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GEOBOTANICAL RESEARCH USING THE CONCEPT OF SIGMASSOCIATIONS. CASUS: NIDA BASIN (SOUTH POLAND)

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This article contains the evaluation of the diversity of the vegetation cover in the agricultural landscape of the Nida Basin (southern Poland). The results of the research have been elaborated with the use of the global phytosociology method and the concept of sigmassociations.

On the area of the Nida Basin 14 complex (big) sigmassociations have been identified and within their limits 30 basic (small) sigmassociations have been determined. Within those units three complex forest and scrub sigmassociations with six basic sigmassociations, two complex non-forest sigmassociations with five basic sigmassociations as well as nine complex synanthropic sigmassociations with 19 basic ones have been distinguished.

Key words: the Nida Basin, vegetation cover, agricultural landscape, the concept of sigmassociations, the potential cultural vegetation.

According to naturalists the region of the Nida Basin (fig. 1) is a valuable natural object; at the same time this part of Poland is dominated by agricultural areas. Therefore, it is an arena of the clash between economical-social interests and those related to the preservation of valuable natural resources and nature values. Does this region have a chance to become a model object of land utilization and the place of sustainable development? What is more, are the local farmers prepared to produce food in an ecological way?

The aim of research and analyses described in this article was to show the diversity of the vegetation cover in the agricultural landscape as well as to highlight the motives of its protection in the context of the accession of Poland to the European Union. The results have been based on sozological research carried out in the agricultural landscape of the Nida Basin (southern Poland) as well as in agrophytocenoses belonging to the Ponidzie Landscape Parks Association.

It has been proven many times that in agricultural landscapes spatial structure and ecological functions are generally simplified, which results in the degradation of the system. Moreover, those systems are particularly prone to energy and matter dispersion. It is often seen in landscapes "oversaturated" by the human activity as well as in the case of resource mining. Changes in the structure and functioning of the agricultural landscape, and the consequent decline in the flora and fauna diversity, are particularly influence by: changes in the chemical and physical structure of soil, pesticides, water eutrophication, elimination of field enclaves (woodlots, boundary strips, field ponds, swamps, grassland communities) as well as changes in the land exploitation and in the structure of crops, including the decline in their diversity.

In recent years, a systemic approach to environmental protection, integrated with other sectors of social and economic life could have been remarked in Poland. Conservation of all endangered species and ecosystems, including those of anthropogenic origin, may constitute the complement of the traditional, conservatory approach to ecology. Such extension of the scope and motives of environmental protection may be the key factor towards implementing the principles of the sustainable development and conservation or increase of the biodiversity. This new approach to environmental protection has been reflected by declarations and documents proposed by the European Union in recent years. They include the following EU programs: "Pan-European Strategy for the Conservation of Biological and Landscape Diversity" and NATURA 2000 currently underway. Those and other programs are supported by a couple of systems and networks and the most important ones within the EU countries are: PEEN (Pan-European Ecological Network), CORINE (Coordination of Information on the Environment), and ECONET-PL (Polish Ecological Network) in Poland [3; 12].

We would like to emphasize that it has been very difficult to adjust Polish legal and organizational system to European standards so it should be noted that in recent years such terms as core areas, green corridors, nature refuges and habitats have started to be appear in the Polish legal system.

The European environmental programs, and PEEN in particular, are based on the assumption that the vast implementation of environmental goals will take place in agricultural landscapes. Core areas will also include semi-natural and degenerated ecosystems to which extensively and intensively exploited agricultural areas can be included. For this reason it will be easier to restore the nature values of those areas within the implementation of environmentally friendly agricultural policy.

The most important motive behind the implementation of the environmentally friendly agricultural policy in Poland is the necessity to go beyond – both in thinking and action – the traditional categories of environmental protection and hammer out a functional approach to the conservation of agricultural landscapes. In the EU countries such policy is being implemented through [12]: formation of the optimal ecological structure on agricultural areas, restoration of the proper water relations, reasonable exploitation of the biological diversity as well as promoting among the farmers the code of good practices limiting the consequences of environmental pollution.

The evaluation of the vegetation cover in the landscape of the Nida Basin has been carried out using the concept of sigmassociations as regarded by Géhu [9] and on the basis of the concept by Vahle [19] concerning the potential cultural vegetation, adapted to the specific character of the Nida Basin. Both authors oriented their concepts on landscape research on a regional scale. Their major assumptions are narrowed the examination of the vegetation landscape, its classification and evaluation of its ecological diversity. They can be used for the implementation of the sustainable natural resource management as well as in spatial planning of rural areas. It seems that these concepts, when slightly modified and adapted to the conditions of the examined area, might find their application in the assessment and forecasting of changes in the vegetation cover, and help in modeling and simulating the ecological processes of the land-scape.

The notion of sigmassociation defined as the sum of plant ecosystems in a given landscape, was used for the first time in mid-70s [1]. Later the term was used by Gehu [9] and Tüxen [17] to determine the existing units of the vegetation cover in vegetation community complexes put together by the method of phytosociology. Since then the sigmassociation has been construed as the fundamental unit within the so called simphytosociology**,** referred to also as the phytosociology of the natural landscape. At the same time it has been highlighted that the relation between the sigmassociation and simphytosociology is the same as between alliance and phytosociology, or species and taxonomy.

Tüxen worked further to improve the concept of the sigmassociation. He pointed to some of its specific features (a/o the average minimal area, a homogenous character of the selected scale) as well as to significant methodological differences between the vegetation community complexes as regarded by Braun-Blanquet [2] and the sigmassociation as regarded by Tüxen [17; 18]. He emphasized the utility and a precise character of the sigmassociation in the assessment of the vegetation cover, particularly in the geobotanical cartography and contrastive analyses of different vegetation landscapes.

According to Wahle [19] potential cultural vegetation is the vegetation that develops on a particular area as consequence of the human activity while increasing its diversity. The concept of the potential cultural vegetation is here identified with the plant communities in a cultural vegetation landscape, transformed by the human activity.

Vegetation landscapes of the rural areas, for instance agricultural fields, meadows and pastures, forests are the main areas of potential cultural vegetation. The intensity of exploitation and the historical aspect of examined landscapes are also taken into account. At the same time rural landscapes are characterized by a huge trophic polarisation. The most intensively exploited and tilled land is located in the countryside and its nearest surroundings, and the intensity of exploitation decreases outwards from the countryside's boundaries. Such type of the cultural gradient was referred to by the landscape ecologists as "the rings". In economic terms, substances are collected from the external, oligotrophic ring, which enriches the internal rings. Vahle [19] suggested matching particular zones of the cultural gradient to phytosociological units in the form of vicarious communities. Those communities changed in accordance with the presented cultural gradient.

Thus, according to Wahle, the essence of the potential cultural vegetation, as opposed to the potential natural vegetation, where the human factor is not taken into account, are the dynamic opportunities of the development of vicarious communities conditioned by the farming land in the agricultural landscape founded and cultivated by man in the gradient of time and space. Moreover it manifests the plant potential in the agricultural landscape, the task that goes far beyond the reach of phytosociology.

This concept can provide satisfactory answers to many questions related to future activity of man in the landscape, but above all, it can show how to prevent the decline in the biodiversity and to ensure the sustainable development in the landscape as well as how natural and semi-natural vegetation communities can coexist with agricultural exploitation.

The macro-region of the Nida Basin according to Kondracki [10] is a kind of synclinorium located in the south-eastern part of the Małopolska Upland. It is litologically diversified. The southern and western part of the upland underwent marine transgression during the Miocene period, leaving calciferous sandstones, limestone, clay and gypsum as well as loess layers with fertile brown soils.

The physical-geographical regionalization of the Nida Basin raised a lot of controversy for a couple of years. For the purpose of this study the notion of the physical-geographical regionalization of the Nida Basin shall be understood as regarded by Kondracki [10]. He proposed to divide the macro-region of the Nida Basin into the following eight mezoregions: Jędrzejów Plateau, Miechów Upland, Proszowice Plateau, Wodzisław Hump, Nida Valley, Solec Basin, Pińczów Hummock and Połaniec Basin. This macro-region occupies the land of 4,700 sqkm and is surrounded by four macro-regions: Kielce Upland from the north, Przedbórz Upland from the south-west, Kraków-Częstochowa from the west and Sandomierz Basin from the south-east.

The landscape of the Nida basin is characterized by a huge diversity of: (A) the land relief (uplands, humps, cuestas, knickpoints, plateaus, basins, plains, dunes, karst landforms), (B) geological diversity (limestone, gypsum, bedrocks, marlstones, dolomites, sandstones, loess, clays, gravels), (C) the soils (rendzinas, podsolic soils, pseudo-podsolic soils, brown soils, chernozems, black soils, alluvial soils, hydrogenic soils, silts, mucks, bog soils) and (D) the biodiversity. In relation to agricultural activity the region has a big production area for the agriculture (farm land – 74 %, grasslands – 9 %).

In order to protect the values of the Nida Basin from anthropogenic threats, several reserves have been established in this area and in 1986 the Ponidzie Landscape Parks Association was set up. It includes three landscape parks: Szaniec, Nida and Kozubów with the total area of 407 sqm [15]. The landscape of the Ponidzie Landscape Parks Association is dominated by chalk hills covered with a loess layer, which contain gullies, washes, and alluvial fans formed through rainfall erosion. A diversified morphology of the land as well as relatively dry and warm climate favors the xerothermic flora and vegetation that concentrates on the slopes of the hills, sides of the gullies and quite often on dry plain surfaces with a lot of karst forms.

Field research in the region of the Nida Basin was carried out from 1978 to 1979 and from 1998 to 2008. The following were the basis for the analysis:

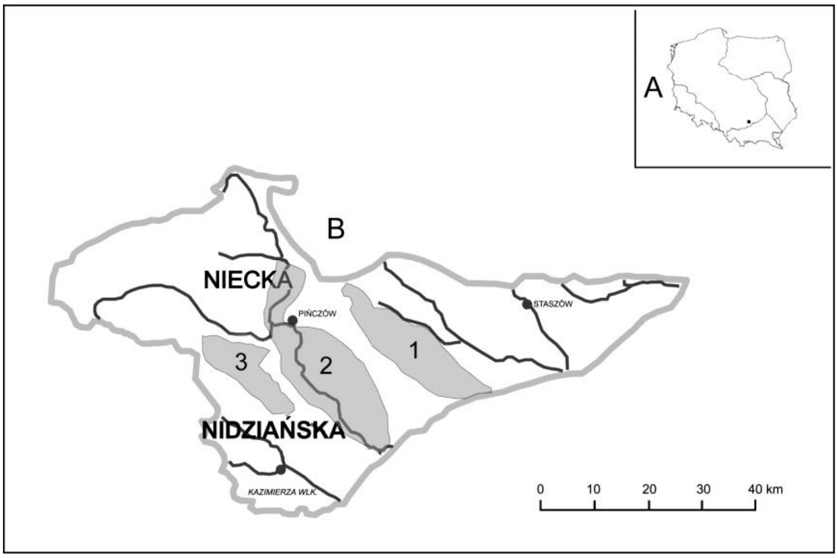

Fig. 1. Location of Ponidzie Landscape Parks Association against the background of Poland (A) and the Nida Basin (B). 1 – Szaniec Landscape Park, 2 – Nida Landscape Park, 3 – Kozubów Landscape Park

- ✓ A – available, published floristic and phytosociological materials,
- ✓ B – on-site stocktaking and valuation of the plant communities,
- ✓ C – 243 phytosociological records taken with the use of the Braun-Blanquet [2] method in the farmlands of the region, including 126 taken between 1998 and 2001 [4],
- ✓ D – the ZPG-K “GEOKART” type maps for mapping of plant communities with the scale of 1 : 100 000,
- ✓ E – maps of the distribution of the complexes of the agricultural utility of soils.

During the research as well as while preparing the materials the method of the global phytosociology, as regarded by Géhu [9] and Vahle [19] was applied. Using this method big complex (Σ) sigmassociations have been identified as spacious, supraecosystemic systems sharing similar habitation conditions and physiognomic features, grouped in several plant communities identified through the method of the classical phytosociology. Within the big complex (Σ) sigmassociations, small basic (σ) sigmassociations have been identified as the intraecosystemic systems resulting from the habitation diversity as the consequence of the human activity in local conditions.

Space types of the plant communities within the sigmassociations have been marked with the following symbols: “0” – continual “=” – linear, “+” – island, “·” – dispersed. In order to evaluate the degree of the vegetation cover of the given mezoregion the Braun-Blanqueta [1] scale has been adopted. The first symbol denotes the space type of the examined plant community and the second one, after the slash sign, denotes its cover, for instance 0/2 stands for a community with a continual space type, covering 5–25 % of the area of the mezoregion.

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Phytosociological records have also been taken in the contact zones between farmland and boundary strips and xerothermic communities. The research was carried out each single year in June and July in cereal crops and from July to on stubble fields and in the areas of root vegetables cultivation. The obtained floristic list has been put in alphabetical order, the species have been analyzed and all has been put together in tables. In the analyzes of the species the following elements were taken into account: the category of threat in accordance with the IUCN/WCU nomenclature [20], the forms of protection and conservation of segetal species in the region were presented in the ten-level sozological scale proposed by the author of this paper [4], live forms according to Raunkiaer [7], geographical-historical analysis [11; 14], as well as the attachment of weed to cultivated land on the basis of agricultural and soil maps prepared by the Voivodeship Office of Land Surveying and Agricultural Land in the city of Kielce.

Botanical nomenclature was taken from Mirek et al. [14]. Phytosociological nomenclature as well as syntaxonomic construction was based on the concepts forged by Matuszkiewicz [13]. Syntaxa below the level of association were distinguished according to the ideas of Warcholińska [21; 22; 23].

Between 2006 and 2007 also a research concerning the production of xerothermic vegetation was carried out [6]. It was conducted on the slope of the Pińczów Hummock in the town of Szaniec as well in the Krzyżanowiec reserve (the Nida Valley). The production of plants was assessed using the method of Traczyk [16] based on the concentration and the average growth of species.

The vegetation cover of the Nida Basin in charac-terized by high nature values and floristic, phytocenotic, habitation and landscape diversity. So far the assessment of this region with the use of the classical phytosociology has been insufficient. So the option of the systemic approach to this problem, with the use of the global phytosociology (see also: methodological assumption) may help to highlight the values of the vegetation landscapes of the region and what is more it can render its protection more efficient.

One of all the aforementioned complex sigmassociations highly distinguishes itself in the contact zones between the phytocenoses of many vegetation communities. Such a specific combination of species with a highly distinguished physiognomy which are the ecotones where one of the components is the agrophytocenosis are the semi-sigmassociations and anthropogenic sigmassociations.

In order to present the "xerothermic communities-farmland" ecotone systems – thus the zones of anthropogenic origin – it seems necessary to have a holistic approach to this issue. So the structures of the vegetation cover on higher levels would be presented as the consequence of processes on the lower levels, in other words the global phytosociology will present the synthetic results of research conducted with the use of the method of phytosociological records as regarded by Braun-Blanquet. Such an approach may appear more useful taking into account the potential use of the results in landscape research.

On the area of the Nida Basin 14 big complex (Σ) sigmassociations, and within them 30 small basic (σ) sigmassociations have been identified. They include:

3 complex forest and scrub sigmassociations with 6 basic sigmassociations, 2 complex non-forest sigmassociations with 5 basic ones as well as 9 complex synanthropic sigmassociations with 19 basic ones.

The composition of the forest and scrub landscapes in the majority of the mezoregions of the Nida Basin is strongly influenced by the sigmassociation with the oak-hornbeam communities - *Tilio cordatae-Carpinetum betuli* – as well as the sigmassociation with the pinewoods communities, mainly *Leucobryo-Pinetum.* But areas along the water streams, mainly in the Nida Valley, are dominated by the riverside carrs and the alder carrs (tab. 1).

Forests occupy about 15 % of the area of the Nida Basin. A strong anthropopression and bad forest management has been the main threat to the forests for quite a while. Although forest complexes are now dispersed, a couple of protected forest areas, located in reserves and in three landscape parks, deserve attention. The biggest protected forest complexes are situated in the Kozubów Landscape Park, where 3,000 ha of forest space – almost the half of the area of the park – are actively protected [15]. For the past couple of centuries of the human activity approximately 80 % of forest and steppe areas in the Nida Basin have been converted into areas of agricultural cultivation. Small forest, scrub and steppe enclaves remain only on the areas which do not represent any agricultural values (arid soils, steep slopes).

Non-forest sigmassociations (excluding agricultural landscapes) in the agricultural landscape of the Nida Basin are represented by xerothermic grasslands and bush as well as bog plants and reed bed (tab. 2). The first group of plants contain calcicole and thermophilic grasslands *(Inuletum ensifoliae, Sisymbrio-Stipetum capillatae, Koelerio-Festucetum rupicolae)* and scrub *(Peucedano cervariae-Coryletum, Pruno-Ligustrietum* i *Prunion fruticosae).* The development of those plants is the product of the geological forms of the late Jurassic and Cretaceous geological periods (limestone, sandstones, calciferous sandstones, limestone, gypsum, gaizes, etc.) as well as of the current character of the land relief in some mezoregions of the Nida Basin with hills divided by valleys, mainly on the area of the Pińczów Hummock, Wodzisław Hump and Miechów Upland. What is more the thermophilic and xerothermic vegetation is secondary with very few species and almost no new species to the domestic flora. The conservation of those plants is possible only if the human activity is modest, which should be taken into account in the strategy of protection of those rare communities in Poland. As to bog plants and reed bed, they are not very common in the Nida Basin. That is why these enclaves should be protected, for instance the small areas of raised bog of the *Oxycocco-Sphagnetea* class and transitional bog of the *Scheuchzerio-Caricetea nigrae* class in the Białe Ługi reserve. The protection of rivers and water streams with very rare reed bed communities should be the key priority. Let us mention here the communities of *Caricetum elatae* and *Caricetum gracilis* as well as the halophilic community of *Puccinellio-Spergularietum salinae* in the Owczary reserve near the town of Busko Zdrój.

Agricultural areas within the Nida Basin and within the Ponidzie Landscape Parks Association are highly diversified in terms of agricultural value and the culture of

Table 1

The forests and scrubs sigma-associations in agricultural landscape of the Nida Basin

Σ	σ	No	1	2	3	4	5	6	7	8
		Mesoregion	DN	NS	NP	PP	PJ	WM	GP	GW
		Area in km^2	2	4	240	150	350	170	1	1
		Number of analises communities	11	12	12	13	16	12	5	6
1		**Riparian and swampy scrub forests**								
	a	*Salicion albae* R.Tx.1955	=/1	./+		./+	./+	./+		
		Ficario-Ulmetum minoris Knapp 1942 em. J. Mat. 1976	./+	./+	./+	./+	./+			
		Fraximo-Alnetum W. Mat.1952	=/+	./+			./+	./+		
		Salicetum pentandro-cinereae (Almq. 1929) Pass. 1961	=/2	./+	+/+	./+	=/+		./r	
		Degeneration of the meadow communities	=/2	+/+	+/+	+/+	./+	./+		./r
	b	*Sphagno squarrosi-Alnetum* Sol.-Górn. (1975)1987	+/+		./+	./+	=/+	./+		
		Ribeso nigri-Alnetum Sol.-Górn. (1975) 1987	+/+	./+	./+		+/+	./+		
		Salicetum triando-viminalis Lohm. 1952	+.+				./+			
		Degeneration of the alder carrs communities	=/1	./+			./+		./r	
		Leafy forests								
2	a	*Tilio cordatae-Carpinetum betuli* Tracz. 1962	./+	./+	0/1	0/1	0/1	0/2	./+	./+
		Degeneration of the oak-hornbeam communities	./+	+/+	0/1	=/1	0/1	0/1	./1	./1
	b	*Potentillo albae-Quercetum* Libb.1933						0/+		
		Degeneration of the oak forest communities						0/1		
		Coniferous forests								
3	a	*Querco roboris-Pinetum* (W. Mat.1981) J. Mat. 1988		./+	+/+	./+	+/1			
		Degeneration of the mixed coniferous forests communities		./+	./+	+/+	0/1		./+	./+
	b	*Cladonio-Pinetum* Juraszek 1927			0/1	./+	0/1	./+		./+
		Leucobryo-Pinetum W. Mat. (1962)1973		=/+	0/2	=/1	0/2	=/+		
		Molinio-Pinetum W. Mat. Et J. Mat. 1973	./+			=/+	0/1			
		Vaccinio uliginosi-Pinetum Kleist 1929			+/+	./+	=/1			
		Degeneration of the coniferous forests communities	./+	./+	0/1	./+	0/2	./+	./+	./+

Explanation of abbreviation:

Σ – complexal sigma-associations (frame surfaces), σ – basic sigma-associations (graded surfaces); DN – Nida Valley, NS – Solec Basin, NP – Połaniec Basin, PP – Proszowice Plateau,

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PJ – Jędrzejów Plateau, WM – Miechów Upland, GP – Pińczów Hump, GW – Wodzisław Hump; Predominations of spatial communities type: 0/ – continuous; =/ – linear; +/ – enclaved; ./ – diffused; Total assessment coverage of mesoregion marked by Braun-Blanquet scale: /r, /+, /1, /2, /3, /4, /5.

Table 2

The non-forests sigma-associations in agricultural landscape of the Nida Basin

Σ	σ	No	1	2	3	4	5	6	7	8
		Mesoregion	DN	NS	NP	PP	PJ	WM	GP	GW
		Area in km^2	380	90	30	10	8	15	70	12
		Number of analises communities	9	14	11	5	7	10	13	10
1	**Xerothermic grasslands, herbage and shrubb thermophilous vegetation**									
	a	*Sisymbrio-Stipetum capillatae* (Dziub. 1925) Medw.-Korn. 1959						=/1	=/+	=/+
		Koelerio-Festucetum rupicolae Kornaś 1952		./+				=/+	+/+	+/+
		Inuletum ensifoliae Kozł.1925		./+	./+		./+	+/1	=/1	+/1
		Thalictro-Salvietum pratensis Medw.-Korn. 1959				./+		+/1	+/+	+/+
		Adonido-Brachypodietum pinnati (Libb. 1933) Krausch 1960		./+				./+	=/+	+/+
		Seslerio-Scorzoneretum purpurae Kozł.1927 em. Medw.-Korn. 1959	./+		./+			./+	+/+	./+
		Carex glauca–Tetragonolobus maritimus ssp. *siliquosus* Medw.-Korn. 1959		./+	./+				./+	
	b	*Frangulo-Rubetum plicati* Neum. in R.Tx.1952 Oberd.	=/+	./+						
		Rubo fruticisi-Prunetum spinosae Web.1974 n.inv. Wittig	./+	./+	./+	./+		./+	./+	
		Rhamno-Cornetum sanguinei (Kais. 1930) Pass. (1957)1962	./+	./+	./+	+/1	+/1	+/1	./+	./+
2	**Peat swampy and rushes vegetation**									
	a	*Oxycocco-Sphagnetea* Br.-Bl.. et R. Tx. 1943		./r	./r					
		Scheuchzerio-Caricetea nigrae (Nordh. 1937) R. Tx. 1937	./r	./r	./r					
	b	*Phragmition* Koch 1926	=/1	+/+	./+		./+		./+	
		Magnocaricion Koch 1926	0/2	=/+	./+	./+				
		Puccinellio-Spergularietum salinae (Feekes 1936) R. Tx. at Volk 1937							+/+	./r
		Glycerietum maximae Hueck 1931	=/+	+/+	+/+			+/+		
		Caricetum elatae Koch 1926	+/+	./+						
		Caricetum gracilis (Graebn. et Hueck 1931) R. Tx. 1937	=/+	./+			./+			

Explanation of abbreviation: see tab. 1.

agricultural management. The presence of as much as 11 complexes of the agricultural utility of soil is the evidence. The majority of them are the wheat complexes (very good, good, faulty) and the rye complexes (very good and good). The soils of those complexes are located above all on the slopes and peaks of hills characterized by a rapid run-off of the rainwater and are vulnerable to water erosion. The area of the Nida Basin is dominated by the brown soil created from loess, brown rendzina and chernozems formed form chalky limestone. Besides, brown acid leached soils created from clay and brown acid soils created from sands residing on clay or limestone, pseudo-podsolic soils created from clay sands with a clay bedrock are also found.

Rural areas, rural settlements, and suburbs – the central ring of the cultural vegetation gradient – are clearly dominated by ruderal communities. The main object of sozological research in the agricultural landscape is the biodiversity. A significant decline in the diversity of segetal weed has been observed on the example of segetal communities in the crops of the Ponidzie Landscape Parks Association [4]. Thus, the following questions may arise: how to preserve this biodiversity in the conditions of human activity? How to integrate it in agricultural farms?

From all of synanthropic sigmassociations (see also Table 1 and 4) the cultural vegetation related to agricultural areas (arable lands, anthropogenic and semi-natural meadows and pastures) has the biggest influence on the physiognomy of the agricultural landscape of the Nida Basin. This is the kingdom of the sigmassociation formed by the segetal weed communities (Σ_5) with four basic sigmassociations ($\sigma_{a\text{-}d}$) distinguished due to their habitation diversity and the forms of anthropogenic transformations. In this sigmassociation, consisting of 17 segetal weed communities (cereal crops, stubble fields and areas of root vegetables cultivation) the following communities have the biggest share in the vegetation cover of the region: *Vicietum tetraspermae*, *Consolido-Brometum, Caucalido-Scandicetum, Echinochloo-Setarietum, Digitarietum ischaemi, Lathyro-Melandrietum noctiflori.* On deforested areas, along the roads, on fallows, fertilized or mown meadows, along the water streams and often in places where the flora has been devastated, grassland communities (Σ_6 i $\sigma_{a,\ b}$) – *Filipendulo-Geranietum, Angelico-Cirsietum oleracei, Arrhenatheretum elatioris* i *Lolio-Cynosuretum cristatae* – to list the most important, have developed. Also the sigmassociations of the ruderal communities (Σ_7 i $\sigma_{a,\ b}$) mark their presence with the following communities: *Artemisio-Tanacetetum vulgaris, Carduetum acanthoidis, Sisymbrietum sophiae, Urtico-Malvetum neglectae, Chenopodietum ruderale, Atriplicetum nitentis* i *Potentillo-Artemisietum absinthii.* The rest of synanthropic sigmassociations have a diverse share in the mezoregions of the Nida Basin. A significant degradation of the forest communities is reflected by the development of the clearing vegetation and shrubs in the forest edge (Σ_1 i $\sigma_{a\text{-}e}$) with the following communities: *Senecioni sylvatici-Epilobietum angustifolii, Rubetum idaei* and *Sambucetum nigrae.* Places that are most frequented by people and farm animals have been dominated by the so called "carpeting vegetation", for instance the *Prunello-Plantaginetum* community (Σ_2 i $\sigma_{a,\ b}$). In the synanthropic sigmassociations, shaping the agricultural landscape of the region also the vegetation of point bars,

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water basins, fringes, forests as well as ecotone vegetation, shrubs in the forest edge and internal vegetation of the forest should be included ($\Sigma_{3,4}$).

The state of diversity of the segetal weed in crops of the Nida Basin was evaluated on the basis of phytosociological records obtained from the research carried out on the cultivated land between 1998 and 2007 in the selected mezoregions of the Nida Basin and repeated between 1998 and 2008 [8 – with all the references].

During the first stage of the floristic research (1978–1979), 249 species of the segetal flora were recorded on the area of the Nida Basin. After nearly 30 years of agricultural cultivation of the examined land changes in the quality and quantity of the segetal weed flora were observed. At least 10 % of species became extinct, mainly archaeophytes and kenophytes. The decline in the coverage and site was observed in 20% of examined species.

Ninety four species of the endangered segetal flora – 38 % of all recorded taxones of the analyzed flora, were put on the list. Sixteen species were characterized as critically endangered (CR), 19 as endangered (EN), 37 as vulnerable (VU), 4 as under a lower risk (LR) and in case 18 species the data was insufficient.

The main causes of extinction of the segetal flora on the area of the Nida Basin are: the abandon of the traditional agriculture, more accurate clearing of the seed material, the use of herbicides, intensive fertilization and other agricultural engineering treatments.

Despite the decline in the population of many rare species there is still a possibility to bring them back to abandoned or degraded habitats. Their renaturization and protection *in situ* should be carried out by establishing agroreserves or introducing ecological agriculture. The *ex situ* solution would be to cultivate them from the acquired diasporas on a specially established areas – herbaria (segetaria).

The extinction of species was the reason of the floristic but also the phytocenotical impoverishment, which resulted in the degradation, fragmentation and disappearance of the segetal communities in the Nida Basin. Yet their potential ranges still exist, due to habitation conditions. In the examined communities, changes in the quantity and quality of the floristic composition as well as the decline in the coverage of many diagnostic species were observed – this concerned mainly the segetal communities of the following groups: *Caucalidion lappulae* and *Polygono-Chenopodion.* As a result, the segetal communities were deformed and their physiognomy changed. The increase in the coverage of ubiquitous and nitrophile species which are resistant to herbicides and modern agricultural engineering was observed.

In the 70's, on the cultivated land of those parks, 20 segetal weed communities were identified, including 7 associations and 4 subassociations that formed in cereal crops, 4 stubble field communities and 4 associations and one subassociation that formed in the areas of root vegetables cultivation. Currently some of the communities are present in the impoverished form, this concerns particularly the communities that develop on limestone rendzina soils.

Systematics of the selected units is as follows:

Cl. *Stellarietea mediae* R. Tx., Lohm. et Prsg. 1950

O. *Centauretalia cyani* R. Tx. 1950

All. *Aperion spicae-venti* R. Tx. et J. Tx. 1960

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Suball. *Aphanenion arvensis* R. Tx. et J. Tx. 1960

1. **Ass.** *Vicietum tetraspermae* (Krusem. et Vlieg. 1939) Kornaś 1950

a. **Subass.** *V. t. typicum*

b. **Subass.** *V. t. consolidetosum*

c. **Subass.** *V. t.* with *Aphanes arvensis* and *Chamomilla recutita*

d. **Subass.** *V. t. myosotidetosum*

e. **Subass.** *V. t. sperguletosum*

2. **Ass.** *Papaveretum argemones* (Libb. 1932) Krusem. et Vlieg. 1939

a. **Subass.** *P. a. typicum*

b. **Subass.** *P. a. consolidetosum*

3. impoverished form **Ass.** *Herniario-Polycnemetum* Fijałkowski 1967

All. *Caucalidion lappulae* R. Tx. 1950

4. **Ass.** *Lathyro-Melandrietum noctiflori* Oberd. 1957

5. impoverished form **Ass.** *Caucalido-Scandicetum* (Libb.1930) R. Tx. 1937

6. impoverished form **Ass.** *Euphorbio-Nigelletum* Wnuk 1976

7. impoverished form *Ass. Kickxietum spuriae* Krusem. et Vlieg. 1939

O. *Polygono-Chenopodietalia* (R. Tx. et Lohm. 1950) J. Tx. 1961

All. *Panico-Setarion* Siss. 1946

8. **Ass.** *Echinochloo-Setarietum* Krusem. et Vlieg. (1939) 1940

All. *Polygono-Chenopodion* Siss. 1946

9. **Ass.** *Bilderdykio-Lamietum amplexicaule* Warcholińska 1990

a. **Subass.** *B.-L. a. typicum*

b. **Subas.** *B.-L. a. veronicetosum*

10. **Ass.** *Galinsogo-Setarietum* (R. Tx. et Beck. 1942) R. Tx. 1950

11. impoverished form **Ass.** *Lamio-Veronicetum politae* Kornaś 1950

Cl. *Isoëto-Nanojuncetea* Br.-Bl. et R. Tx. 1943

O. *Cyperetalia fusci* (Klika 1935) Müller-Stoll et Pietsch 1961

All. *Radiolion linoidis* (Rivas Goday 1961) Pietsch 1965

12. **Ass.** *Spergulario-Illecebretum verticillati* Sissingh 1957

13. **Ass.** *Ranunculo-Myosuretum minimi* Diem., Siss. et Westh. 1940

14. *Centaurium pulchellum-Pottia truncata* **community** Wójcik 1968

After three years of floristic and phytosociological observations carried out in the contact zones between xerothermic communities and farmland it was concluded that at least six communities, according to the nomenclature proposed by Matuszkiewicz [13], were observed: *Rubo fruticosi-Prunetum spinosae, Frangulo-Rubetum plicati, Dauco-Picridetum hiera-cioidis, Falcario vulgaris-Agropyretum-repentis, Adonido-Brachypodietum pinnati* and *Geranio-Peucedanetum cervariae* (tab. 3).

The flora and communities of the examined ecotones form together with the shrubs in the forest edge and the internal vegetation of the forest a characteristic composition in the spatial chain of synanthropic sigmassociations.

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Table 3

The ecotone vegetation sigma-associations in agricultural landscape of the Nida Basin

Σ	σ	No	1	2	3	4	5	6	7	8
		Mesoregion	DN	NS	NP	PP	PJ	WM	GP	GW
		Area in km^2	10	2	3	2	2	3	5	3
		Number of analises communities	9	14	11	5	7	10	13	10
1	**Ecotone between of xerothermic vegetation surface and fields cultivation**									
	a	*Dauco-Picridetum hieracioidis* (Fab. 1933) Görs 1966	=/1	=/+	=/+	+/+	=/+	=/1	=/+	=/+
		Onopordetum acanthii Br.-Bl. ex Br.-Bl. et all. 1936		./+				=/+	+/+	+/+
		Falcario vulgaris-Agropyretum-repentis Müller et Görs 1969		./+	./+		./+	+/1	=/1	+/1
		Adonido-Brachypodietum pinnati (Libb. 1933) Krausch 1960				./+		+/1	+/+	+/+
	b	*Peucedano cervariae-Coryletum* Kozł.1925 em. Medw.-Korn. 1952			./+	./+	./+	+/1	+/1	+/1
		Pruno-Ligustrietum R. Tx. 1952 nom. inv. Oberd. 1970		./+	./+	./+	./+	+/1	+/1	+/+
		Prunion fruticosae R. Tx. 1952		./+				./+	./+	./+

Explanation of abbreviation: see tab. 1.

The examined ecotones differed in width and sharpness: the boundary in the segetal communities was narrower and less natural than the boundary of the xerothermic grasslands environment. The average width of an ecotone in a farmland (excluding boundary strips) was 3.8 m, whereas in xerothermic grasslands – 2.3 m. The boundaries of the ecotones in xerothermic grasslands were changing constantly and were more natural than those of segetal community – the reason of such state is that cultivated farmland is subject to a constant interference by man. On the boundaries of the majority of two neighboring phytocenoses a contact effect could be remarked; within the ecotones, most often with cereal crops, a 1.5 m wide strip with a big concentration of thermophilic and heliophillic species from the *Geranion sanguinei* alliance (the *Origanetalia* order) could be observed. The research did not give any basis to distinguish any unusual syntaxonomic units in the examined ecotones.

The research was carried out in 4 phytosociologically different patches of the xerothermic grassland communities: *Adonido-Brachypodietum pinnati* and *Thalictro-Salvietum pratensis* in the Krzyżanowice reserve (the Nida Valley) as well as *Koelerio-Festucetum rupicolae* and *Sisymbrio-Stipetum capillatae* on the slope of the hill called Góra Kamnica (the Pińczów Hummock).

Brachypodium pinnatum, Adonis vernalis, Elymus hispidus and *Festuca rupicola* were most frequent in the examined communities. *Brachypodium pinnatum* and *Festuca* *rupicola* dominated in terms of concentration, but the highest total concentration of species was recorded in the patches of *Adonido-Brachypodietum pinnati* (4614 shoots per 10 m^2 for 33 species). *Anthericum ramosum, Centaurea scabiosa, Daucus carota, Ononis spinosa* and *Thalictrum minus* were characterized by the biggest ontogenic mass. *Brachypodium pinnatum, Festuca rupicola, Elymus hispidus* and *Galium verum* had the biggest share in the production.

On the examined areas 42 taxones were recorded in the sward of the grasslands. The biggest diversity of species was found in *Thalictro-Salvietum pratensis* (38), and their number in the rest of the communities was slightly smaller. But in terms of species concentration and total production the phytocenosis of *Adonido-Brachypodietum pinnati* (4618 plants/ 10 m^2 and 4 760 g dry wt 10 m^{-2} correspondingly). The rest of the communities were characterized by a significantly smaller number of plants or production. The value of the estimated primary production in the examined xerothermic communities closed between 1647 and 4761 g dry wt · 10 m^{-2}.

The examined areas of xerothermic grasslands showed a high diversity of species (30–38 species per 10 sqm). The selected communities are characterized by a large share of not only typical species in an association, but also a very large share of diagnostic species with the participation of high-level syntaxones *(Cirsio-Brachypodion pinnati, Festuco-Stipion, Festucetalia valesiacae, Festuco-Brometea).* The number of diagnostic species, ranging from association to class, is about 55 % in the *Adonido-Brachypodietum pinnati* community and about 40 % in the three remaining communities.

A significant diversity of species may be reflected by a high value of the primary production in the examined grasslands (1647–4760 g dry wt · 10 m^{-2}).

The natural vegetation of the Nida Basin consists of 14 big sigmassociations and within their limits – 30 small sigmassociations. They are mainly forest areas, scrubs, meadows and xerothermic grasslands.

From all of the synanthropic sigmassociations the synanthropic communities (segetal and ruderal communities) related to agricultural areas have the biggest influence on the physiognomy of the agricultural landscape of the Nida Basin. The results of the research based on the concept of sigmassociations, as regarded by Géhu [9] and Vahle [19], may help in the implementation of the sustainable natural resource management on the regional scale at least, as well as in spatial planning of rural areas and may find their application in the assessment of the changes in the vegetation cover in the agricultural landscape.

After nearly 30 years of agricultural cultivation in the Nida Basin at least 10 % of species of the segetal flora became extinct and another 10 % is threatened with extinction.

The most intense impoverishment of the segetal flora diversity in the Nida Basin has been observed among anthropophytes, typically in rendzina soils in the alliance community of *Caucalidion lappulae* (on the cereal crops and stubble fields) and the association community of *Lamio-Veronicetum politae* (the areas of root vegetables cultivation).

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In the segetal flora of the Nida Basin 94 species from 249 taxones have been included in one of the listed threat categories – almost 38 % of all recorded species.

Species with the frequency of 1–2^o should be protected in agroreserves or agricultural ecological sites, and the habitats with the frequency of 3–4^o might be protected in sites of a smaller regime within the ecological agricultural production.

For the past 30 years the structure of segetal communities on cultivated areas of the Nida Basin has been significantly changed. These changes have been brought about by agricultural chemistry and engineering (fertilization, herbicides, melioration, modern technical devices).

The protection of agricultural ecosystems should be the key priority when implementing the sustainable development in the agricultural landscape of the Nida Basin. This would boost the floristic diversity. Thanks to the proposed protective measures the ecological processes aimed at the revitalization of the flora and segetal vegetation could be initiated.

The examined xerothermic communities were dominated by the species of the *Festuco-Brometea* class, and the farmland – by the species of the *Stellarietea mediae* class.

In order to maintain the stability of the presented "xerothermic grasslands-farmlands" ecotones they should be protected in ecological sites.

The following grasses: *Brachypodium pinnatum, Elymus hispidus* and *Festuca rupicola* dominated in the examined xerothermic grassland communities in terms of frequency, concentration and production. The highest value of total production was recorded in the sward of *Adonido-Brachypodietum pinnati* and *Koelerio-Festucetum rupicolae.*

A high productivity of xerothermic grasslands of the Nida Bassin, with the dominant share of grasses and perennial plants, should be modestly exploited to acquire biomass through cutting (one cutting a year with shallow ploughing) or subjected to extensive grazing in order to decrease the amount of plant debris and felt.

The adopted methodology of assessing the primary production of xerothermic grasslands is simple and easily applicable. When extended by the dynamics of vegetative productivity, it may prove to contribute to a better understanding of the ecology and the functioning of the ecosystems of grasslands and improve their protection.

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ГЕОБОТАНІЧНІ ДОСЛІДЖЕННЯ ІЗ ЗАСТОСУВАННЯМ КОНЦЕПЦІЇ СІГМАСОЦІАЦІЇ. CASUS: НЄЦКА НІДЗЯНЬСКА (ПІВДЕННА ПОЛЬЩА)

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Оцінено різноманітність рослинності сільськогосподарського ландшафту Нєцки Нідзяньскої (Південна Польща). Використано метод глобальної геоботаніки із застосуванням концепції сігмасоціації за теорією Гегу (1977) і Вахле (2001). В межах Нєцки Нідзяньської виділено 14 комплексних великих сігмасоціацій, а в їхніх межах 30 основних малих сігмасоціацій. У цих об’єктах виділено три лісові, дві нелісові та дев’ять синантропних сігмасоціацій.

Ключові слова: рослинність, сільськогосподарський ландшафт, потенційна сільськогосподарська рослинність, концепція сігмасоціації.

ГЕОБОТАНИЧЕСКИЕ ИССЛЕДОВАНИЯ С ПРИМЕНЕНИЕМ КОНЦЕПЦИИ СИГМАССОЦИАЦИИ. CASUS: НЕЦКА НИДЗЯНЬСКА (ЮЖНАЯ ПОЛЬША)

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Оценено разнообразие растительности сельскохозяйственного ландшафта Нецки Нидзяньской (Южная Польша). Использован метод глобальной геоботаники с применением концепции сигмассоциации по теории Гегу (1977) и Вахль (2001). В рамках Нецки Нидзяньской выделено 14 комплексных крупных сигмасоциаций, а в их пределах 30 основных малых сигмассоциаций. В этих объектах выделено три лесных, две нелесных и девять синантропных сигмассоциаций.

Ключевые слова: растительность, сельскохозяйственный ландшафт, потенциальная сельскохозяйственная растительность, концепция сигмассоциации.