obszarach, gdzie nadrzędnym celem jest odtworzenie ich walorów przyrodniczych. W okresie wiosny 2011-2013 prowadzono badania geobotaniczne na polderze Zagórów, gdzie wzdłuż sieci przepustów zlokalizowanych w wałach przeciwpowodziowych łączących międzywale z zawalem wykonano w czterech transektach 77 zdjęć fitosocjologicznych. Na podstawie ich analizy metodą fitoindykacji wskaźnikami Ellenberga i in. (1992) oceniono: uwilgotnienie (F) oraz zawartość azotu w glebie (N). Wartość użytkową runi wyróżnionych zbiorowisk określono na podstawie: struktury grup użytkowych, wskaźnika Lwu ocenionego metodą Filipka (1973) oraz występowania roślin miododajnych, ziół oraz energetycznych. Renaturyzacja gospodarki wodnej pozwala nie tylko przywracać walory przyrodnicze zbiorowisk łąkowo-szuwarowych, ale także ich wartość użytkową, głównie pozapaszową. Uwilgotnienie oraz ekstensywne użytkowanie ma wpływ na udział w pokryciu: gatunków miododajnych, ziół i roślin energetycznych.
***Słowa kluczowe:** dolina Warty, wartość użytkowa, rośliny miododajne, zioła, rośliny energetyczne*

1. Introduction and aim of study

Meadow habitats in the Warta valley, particularly in the 1970's, were destroyed as a result of land reclamation and investment works [1]. While the transformations in vegetation were directly influenced by land reclamation works due to changes in moisture contents and trophic character of habitats, an indirect effect was observed for investment works, particularly roads, as well as those connected with inappropriate water management for waters from the Jeziorsko reservoir. Thus in order to restore lost nature value, sections for ecological compensation were identified in certain areas of the valley [2]. However, in view of the fact that these are natural floodplains overgrown by meadow vegetation, restoration of nature value thanks to ecological compensation is possible only at their adequate use.

The direction of use of vegetation in meadow plant communities is frequently determined by habitat conditions, first of all moisture content. In areas of moderate moisture content, having no exceptional nature value, the primary utility function of grassland plant communities is to supply cheap, quality fodder to farm animals [3]. In turn, in areas with excessive or variable moisture content the potential fodder use of meadow sward is limited, but its floristic richness may provide other utility values, e.g. as feeding ground for bees, a source of herb material or fuel. However, the simultaneous maintenance of high nature value of meadow swards requires extensive use, but in such a case it exhibits a lower fodder value. It needs to be stressed here that such multi-species meadow plant communities are valuable for the protection of biodiversity, presenting high nature value and a simultaneous considerable utility value [4, 5].

An example of the potential non-fodder use of sward is provided by meadow plant communities formed in habitats with variable moisture content in the Warta valley in ecological compensation areas in the region of Zagórów [6].

The aim of multifaceted floristic and habitat studies conducted in the Zagórów polder covered by the water management renaturisation programme was to assess the potential for restoration of utility value of meadow plant

communities in the areas, where the primary aim is to recreate their nature value.

2. Methods

In the spring seasons of 2011-2013 geobotanical studies were conducted in the Zagórów polder. Along the network of culverts located in flood embankments linking the inter-embankment zone with the area behind the embankment were conducted in four transects of 77 relevés, each of 50 - 100 m^2. Based on their analyses the phytoindication method with the use of indexes according to Ellenberg et al. [7] was applied for moisture content (F) and nitrogen content in soil (N). Utility value of sward in distinguished plant communities was determined based on the structure of utility groups, fodder value score (Lvs) assessed using the method proposed by Filipek [8] and the occurrence of melliferous plants, herbs and energy materials. Classification of plants as used by bees was based on the Great atlas of melliferous plants [9], as herb raw material based on the Key to plant identification [10], as energy material based on the potential subsidy to cultivation of energy crops [11].

Nomenclature of plant species was adopted after Mirek et al. [12], while plant communities were classified following the binding phytosociological system [13].

In order to indicate the potential to obtain the best possible utility value at the simultaneous primary objective of ecological compensation, the results were analysed statistically using the Canoco 5 for Windows programme [14].

3. Results

The utility value of swards in plant communities growing in areas covered by ecological compensation resulted from geomorphology of the area, moisture conditions and use (Table 1).

Ecological compensation works conducted since 2009, supplying water through the system of culverts, facilitated water management and initiated succession changes, aiming first of all at the restoration of nature value in the Warta floodplain. This resulted in the development of a considerable share of phytocenoses connected with wet and moist habitats. They represent classes *Phragmitetea* and *Molinio-Arrhenatheretea*. As it was reported by Kryszak et al. [15], currently the largest areas are covered by syntaxa of extensively used habitats with periodical excessive moisture content, of orders *Trifolio fragiferae-Agrostietalia stoloniferae* and *Molinietalia*. They developed within the range of the impact of water supplied by culverts. In turn, elevated areas, not reached by the waters of the reservoir, are overgrown by plant communities with *Festuca rubra*, with *Holcus lanatus*, with *Nardus stricta* and with *Agrostis capillaris*.

Such a structure of plant communities and their floristic composition result in the their current relatively low utility value. Plants with low fodder value, i.e. wild grasses, sedges and the so-called plants from the groups of herbs and weeds, predominate in the swards of most of these communities. A particularly high share in the ground cover was found for wild grasses. In turn, cultivated grasses, most frequently at a slight percentage, were found only in swards of systematically used phytocenoses of *Phalaridetum arundinaceae*, *Alopecuretum pratensis*, the community with *Festuca rubra*, where the accounted for over 64%. Their high proportion resulted in an almost good utility value of the sward, which reached the Lwu value of over 5.4. In swards of the other plant communities the share of cultivated grasses ranged from 0.06 to approx. 31%, and its utility value assessed using the fodder value index was lower, i.e. mediocre.

Moreover, we need to stress the slight percentage of legumes in the sward, amounting to 0.21-3.51%. In most phytocenoses in which they were found they accounted for up to 0.5%. The greatest share in the ground cover was recorded for these plants in phytocenoses of *Alopecuretum pratensis*.

The low utility value of swards is connected with the occurrence of sedges. At their high share in the sward they result in low, mediocre fodder value.

Table 1. Habitat conditions in meadow plant communities found in the ecological compensation area in the Zagórów polder

Tab. 1. Warunki siedliskowe zbiorowisk łąkowych występujących na terenie prowadzenia kompensacji przyrodniczej polderu Zagórów

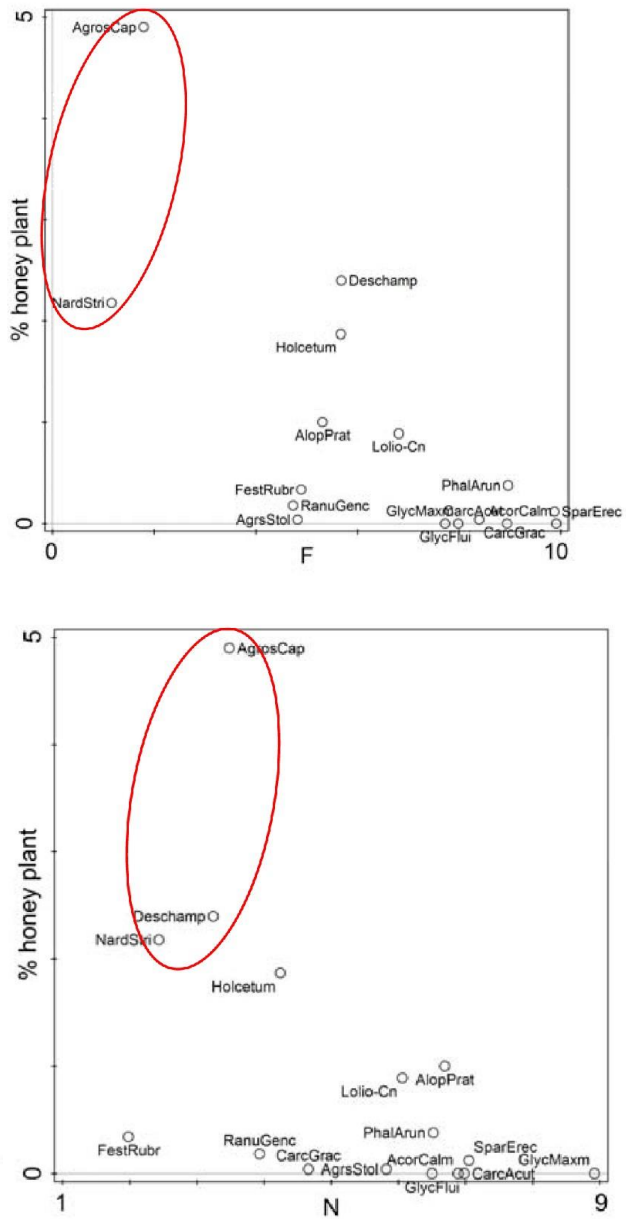
Plant community	Mean Ellenberg's index		
	F	R	N
Rush plant communities of *Phragmitetea* class			
Acoretum calami	9,91	6,72	6,89
Glycerietum maximae	7,98	7,90	8,92
Sparganietum erecti	9,87	6,95	7,05
Glycerietum fluitantis	7,72	0,24	6,50
Caricetum gracilis	8,39	5,26	4,66
Caricetum acutiformis	8,94	8,94	6,98
Phalaridetum arundinaceae	8,96	6,30	6,52
Communities of *Molinio-Arrhenatheretea* class			
Community *Deschampsia caespitosa*	5,68	1,10	3,24
Community with *Holcus lanatus*	5,67	0,71	4,24
Ranunculo-Alopecuretum geniculati	4,73	0,87	3,93
Community *Agrostis stolonifera-Potentilla anserina*	4,82	1,55	5,82
Community with *Festuca rubra*	4,89	3,83	1,98
Alopecuretum pratensis	5,31	4,32	6,69
Lolio-Cynosuretum	6,81	4,38	6,06
Communities of *Nardo-Callunetea* class			
Community with *Nardus stricta*	1,16	0,05	2,43
Community with *Agrostis capillaries*	1,79	2,97	3,48

Source: Own work / Źródło: opracowanie własne

In certain phytocenoses located in sites flooded over extensive periods of time willow, poplar or birch seedlings were even found, which confirms that the primary objective of ecological compensation in this area, i.e. restoration of its nature value, is met (Table 2).

The multispecies sward in almost all evaluated plant communities in the Zagórów washland has no high fodder value; however, certain plants potentially constituting herb raw material, energy material or plants used by bees have a positive effect on its utility value.

Melliferous plants, although the presence of 22 species was recorded in that area, did not account for a considerable ground cover in swards of all distinguished plant communities. Their share in the sward decreased with an increase in moisture content of habitats and low nitrogen content in soil (Fig. 1).



Source: Own work / Źródło: opracowanie własne

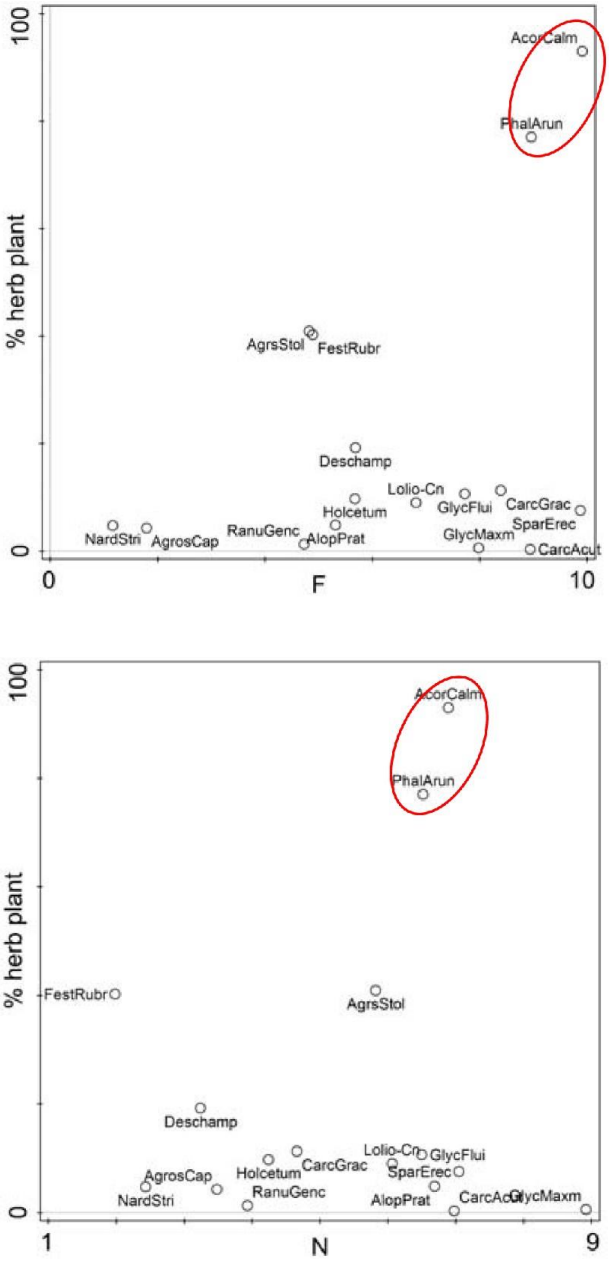
Fig. 1. The share of melliferous plants (%) in ground cover in meadow and rush plant communities depending on moisture content of habitats and nitrogen content in soil

Rys. 1. Udział w pokryciu roślin miododajnych (%) w wyróżnionych zbiorowiskach łąkowo-szuwarowych w zależności od uwilgotnienia siedliska i zawartości azotu w glebie

The greatest number of species was recorded in the sward of the community *Agrostis stolonifera-Potentilla anserina* (10); however, they constituted a small percentage of the ground cover (0.34%). In turn, the greatest share (4.90%) was recorded in the sward of the community with *Agrostis capillaris* (Table 2). The most common melliferous species included *Salix cinerea, Trifolium repens, Leontodon autumnalis, Taraxacum officinalis* as well as *Lythrum salicaria* and *Linaria vulgaris.* It needs to be stressed here that at a higher share of melliferous species in the ground cover, the utility value of the sward was low, assessed as mediocre (Table 3).

In contrast, in the species composition of swards a greater richness was recorded for plants potentially constituting herb raw material. A total of 52 taxa were recorded, but with a higher share they are found in swards of plant communities in habitats with high moisture content, i.e. *Acoretum calami* and *Phalaridetum arundinaceae* (Fig. 2).

A particularly high number of these species (23) and at the same time their considerable shares in ground cover were recorded in the community *Agrostis stolonifera-Potentilla anserina* (40.25%) (Table 2). Among herb species the most frequent occurrence in plant communities was recorded for *Potentilla anserina, Rumex acetosa, Lysimachia nummularia, Acorus calamus, Urtica dioica, Plantago lanceolata* and *Taraxacum officinale.* Swards with a higher share of plants having medicinal value generally had poor and mediocre utility value (Table 3).



Source: Own work / Źródło: opracowanie własne

Fig. 2. The share of herbs (%) in ground cover in meadow and rush plant communities depending on habitat moisture content and nitrogen content in soil

Rys. 2. Udział w pokryciu ziół (%) w wyróżnionych zbiorowiskach łąkowo-szuwarowych w zależności od uwilgotnienia siedliska i zawartości azotu w glebie

Table 2. Richness of species, geo-historical spectrum and nature valuation of plant communities in the Zagórów polder
Tab. 2. Bogactwo gatunkowe, spektrum geograficzno-historyczne oraz waloryzacja przyrodnicza wyróżnionych zbiorowisk polderu Zagórów

Plant community	Number of plant species		Structure of use type plant species (% in cover)					Utility value							
			Grasses		Sedge	Legumes	Other plant dicotyledonous	Fodder value Score (Fvs)	Plant species						
									Melliferous		Herbs		Energy		
	Total	In phytosociological releves	Cultivar	Non-cultivar					Number	% in cover	number	% in cover	number	% in cover
Acoretum calami	12	12	0,06	3,09	0,06	-	96,79	1,12	-	-	2	93,02	1	3,09
Glycerietum maximae	5	5	0,56	98,2	-	-	1,23	5,03	-	-	1	0,56	1	98,20
Sparganietum erecti	12	12	6,23	-	0,62	-	93,15	1,34	1	0,12	4	7,59	3	6,97
Glycerietum fluitantis	15	15	0,96	81,88	-	-	17,16	4,34	-	-	3	10,68	-	-
Caricetum gracilis	41	13,4	12,7	0,38	67,99	-	18,93	1,99	2	0,04	13	11,3	4	76,26
Caricetum acutiformis	11	4,5	1,75	-	95,54	-	2,71	3,96	-	-	2	0,35	2	97,29
Phalaridetum arundinaceae	41	14,5	74,63	0,22	7,47	0,32	17,36	5,44	4	0,38	12	77,04	5	80,29
Alopecuretum pratensis	43	99	64,05	4,76	-	0,21	30,98	6,21	6	2,40	14	19,24	1	10,88
Community *Deschampsia caespitosa*	55	21,3	11,85	55,15	0,76	0,34	31,9	3,39	7	1,87	12	9,79	3	0,06
Community with *Holcus lanatus*	9	9	10,15	87,65	0,92	-	1,28	5,17	1	0,18	3	1,28	-	-
Ranunculo-Alopecuretum geniculati	20	30	0,67	58,57	2,97	-	37,79	3,54	1	0,04	6	4,96	1	0,46
Community *Agrostis stolonifera-Potentilla anserina*	87	14,4	5,93	30,51	7,58	0,50	55,48	2,90	10	0,34	23	40,25	11	6,47
Lolio-Cynosuretum	29		30,55	3,3	-	-	66,15	4,99	1	1,0	7	4,85	1	23,95
Community with *Festuca rubra*	19	19	63,8	16,32	0,15	-	19,73	5,77	2	0,89	4	9,05	1	0,15
Community with *Nardus stricta*	38	38	0,36	78,4	0,14	-	21,1	2,58	4	2,18	10	4,77	3	0,19
Community with *Agrostis capillaris*	37	23,5	0,07	83,82	0,07	3,51	12,53	4,83	6	4,90	8	4,32	1	0,07
On Zagórów washland			x	x	x	x	x		22	x	52	x		x

Source: Own work / Źródło: opracowanie własne

Table 3. Melliferous and herb species in meadow plant communities

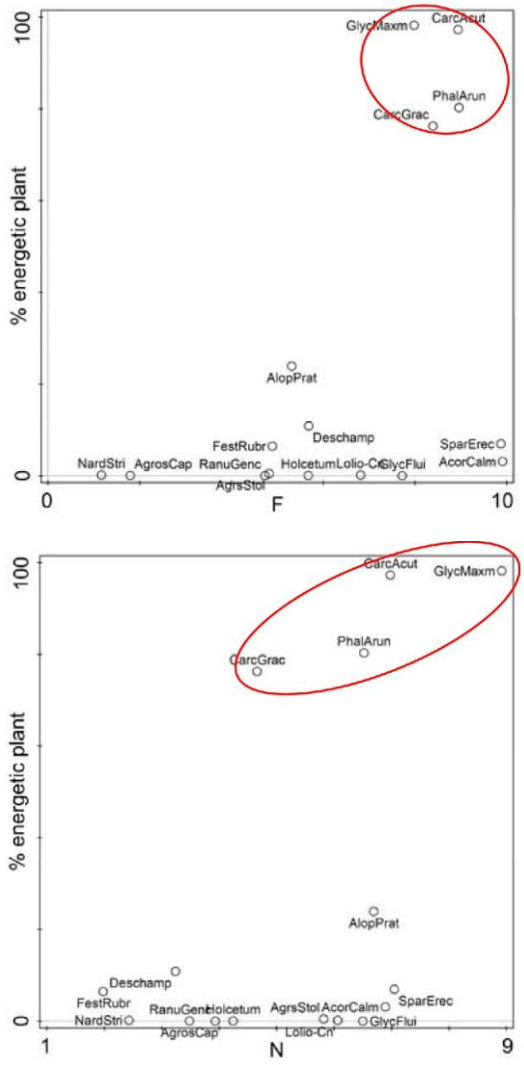
Tab. 3. Gatunki miododajne i zielarskie w wyróżnionych zbiorowiskach łąkowych

Plant species	*Acoretum calami*	*Glycerietum maximae*	*Sparganietum erecti*	*Glycerietum fluitantis*	*Caricetum gracilis*	*Caricetum acutiformis*	*Phalarideturn arundinaceae*	Com. with *Festuca rubra*	Com. *Deschampsia caespitosa*	Com. with.*Holcus lanatus*	*Ranunculo-Alopecuretum geniculati*	Com. *Agrostis stolonifera-Potentilla anserina*	Com. with *Nardus stricta*	Com. with *Agrostis capillaris*	*Alopecuretum pratensis*	*Lolio-Cynosuretum*	Number of occurrences
Melliferous plants																	
Salix cinerea			+			+		+	+			+					5
Trifolium regens						+			+			+		+	+		5
Leontodon autumnalis								+	+			+	+	+			5
Taraxacum officinalis									+		+		+	+	+		5
Lythrum salicaria					+	+						+					3
Linaria vulgaris									+				+	+			3
Salix purpurea									+			+					2
Symphytum officinalis						+						+					2
Calluna vulgaris													+	+			2
Hypericum perforatum									+				+				2
Lamium album															+	+	2
Lamium purpureum															+	+	2
Salix alba												+					1
Trifolium pratense														+			1
Trifolium dubiom												+					1
Succisa pratensis					+												1
Frangula alnus												+					1
Geranium pratense												+					1
Lotus corniculatus														+			1
Prunella vulgaris										+							1
Centaurea cyanus															+		1
Sinapsis alba															+		1
Herbs																	
Potentilla anserine	+	+		+	+	+	+		+	+	+	+	+	+			12
Rumex acetosa					+			+	+	+		+	+	+	+		8
Lysimachia nummularia				+	+		+				+	+					5
Acorus calamus	+		+			+	+					+					5
Urtica dioica					+		+		+						+	+	5
Plantago lanceolata								+	+			+	+		+		5
Taraxacum officinale									+		+		+	+	+		5
Iris pseudacorus			+		+		+					+					4

Plantago major				+			+				+	+					4
Mentha pulegium					+				+		+	+					4
Lycopus europaeus					+		+					+					3
Lythrum salicaria					+		+					+					3
Oenanthe aquatica					+		+						+				3
Sium latifolium					+		+					+					3
Hieracium pilosella									+				+	+			3
Solanum dulcamara							+					+					2
Symphytum officinale							+					+					2
Potentilla erecta								+						+			2
Chenopodium bonus-henricus					+							+					2
Chenopodium album															+	+	2
Polygonum hydropiper					+				+								2
Filipendula almaria					+							+					2
Cirsium oleraceum											+	+					2
Betula sp.													+	+			2
Hypericum perforatum									+				+				2
Tanacetum vulgare													+	+			2
Prunella vulgaris									+	+							2
Capsella bursa-pastoris															+	+	2
Lamium album															+	+	2
Thlaspi arvense															+	+	2
Oenanthe aquatica			+														1
Sium latifolium			+														1
Urtica urens												+					1
Ranunculus regens								+									1
Mentha piperita												+					1
Frangula alnus												+					1
Matricaria chamomilla												+					1
Polygonum hydropiper												+					1
Quercus petraea												+					1
Salix alba												+					1
Pinus sp.													+				1
Bellis perennis									+								1
Euphrasia rostkoviana									+								1
Helichrysum arenarium														+			1
Arctium lappa															+		1
Artemisia vulgaris															+		1
Centaurea cyanus															+		1
Fumaria officinalis															+		
Heracleum sphondylium ssp. Sphondylium															+		1
Sinapis alba															+		1
Brassica napus																+	1
Glechoma hederacea																+	1

Source: Own work / Źródło: opracowanie własne

The greatest number of species potentially constituting energy material was recorded in the sward of the community *Agrostis stolonifera-Potentilla anserina;* however, their share in ground cover is slight, i.e. approx. 6.5%. In contrast, the greatest ground cover by energy species was observed in plant communities in wet and moist habitats and those with a high nitrogen content in soil: *Glycerietum maximae, Caricetum acutiformis* and *Phalaridetum arundinaceae* (Fig. 3).



Source: Own work / Źródło: opracowanie własne

Fig. 3. The share of energy plants (%) in ground cover of meadow and rush plant communities depending on habitat moisture content and nitrogen content in soil

Rys. 3. Udział w pokryciu roślin energetycznych (%) w wyróżnionych zbiorowiskach łąkowo-szuwarowych w zależności od uwilgotnienia siedliska i zawartości azotu w glebie

In these phytocenoses with slight utility value such a considerable ground cover, over 80%, was recorded only for a very small number of species such as *Glyceria maxima, Phalaris arundinacea* (Table 3).

4. Discussion

The species composition of semi-natural plant communities, developed and maintained as a result of indirect or direct human activity, is undergoing continuous changes [16]. Sometimes these changes, particularly concerning habitat conditions, threaten stability meadow plant communities leading to their reduced nature and utility value [17]. Thus, as made possible particularly by hydrometeorological conditions in a given area and financial means, there is a need to recreate habitat conditions ensuring restoration of nature value and thus utility value of meadow plant communities growing there [2]. An analysis of the current floristic structure in plant communities located in Zagórów in the area behind the embankment confirms that water management by opening and closing of culverts under controlled hydrological conditions, facilitating renaturisation of water circulation, has already initiated succession changes in vegetation [15]. These changes are manifested in these phytocenoses in an increased share of species preferring moist localities, which indicates restoration of vegetation typical of floodplains in river valleys. It needs to be assumed that a continuation of such land reclamation works will promote further succession changes in the occurrence of species with non-fodder value in the swards of these plant communities. However, taking into consideration the fact that this area is utilised agriculturally and many plant communities are of anthropogenic origin, the process of their restoration is very slow [18, 19, 20].

Occurrence of nature value in such regions, as confirmed by results of studies from Zagórów, leads to the recreation of multispecies swards and the presence of species with e.g. a dietary and herb therapeutic role. Many authors [21, 22, 23, 24] point to the importance of these plants not only in relation to the fodder value of swards, but also as herb raw material. In view of the fact that some of them, particularly those found in areas with excessive or periodical moisture content, are threatened with extinction throughout the country, the need to maintain their localities is important both for the preservation of biodiversity as well as the potential collection of these herbs, which may be collected only from natural habitats.

Occurrence of pollen- and nectar plants such as e.g. common dandelion, meadowsweet, bistort, clover species and field mint, serves a biocenotic role for the balanced development of bee families, but also certain beetles, dipterans, butterflies and thrips [25, 26, 27].

Among plants of wetlands and area with excessive moisture content there are species constituting a potential source of renewable energy due to their high yield of biomass, even as high as over 14 t d.m. ha^{-1} [28, 29]. In ecological compensation areas in Zagórów there are areas covered by plant communities, from which collection of biomass for energy purposes has no negative effect on their nature value.

Habitat conditions determine not only the direction of use for meadow plant communities, but also its intensity [30]. Conducted renaturisation of water management in the case of conditions found in Zagórów requires extensive use or is even sporadically dependent on the current habitat moisture content. Although its primary aim is to recreate nature value of plant communities, the need to collect biomass rich in plant species may be a source of valuable cattle feed by enriching it with macro- and micronutrients as well as diverse biologically active substances [31, 32]. Dairy products produced from milk coming from cows fed fodder from such meadows will present high nutritive value.

5. Conclusions

1. Renaturisation of water management makes it possible not only to restore nature value of meadow and rush plant

communities, as well as their utility value, primarily non-fodder.

2. Utility value of plant communities in such areas is connected with the presence of melliferous plants, herbs and species constituting energy raw material in their species composition.

3. Occurrence of species with non-fodder importance is dependent on geomorphology of the area and the resulting habitat conditions, primarily moisture content and extensive use, as indicated by the highest share in ground cover:

- recorded for melliferous species in elevated areas with a lower moisture content,
- herb species and energy species in areas with permanent or periodical excessive moisture content.

6. References

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