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ECOSYSTEM SERVICES OF EXTENSIVE WET GRASSLANDS. WIELKOPOLSKA REGION (POLAND) CASE STUDY

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ŚWIADCZENIA EKOSYSTEMÓW EKSTENSYWNYCH PODMOKŁYCH UŻYTKÓW ZIELONYCH. STUDIUM PRZYPADKU REGIONU WIELKOPOLSKIEGO

STRESZCZENIE: Określono ekosystemowe świadczenia dwóch typów mikrokrajobrazów z seminaturalnymi łąkami z Calthion, a zarazem z bogactwem biocenoz naturalnych. Są one powiązane z ekstensywnymi (tradycyjnymi) formami użytkowania gruntów rolnych. W identyfikacji świadczeń ekosystemowych zastosowano system przedstawiony w Millennium Ecosystem Assessment, zmodyfikowany przez K. J. Wallace. Modyfikacja ta jest wynikiem krytycznego ustosunkowania się jej autora do konstrukcji powszechnie stosowanego systemu MA, rodzącego poważne problemy efektywnego zarządzania obszarami stanowiącymi mozaikę gruntów rolnych powierzchniowo zdominowanych przez antropogeniczne biocenozy synantropijne segetalne i ruderalne oraz geoekosystemów naturalnych. Wskazano zagrożenia świadczeń ekosystemowych związane z dynamicznym, gospodarczym rozwojem Wielkopolski. Omówiono jeden ze sposobów przeciwdziałania zagrożeniom świadczeń ekosystemowych w sektorze rolnictwa, jakim jest Program Rolno-Środowiskowy objęty Programem Rozwoju Obszarów Wiejskich na lata 2007-2013.

SŁOWA KLUCZOWE: Calthion, mikrokrajobraz, program rolno-środowiskowy, sigmasocjacja, symfitosocjologia, świadczenia ekosystemowe, łąki łęgowe

Introduction

Over the last decade, a distinct increase in the number of publications on ecosystem services (ES) has been observed, as shown by B. Fisher et al.[1]. Presumably, it is an after-effect of the work Millennium Ecosystem Assessment[2], calling for research on measuring, modelling and mapping ecosystem services. This subject has been discussed also in the Polish scientific literature (e.g. A. Mizgajski[3], Z. M. Rosin et al.[4]), however, without contribution of specialists in structure and functioning of ecosystems and, at the same time, in biodiversity conservation.

This article responds to a clarion of the MA[2]. Its aim was to determine ecosystem services served by vegetation cover of permanent meadows and permanent pastures. This has been accomplished through an analysis of two types of microlandscapes that are representative for natural conditions of Wielkopolska and widespread in this region. These microlandscapes are characterised by the surface dominance of seminatural wet *Calthion* meadows. Both types are connected with the extensive forms of grassland use. Due to these forms, mosaic arrangements of agricultural lands and natural ecosystems have developed (historically) and survived up to the present day. Such areas are characterised by high biodiversity, however, exposed to threat from the intensification of agricultural production. In Europe, they are regarded as disappearing P. Harrison et al.[5]. On account of their natural-seminatural character, they are considered by some scientists as hot spots of multiple delivery of ecosystem services (e.g. S. Lavorel et al.[6]). The analysed microlandscapes differ significantly one from the other in terms of biotic and abiotic characteristics, but, generally, they provide the same categories of ecosystem services. However, they differ in these ecosystem services that depend on the character of their flora and phytocoenotic structure of vegetation. Both types of microlandscapes are connected with the Natura 2000 habitat code *91E0, occurring in ecological corridors of river valleys. In 2009, in Poland, works on the projects of protective plans for the areas of European Eco-

[1] B. Fisher, R. K. Turner, P. Morling, *Defining and classifying ecosystem services for decision making*, "Ecological Economics" 2009 No. 68, p. 643-653.

[2] *The Millennium Ecosystem Assessment, Ecosystems and Human Well-being: Biodiversity Synthesis*, Island Press, Washington 2005.

[3] A. Mizgajski, *Świadczenia ekosystemów jako rozwijające się pole badawcze i aplikacyjne*, „Ekonomia i Środowisko" 2010 No. 1(37), p. 10-19.

[4] Z. M. Rosin et al., *Koncepcja świadczeń ekosystemowych i jej znaczenie w ochronie przyrody polskiego krajobrazu rolniczego*, „Chrońmy Przyrodę Ojczystą" 2011 No. 67(1), p. 3-20.

[5] P. Harrison et al., *Identifying and prioritising services in European terrestrial and freshwater ecosystems*, "Biodiversity and Conservation" 2010 No. 19(10), p. 2791-2821.

[6] S. Lavorel et al., *Using plant functional traits to understand the landscape distribution of multiple ecosystem services*, "Journal of Ecology" 2011 No. 99(1), p. 135-147.

logical Network Natura 2000 were initiated. The aim of these plans is to ensure a proper protection condition of Natura 2000 natural habitats and species, among others, the aforementioned N2000 code *91E0, and, at the same time, to maintain them in the landscape as elements of socio-ecological system of ecosystem services. Tasks included in the plans involve recognition of biodiversity threats and ways of their minimalization or elimination. One of tools, which serves the implementation of protective proposals, already included in these plans, is the Agri-environmental Programme, covered by the Rural Development Programme (RDP) for 2007-2013[7], and financed by the European Agricultural Fund for Rural Development (*EAFRD*).

Material and methods

Ecosystem services of vegetation complexes connected with the potential biochores of two natural habitats, willow forest *Salicetum albae* and ash-alder tree stand *Fraxino-Alnetum*, were determined. These vegetation complexes, analysed typologically, are microlandscapes according to T. Chmielewski & J. Solon[8]. Their vegetation structure was documented by the symphytosociological method of R. Tüxen[9] for *relevés in sigmassociations.* In the two types of analysed microlandscapes, 20 *relevés were made, 10 in each. During the selection of patches for relevés, among others, the results of studies by J.* Borysiak[10,11] and J. Borysiak & M. Kasprowicz[12] *were used. The phytocoenotic differentiation of present vegetation complexes was determined following the* Braun-Blanquet method, using a syntaxonomic system included in the publication by A. Brzeg & M. Wojterska[13]. Specific names of plants were given according to Z. Mirek et al.[14].

[7] Rural Development Programme for 2007-2013 (RDP 2007-2013). 2007. Ministry of Agriculture and Rural Development, Warsaw, http://www.minrol.gov.pl/eng/content/view/full/18575 [Date of entry: 28-09-2012].

[8] T. Chmielewski, J. Solon, *Podstawowe przyrodnicze jednostki przestrzenne Kampinoskiego Parku Narodowego: zasady wyróżniania i kierunki ochrony*, in: *Badania ekologiczno-krajobrazowe na obszarach chronionych*, ed. Mariusz Kistowski, Uniwersytet Gdański 1996, p. 130-142.

[9] R. Tüxen, *Zür Homogenität von Sigmassoziationen, ihrer syntaxonomischen Ordnung und ihrer Verwendung in der Vegetations Kartierung*, "Doc. Phytosoc. N.S." 1977 No. 1, p. 321-327.

[10] J. Borysiak, *Struktura aluwialnej roślinności lądowej środkowego i dolnego biegu Warty*, Wydawnictwo Naukowe UAM, Biologia 52, Poznań 1994, p. 258.

[11] J. Borysiak, *Plant cover of The Lower Oder River Valley Landscape Park*, Wydawnictwo Naukowe UAM, Biologia 70, Poznań 2004, p. 143 + CD.

[12] J. Borysiak, M. Kasprowicz, *Mikrokrajobrazy roślinne dorzecza Prosny w okolicach Wieruszowa*, „Badania Fizjograficzne nad Polską Zachodnią" B' 1998 No. 47, p. 205-225.

[13] 220 A. Brzeg, M. Wojterska, *Zespoły roślinne Wielkopolski, ich stan poznania i zagrożenie*, w: *Szata roślinna Wielkopolski i Pojezierza Południowopomorskiego*, ed. Maria Wojterska, Bogucki Wydawnictwo Naukowe, Poznań 2001, p. 39-110.

[14] Z. Mirek, H. Piękoś-Mirkowa, A. Zając, M. Zając, *Flowering plants and pteridophytes of Poland. A checklist*, in: *Biodiversity of Poland 1*, ed. Zbigniew Mirek, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków 2002, p. 442.

Microlandscapes of extensive permanent grasslands of Wielkopolska

In Wielkopolska, private farms exceeding 1ha of agricultural land decidedly dominate (122,1 thous.). They conduct agricultural activity in the land area of 1475,0 thous. ha, in good agricultural condition. Within this area, 15% are permanent meadows (190,8 thous. ha) and permanent pastures (20,5 thous. ha). According to the Agricultural Census 2010, the average area of a private farm in Wielkopolska was 12,08 ha, in Poland 8,82 ha (H. Dmochowska[15]). Since many generations, in such small private farms extensive (traditional) forms of cultivation have been widely practised. They are advantageous for the preservation of historically shaped biodiversity of rural landscape. To illustrate this biodiversity and identify problems related to its protection, two types of natural-seminatural microlandscapes connected with permanent grasslands were selected. One of these types is connected with the habitats of potential natural vegetation of *Salicetum albae*, in which dominate *Ranunculo-Alopecuretum pratensis* meadows developed on Fluvisols. The domain of other type are potential biochores of *Fraxino-Alnetum*, with dominating *Angelico-Cirsietum oleracei* grasslands on Eutric Gleysols and Histosols. Vegetation complexes that correspond to these types are most widespread among permanent grasslands of Wielkopolska.

Microlandscapes with *Ranunculo repentis-Alopecuretum pratensis* meadows

The main axis (collecting and generating) of the natural system of Wielkopolska is the Warta river valley. It plays a function of the supraregional ecological corridor. The course of the river between Poznań and Koło is an important area for bird nesting and migration (A. Derc[16], A. Mizgajski & Zwierzchowska[17]. Most of this area has been included in the European Ecological Network of Natura 2000. Some fragments are not embanked, like Polders: Lądek, Wrąbczyn i Rataje. Due to frequent floods, these polders are extensively used. Within the riverbed of unregulated course, in the zone of systemic inundations, habitats with the potential natural vegetation of *Salicetum albae* and alluvial soils covered by permanent grasslands dominate. Vegetation complexes, which are related to

[15] H. Dmochowska, *Rocznik statystyczny województw 2011*. Główny Urząd Statystyczny, Warszawa. Statistical Yearbook of the Regions. Central Statistical Office, Warsaw http://www.stat.gov.pl/cps/rde/xbcr/gus/rs_rocznik_stat_wojew_2011.pdf [Date of entry: 10-09-2012].

[16] A. Derc (Chief Project Eng.) *Plan zagospodarowania przestrzennego województwa wielkopolskiego. Samorząd Województwa Wielkopolskiego* http://www.wbpp.poznan.pl/plan/index.html [Date of entry: 10-09-2012].

[17] A. Mizgajski, I. Zwierzchowska, *Środowisko przyrodnicze, w: Studium uwarunkowań rozwoju przestrzennego Aglomeracji Poznańskiej*, ed. Tomasz Kaczmarek, Centrum Badań Metropolitalnych Uniwersytetu im. Adama Mickiewicza w Poznaniu, http://metropolia2020.poznan.pl/tresc-dokumentu [Date of entry: 10-09-2012].

these areas, are distinguished by the high differentiation of phytocoenotic structure due to their connection with various fluvial landforms. The higher geodiversity of these landforms, the greater differentiation of plant communities of the complex at the levels α (intraphytocoenotic) and β, i.e., between the types of phytocoenoses (J. Borysiak & W. Stachnowicz[18]). In ten patches of such complexes selected for an analysis, in the examined sigmassociations (0,3-0,6 ha) decidedly dominated meadow phytocoenoses of *Ranunculo repentis-Alopecuretum pratensis* (Table 1). Persistently present, but in much lower surface proportion, were patches of *Stellario-Deschampsietum*. Both types of meadows belong to *Calthion*. In the intra-grassland depressions (mostly channel fills) or depressions situated by the natural levee, flooded swards of *Ranunculo repentis-Alopecuretum geniculati* or rushes of *Phalaridetum arundinaceae* occurred. In places often visited by wild water birds, phytocoenoses of *Potentilletum anserinae* and *Potentilletum reptantis* were noted. The grasslands were adjacent either to the present Warta river bed or old river bed, what was marked by the stands of *Salicetum albae* and *Salicetum triandro-viminalis*, which are rated as the Natura 2000 habitat code *91E0 (alluvial forests), of priority protection[19]. A manual characteristics of such habitats was presented by J. Borysiak[20]. Along water courses and in the ecotone zone of forests and thickets, hydrophilous and nitrophilous tall herb fringe communities of plains from *Convolvulion sepium*: *Achilleo salicifoliae-Cuscutetum lupuliformis*, *Carduo crispi-Rubetum caesii*, *Fallopio-Humuletum lupuli*, *Urtico-Convolvuletum sepium* and, less frequently, with *Convolvulo sepium-Cuscutetum europaeum* and *Fallopio-Cucubaletum bacciferi* were noted. All of them represent the Natura 2000 habitat code 6430. Sometimes, among grasslands, forbs of *Scutellario hastifoliae-Veronicetum longifoliae* were observed. On the muddy river banks of the Warta river, or in the fresh deposits of alluvial terraces, the annual pioneer nitrophilous communities of *Isoëto-Nanojuncetea* (*Cypero fusci-Limoselletum* and *Juncetum bufonii*) and *Bidentetea tripartitae* (*Agrostio stoloniferae-Pulicarietum vulgaris*, *Chenopodio rubri-Polygonetum brittingeri* and *Rumicetum maritime*) developed. These associations represent the Natura 2000 habitat code 3270. Their general characteristics is

[18] J. Borysiak, W. Stachnowicz, *Vegetation in relation to fluvial mesoforms – The River Warta case study*, "Perspectives in Environmental Sciences" 2000 No. 1, p. 7-12.

[19] Rozporządzenie Ministra Środowiska z dnia 13 kwietnia 2010 r. w sprawie siedlisk przyrodniczych oraz gatunków będących przedmiotem zainteresowania Wspólnoty, a także kryteriów wyboru obszarów kwalifikujących się do uznania lub wyznaczenia jako obszary Natura 2000 (Dz.U. 2010.77.510). [Regulation of the Minister of Environment of 13 April 2010 on habitats and species being the subject of interest for the European Union, and the selection criteria for the areas qualifying for recognition or designation as the Natura 2000 areas (Journal of Laws 2010.77.510)].

[20] J. Borysiak, *Nadrzeczny łęg wierzbowy Salicetum albae*, w: *Lasy i bory. Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny* No. 5, ed. J. Herbich, Ministerstwo Środowiska, Warszawa 2004, p. 205-210, http://natura2000.gdos.gov.pl/strona/tom-6 [Date of entry: 10-09-2012].

included in the paper by J. Borysiak[21]. In the examined sigmassociations of the analysed microlandscape, 22 plant associations were recorded in total, including 15 (68%) of natural syngenesis and 5 (23%) seminatural. The latter (meadows and pastures) occupied 75-85% of the patch of vegetation complex. This spatial vegetation unit is characterised by a high degree of naturalness. Among natural associations, three are rated as vulnerable, according to the classification by A. Brzeg & M. Wojterska[13]. These are: *Fallopio-Humuletum lupuli*, *Salicetum albae* and *Scutellario hastifoliae-Veronicetum longifoliae*. In the phytocoenoses of associations found in sigmassociations or in various trophic subassociations and variants of these associations, from 10 to 20 threatened species of plants can potentially occur, including, two endangered (EN) – *Allium angulosum* and *Sonchus palustris*, and six vulnerable (VU): *Euphorbia lucida*, *Gratiola officinalis*, *Oenanthe fistulosa*, *Petasites spurius*, *Senecio fluviatilis* and *S. paludosus*. In addition, 4 species under strict protection, listed in the Regulation of the Minister of the Environment[22], can be found. These are: *Angelica archangelica*, *Centaurium pulchellum*, *Corrigiola litoralis* (threat category CR) and *Gratiola officinalis* (VU). Undesirable elements in the described microlandscape are phytocoenoses of two xenospontaneous associations (neophyte communities), i.e. *Bidenti-Atriplicetum prostratae* with the participation of expansive kenophyte *Bidens frondosa* and *Chenopodio rubri-Xanthietum riparii* with the alien species *Xanthium albinum*. A very high degree of naturalness causes that the threat of neophytisation with the participation of these and other anthropophytes is relatively small. Only sporadically such kenophytes (according to the classification by A. Zając et al.[23] as *Aster lanceolatus* and *Solidago gigantea* were observed. An alarming process is a mass appearance of *Echinocystis lobata* in the all mentioned associations of *Calystegion sepium*, which form a vegetation complex of the discussed type of microlandscape. This plant eliminates from the floristic composition numerous native species, such as: *Calystegia sepium*, *Cucubalus baccifer*, parasitic *Cuscuta europaea* and *C. lupuliformis*, *Fallopia dumetorum*, and *Humulus lupulus*. These species represent a quite rare life form for the flora of Poland – climbers. An economic growth noted in Wielkopolska can result in the appearance of new kenophytes – plants brought, among others, for ornamental purposes.

[21] J. Borysiak, *Zalewane muliste brzegi rzek*, w: *Wody słodkie i torfowiska. Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny* No. 2, ed. Jacek Herbich, Ministerstwo Środowiska, Warszawa 2004, p. 107-112, http://natura2000.gdos.gov.pl/strona/tom-3 [Date of entry: 10-09-2012].

[22] Rozporządzenie Ministra Środowiska z dnia 5 stycznia 2012 r. w sprawie ochrony gatunkowej roślin Dz.U. 2012, nr 0, poz. 81 [Regulation of the Minister of Environment of 5 January 2012 on plant species protection] (Journal of Laws 2012.81).

[23] A. Zając, M. Zając, B. Tokarska-Guzik, *Kenophytes in the flora of Poland: list, status and origin*, "Phytocoenosis" 1998 No. 10(9), p. 107-116.

Table 1
Phytocoenotic structure of the grassland microlandscape in the Warta river valley with the surface domination of *Ranunculo repentis-Alopecuretum pratensis* hay meadows

Number of sigmassociation	1	2	3	4	5	6	7	8	9	10
Date (year)	2009	2010	2011	2011	2010	2010	2011	2011	2011	2011
Forests, shrubs [%]	5	10	10	5	10	10	10	10	10	10
Meadows, pastures [%]	85	75	75	80	70	75	75	75	75	80
Tall forbs [%]	10	10	10	10	10	10	10	10	10	10
Reeds [%]	<5	5	5	5	10	5	5	5	5	<5
Therophytic phytocoenoses [%]	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Area of sigmassociation [ha]	0,4	0,4	0,4	0,3	0,4	0,4	0,6	0,3	0,5	0,4
Number of associations	20	19	15	14	12	12	15	13	10	12
Salicetea purpureae:										
Salicetum albae	1.	2/	2/	1.	1.	2/	2/	2/	2/	2/
Salicetum triandro-viminalis	1.	2.	2/	1.	2/	1.	2/	1.	2/	1.
Molinio-Arrhenatheretea:										
Ranunculo repentis-Alopecuretum pratensis	40	40	30	40	40	40	40	40	40	30
Stellario palustris-Deschampsietum cespitosae	+.	1.	20	1.	1.	1.	1.	1.	20	20
Ranunculo repentis-Alopecuretum geniculati	1.	1.	20	+.	+.	1.	1.	+.	+.	20
Potentilletum anserinae	20	1.	1.	1.	+.	+.	20	+.	.	.
Potentilletum reptantis	20	+.	20	1.	.	+.	+.	+.	.	+.
Artemisietea:										
Urtico-Convolvuletum sepium	1.	2.	20	2/	2.	1/	2.	2/	2.	2/
Carduo crispi-Rubetum caesii	2/	1.	1.	1.	1.	2/	1.	1.	+.	+.
Convolvulo sepium-Cuscutetum europaeae	.	1.	1.	1.	1.	.	.	.	1.	1.
Fallopio-Humuletum lupuli	1.	1.	.	+.	.	1.	1.	.	.	.
Achilleo salicifoliae-Cuscutetum lupuliformis	1.	.	.	.	.	.	1.	1.	.	.
Scutellario hastifoliae-Veronicetum longifoliae	1.	1.	.	.	.	.	.	.	.	.
Fallopio-Cucubaletum bacciferi	.	.	.	.	.	.	+.	.	.	.
Phragmitetea:										
Phalaridetum arundinaceae	1.	2.	2.	2.	2/	2.	2/	2.	2.	1.
Isoëto-Juncetea bufonii et Bidentetea:										
Bidenti-Atriplicetum prostratae	1.	1.	1.	1.	1.	1.	+.	1.	1.	1.
Cypero fusci-Limoselletum	+.	1.	1.	+.	1.	.	.	.	.	.
Juncetum bufonii	+.	1.	1.	.	.	.	+.	.	.	+.
Rumicetum maritimi	1.	1/	.	.	.	.	.	+.	.	.
Chenopodio rubri-Polygonetum brittingeri	1.	1.	.	.	.	.	.	.	.	.

Number of sigmassociation	1	2	3	4	5	6	7	8	9	10
Chenopodio rubri-Xanthietum riparii	+.	.	1.	.	.	.	.	.	.	.
Agrostio stoloniferae-Pulicarietum vulgaris	+.	1.	.	.	.	.	.	.	.	.

Occurrence way of plant community in vegetation complex: 0 – over great surface, / – in long, narrow linear form, . – singular or dispersed in irregular form; quantity – Braun-Blanquet scale: + – in a minimal degree, 1 – ≤5% vegetation cover, 2 – 5-25%, 3 – 25-50%, 4 – 50-75%, 5 – 75-100%

Microlandscapes with *Angelico-Cirsietum oleracei* meadows

Wielkopolska has a well developed hydrographic network, particularly, within the Wielkopolska Lakeland. In addition to the Warta river, the network is formed by the Warta tributaries of various order. Among the larger right-bank tributaries are: Ner, Wełna and Noteć rivers, while among the left-bank are Prosna and Obra. In the Land Development Plan prognosis (M. Czerniak et al.[24]) for the Wielkopolska province, on the map 'Natural Environment', watercourses smaller than Warta are designated as regional and local ecological corridors. In the valleys of aforementioned Warta tributaries and, also, their larger branches, the range of alluvial soils is strongly restricted and, thus, microlandscapes with the participation of *Ranunculo repentis-Alopecuretum pratensis* hay meadows occur only sporadically. Generally, well developed, flat terraces of the discussed hydrographic network are a domain of Eutric Gleysols or Histosols and habitats of the potential natural vegetation of *Fraxino-Alnetum*. They are characterised by a high level of ground water for most of the year and are used as meadows. Within them, as a result of extensive management, vegetation complexes dominated by the *Angelico-Cirsietum oleracei* phytocoenoses are most frequently noted. In the examined sigmassociations, 17 plant associations were recorded in such complexes in total (Table 2), including 14 of natural syngenesis and 3 seminatural. Grassland phytocoenoses covered 85-95% of the complex area (0,4-1,2 ha), forests and thickets 5-15%, while the remaining types <5%. The constant and frequent elements of that microlandscape included: treestands of *Fraxino-Alnetum* (Natura 2000 habitat code *91E0[19]); thickets of *Aegopodio-Sambucetum nigrae*; grasslands of *Angelico-Cirsietum oleracei*, *Scirpetum sylvatici* and *Stellario-Deschampsietum*; and ecotone tall herb fringe communities of Natura 2000 code 6430: *Eupatorietum cannabini*, *Fallopio-Humuletum* and *Urtico-Convolvuletum*. In the analysed complexes, 6 associations threatened with extinction in Wielkopolska were found, according to the classificaction by A. Brzeg & M. Wojterska. Under the category V (vulnerable) fall grassland communities – *Angelico-Cirsietum oleracei*, *Caricetum cespitosae*, *Poo palustris-Lathyretum palustris* and *Scirpetum sylvatici*, and, also, the spring community

24 M. Czerniak et al., *Plan zagospodarowania przestrzennego województwa wielkopolskiego. Prognoza oddziaływania na środowisko*. Samorząd Województwa Wielkopolskiego, http://www.wbpp.poznan.pl/plan/index.html [Date of entry: 10-09-2012].

Cardamino-Chrysosplenietum alternifolii. On dirt roads used for hay transport, *Poetum annuae* was noted, while in the wallows of the wild boar *Sus scrofa* or in tractor ruts, muddy annual communities – *Bidenti-Polygonetum hydropiperis* or *Bidenti-Polygonetum mitis*. In the different forms of patches of the above-mentioned associations (subassociations and variants) about 20 species threatened with extinction and 15 under the law's protection can be found. According to the red list by B. Jackowiak et al.[25], the following species fall under the category EN: *Alchemilla acutiloba*, *Cirsium rivulare*, *Neottia nidus-avis* and *Thalictrum simplex*, while under the category VU: *Alchemilla gracilis*, *Astrantia major*, *Calamagrostis stricta*, *Circaea intermedia*, *Senecio aquatica*, *Trisetum flavescens* and *Trollius europaeus*. From the group of plants under the strict law's protection, listed in the Regulation of the Minister of the Environment[22], there are such species as: *Dactylorhiza incarnata* (LC), *D. majalis* (LC), *Daphne mezereum* (LC), *Epipactis helleborine*, *Hepatica nobilis*, *Leucoium vernum* (DD), *Neottia nidus-avis* (EN) and *Trollius europaeus* (VU), while among the species partially protected – *Asarum europaeum*, *Climacium dendroides*, *Frangula alnus*, *Galium odoratum*, *Hedera helix*, *Menyanthes trifoliata* and *Viburnum opulus*.

Table 2

Phytocoenotic structure of the grassland microlandscape in the Warta river valley with the surface domination of *Angelico-Cirsietum oleracei* hay meadows

Number of sigmassociation	1	2	3	4	5	6	7	8	9	10
Date (year)	2010	2010	2011	2011	2011	2010	2011	2012	2010	2011
Stream valley										
Forests, shrubs [%]	10	10	10	10	5	10	5	15	10	5
Meadows, meadow tall forbs [%]	90	90	90	90	95	90	95	85	90	95
Tall forbs [%]	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carpet phytocoenoses [%]	-	<5	<5	<5	<5	-	<5	-	-	-
Therophytic phytocoenoses [%]	<5	<5	<5	-	-	-	-	-	<5	-
Spring phytocoenoses [%]	-	-	-	-	-	-	<5	-	<5	-
Area of sigmassociation [ha]	0,6	0,8	0,4	0,5	0,6	0,4	0,6	1,2	0,4	0,7
Number of associations	13	14	13	10	9	8	8	9	9	8
Querco-Fagetea:										
Fraxino-Alnetum	20	20	2/	10	20	20	20	2/	10	2/
Rhamno-Prunetea:										
Aegopodio-Sambucetum nigrae	1.	1.	1.	2/	+.	1.	+.	1/	2/	+.
Molinio-Arrhenatheretea:										

[25] B. Jackowiak, Z. Celka, J. Chmiel, K. Latowski, W. Żukowski, *Red list of vascular flora of Wielkopolska (Poland)*, „Biodiversity: Research and Conservation" 2007 No. 5-8, p. 95-127.

Number of sigmassociation	1	2	3	4	5	6	7	8	9	10
Angelico-Cirsietum oleracei	40	40	40	50	50	50	40	40	40	40
Scirpetum sylvatici	+.	+.	1.	+.	+.	+.	20	1/	20	20
Stellario palustris-Deschampsietum cespitosae	1.	1.	20	1.	+.	.	.	20	1.	+.
Lysimachio vulgaris-Filipenduletum	+.	+.	.	.	+.	+.	.	+.	.	.
Caricetum cespitosae	30	20	1.	.	.	.	.	+.	.	.
Filipendulo-Geranietum palustris	+.	.	+.	+.	.	.	.	.	.	+.
Poo palustris-Lathyretum palustris	+.	1.	.	.	.	.	.	.	.	.
Artemisietea:										
Fallopio-Humuletum	+.	1/	+.	1/	+.	1.	+.	1/	.	+.
Urtico-Convolvuletum sepium	1.	+.	1.	+.	.	+.	+.	.	+.	.
Eupatorietum cannabini	+.	1/	1.	.	+.	.	.	+.	+.	.
Epilobio hirsuti-Convolvuletum sepium	.	+.	+.	+.	.	.	+.	.	.	.
Bidentetea:										
Bidenti-Polygonetum mitis	+.	.	+.	.	.	.	.	.	.	.
Bidenti-Polygonetum hydropiperis	.	+.	.	.	.	.	.	.	+.	.
Polygono arenastri-Poetum annuae:										
Poetum annuae	.	1/	1/	1/	+.	+.	+.	.	.	.
Montio-Cardaminetea:										
Cardamino-Chrysosplenietum alternifolii	.	.	.	.	.	.	.	.	1.	+.

Occurrence way of plant community in vegetation complex: 0 – over great surface, / – in long, narrow linear form, . – singular or dispersed in irregular form; quantity – Braun-Blanquet scale: + – in a minimal degree, 1 – ≤5% vegetation cover, 2 – 5-25%, 3 – 25-50%, 4 – 50-75%, 5 – 75-100%

Ecosystem services of microlandscapes with *Calthion* hay meadows

According to the classification of the Millennium Ecosystem Assessment2, ecosystem services provided by the analysed microlandscapes with *Calthion* meadows comprise: provisioning ES – food production, genetic resources, natural medicines; regulating ES – air quality regulation, climate regulation, water regulation, erosion regulation, disease regulation, pest regulation and pollination; cultural ES – cultural diversity, spiritual and religious values, recreation and ecotourism, aesthetic values, knowledge systems and educational values; and supporting ES – soil formation, photosynthesis, primary production, nutrient cycling and water cycling. A large modification of the MA system (l.c.) is the classification of ecosystem services (ES) proposed by K. J. Wallace[26]. This classification is the result of a critical stance on the construction of the commonly used MA system, which gives rise to serious problems in the effective manage-

[26] K. J. Wallace, *Classification of ecosystem services: Problems and solutions*, "Biological Conservation" 2007 No. 139, p. 235-246.

ment of a mixture of agricultural land and natural vegetation. Earlier, it has been shown that the analysed extensive microlandscapes with the surface domination of wet *Calthion* meadows are connected with such areas. K. J. Wallace (l.c.) groups ecosystem services in the category of human values. He ascribes to each category a list of ecosystem services. Moreover, he mentions those ecosystem services and natural assets which should be managed to ensure that their ecosystem services are provided. Accordingly, the two analysed plant microlandscapes, despite substantial geobotanical differences between them (Table 3), provide the same multiple services resulting form the complex phytocoenotic composition – a mosaic of seminatural (dominating meadow and pasture phytocoenoses) and natural (forests, thickets and tall herb communities) ecosystems. These comprise the following services, experienced at the individual human level: food, oxygen, protection from disease and benign environmental regimes (of temperature, moisture, light and chemical). In the category socio-cultural fulfilment these are: spiritual/philosophical contentment, recreation/leisure, aesthetics, capacity for cultural and biological evolution (knowledge/education resources, genetic resources). According to Wallace (l.c.), to secure these services, it is necessary to manage such processes and assets as: biological regulation, climate regulation, disturbance regimes (flooding), gas emission regulation, management of 'beauty' at the landscape and local scales, management of land for recreation, nutrient regulation, pollination, production of food, production of medicines, soil formation, soil retention, waste regulation and economic processes. Management of the mentioned processes is expected to protect a particular composition and structure of ecosystem elements (biotic and abiotic).

Threats to ecosystem services of microlandscapes with *Calthion* meadows

In 2010, the land development plan for the Wielkopolska region (A. Derc16) was passed. The data included in the plan prognosis, presented by M. Czerniak et al., show that ecosystem services of microlandscapes with *Calthion* meadows are seriously threatened. In the years 2001-2008, in Wielkopolska (also generally in Poland), alarming change trends in the environment resources and natural values occurred, resulting from the increased anthropization generated by the economic development of this region. In these years, investment in housing development and technical infrastructure substantially raised. This caused, among others, an increase in spatial fragmentation and decrease in agricultural land area by 0.6%. Disappearance of agricultural functions is particularly visible in the area of Poznań Agglomeration (see also A. Mizgajski and I. Zwierzchowska). Waters of the whole region continue to be of a very low quality, mainly due to the poorly developed sewer system in rural areas and high chemization of agriculture. Waters of the class IV (of unsatisfactory quality) were found in 47% of measurement and control points, while of the class V (of poor quality) in as many

Table 3

Geobotanical outline of the river valley microlandscapes of Wielkopolska with surface domination of *Calthion* meadows

	Microlandscape with the surface domination of wet hay meadows	
	Ranunculo repentis-Alopecuretum pratensis	*Angelico-Cirsietum oleracei*
Area of occurrence	floodplains in the Warta river valley	well developed bottom terraces with slight transverse and longitudinal gradients and high level of groundwater in the valleys of Warta river larger tributaries and their branches
Position in the ecological network of Wielkopolska	national ecological corridor	local and regional ecological corridors
Natural potential vegetation	*Salicetum albae*	*Fraxino-Alnetum*
Soil cover	Fluvisols	Histosols, Eutric Gleysols
Number of plant associations (natural/seminatural); acc. to Table 1* and Table 2^	22 (15/5)*	17 (14/3)^
Number of threatened plant associations in Wielkopolska; acc. to Table 1* and Table 2^	3*: *Fallopio-Humuletum lupuli*, *Salicetum albae*, *Scutellario hastifoliae-Veronicetum longifoliae*	6^: *Angelico-Cirsietum oleracei*, *Cardamino-Chrysosplenietum alternifolii*, *Caricetum cespitosae*, *Poo palustris-Lathyretum palustris*, *Scirpetum sylvatici*
Natural habitats of the European Ecological Network Natura 2000 and their representative plant associations; acc. to Table 1* and Table 2^	91E0*: *Salicetum albae*, *Salicetum triandro-viminalis* 6430: *Achilleo salicifoliae-Cuscutetum lupuliformis*, *Carduo crispi-Rubetum caesii*, *Fallopio-Humuletum lupuli*, *Urtico-Convolvuletum sepium*, *Convolvulo sepium-Cuscutetum europaeum*, *Fallopio-Cucubaletum bacciferi* 3270: *Agrostio stoloniferae-Pulicarietum vulgaris*, *Chenopodio rubri-Polygonetum brittingeri*, *Cypero fusci-Limoselletum*, *Juncetum bufonii*, *Rumicetum maritime*	91E0^: *Fraxino-Alnetum* 6430: *Eupatorietum cannabini*, *Fallopio-Humuletum*, *Urtico-Convolvuletum*
Threatened species in Wielkopolska that may occur	EN: *Allium angulosum*, *Sonchus palustris* V: *Euphorbia lucida*, *Gratiola officinalis*, *Oenanthe fistulosa*, *Petasites spurius*, *Senecio fluviatilis* i *S. paludosus*	EN: *Alchemilla acutiloba*, *Cirsium rivulare*, *Neottia nidus-avis*, *Thalictrum simplex* VU: *Alchemilla gracilis*, *Astrantia major*, *Calamagrostis stricta*, *Circaea intermedia*, *Senecio aquatica*, *Trisetum flavescens*, *Trollius europaeus*
Species under strict protection that may occur	*Angelica archangelica*, *Centaurium pulchellum*, *Corrigiola litoralis* (CR), *Gratiola officinalis* (VU)	*Dactylorhiza incarnata* (LC), *D. majalis* (LC), *Daphne mezereum* (LC), *Epipactis helleborine*, *Hepatica nobilis*, *Leucoium vernum* (DD), *Neottia nidus-avis* (EN), *Trollius europaeus* (VU)
Species under partial protection that may occur		*Asarum europaeum*, *Climacium dendroides*, *Frangula alnus*, *Galium odoratum*, *Hedera helix*, *Menyanthes trifoliate*, *Viburnum opulus*

as 36%. Still, only a part of rural population has sewage treatment service provided (29% of the whole population). Pesticides (NPP) usage has increased by 56.6%, which corresponds to the agricultural intensification. As much as 8.3% of the region are sensitive waters and areas particularly exposed to the contamination by nitrogen compounds of agricultural origin. These areas comprise reception basins of 13 watercourses. Also, the extent of acoustically favourable areas decreased. In some fragments of the roads S2, S5, S11, 25, 92 and A2, and also for the railway No. 3, the forecast indicator of daily traffic of high threat level to acoustic climate was exceeded. An emission of gaseous contaminants from the particularly burdensome factories increased by 2.3%, while the number of such factories by 1.6%. In the whole region, the target level and long-term target level of ozone O_3 were exceeded. The investment expenditures for small water retention decreased by 77%. A considerable area of the region (4%) is directly threatened with flooding. A high frequency and dynamics of floods has been observed. A decrease in afforestation activities occurred, from 1584 ha in 2001 to 442 ha in 2008. The size of protected areas (excluding the Natura 2000 sites), which ensure a relative balance of ecological processes supporting ecosystem services, increased as little as 1%.

In the quoted prognosis by M. Czerniak et al., the presented data for the years 2001-2008 were optimistic in terms of preservation of ecosystem services provided by the discussed plant microlandscapes with *Calthion* meadows. Significantly increased expenditures (by 65%) for fixed assets (per inhabitant) that serve environmental protection. The sewage quantity, requiring purification, channelled to surface waters or to the ground decreased by 8%. The estimation of atmospheric air pollution, conducted in 2008 in terms of plant protection, showed the class A level due to SO_2 and NO_x pollution. Crop fields in Wielkopolska were contaminated with heavy metals only to a small degree and met requirements for healthy food production. The number of certified ecological farms increased almost 12 times (by 190). According to H. Dmochowska, 456 certified organic farms on 20,755 ha of organic agricultural land and 292 organic farms under conversion on 22,758 ha were recorded in Wielkopolska in 2010.

Agri-environmental Programme – a tool for protecting ecosystem services of microlandscapes with *Calthion* meadows

The Agri-environmental Programme[27] is one of tools which secures ecological processes and assets required for the maintenance of ecosystem services

[27] Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 26 lutego 2009 r. w sprawie szczególnych warunków i trybu przyznawania pomocy finansowej w ramach działania 'Program rolnośrodowiskowy' objętego Programem Rozwoju Obszarów Wiejskich na lata 2007-2013. Dz.U. 2009.33.262 [Regulation of the Minister of Agriculture and Rural Development of 26 February 2009 on specific conditions and mode of granting financial support within the 'Agri-

provided by microlandscapes with *Calthion* meadows. This programme is covered by Rural Development Programme for 2007-2013[7], financed by the European Agricultural Fund for Rural Development (*EAFRD*). *Every farmer (in the whole country), who has the farm ID number and agricultural land of no less than* 1 ha, can voluntarily enter this programme. Within the programme, a farmer's task, equally important as food production, is to maintain and shape natural values. A farmer performs this task through realization of the Programme packages requirements, over the subsequent 5 years. The protection of semi-natural grasslands included in the European Ecological Network Natura 2000 is addressed by the Package 3. 'Extensive permanent grassland', and Package 5. 'Protection of endangered bird species and natural habitats in Natura 2000 areas' Variant 6. 'Semi-natural wet meadows', while these not covered by Natura 2000, by the Package 4. 'Protection of endangered bird species and natural habitats outside of Natura 2000 areas' Variant 6 'Semi-natural wet meadows'. The broader range of protection of ecosystem services provided by the analysed microlandscapes ensure the Packages 4 and 5. To realize them, a farmer is required to have the Natural Habitat Documentation prepared by an expert botanist, authorised by the Ministry of Agriculture and Rural Development of Poland and specifically prepared to serve the Agri-environmental Programme. An expert prepares documentation based on the field analysis of grassland vegetation condition and its environmental determinants. Over a 5 year period, a farmer conducts agro-technical procedures, following strictly the requirements of the declared package. These requirements (Table 4) were specified in the Regulation of the Minister of Agriculture and Rural Development[27]. Experts are entitled to formulate their own protective recommendations. They are introduced to the agri-environmental plan as obligatory liabilities. The approved plan is a basis for receiving a bonus payment for meeting the requirements and additional recommendations. In case of the package 3, the payment amounts to 500 PLN/ha/year x 5 years, while for the package 4.6 – 800 PLN/ha/year x 5 years, and for the package 5.6 – 840 PLN/ha/year x 5 years. If the statutory requirements have not been met, a farmer incurs financial sanctions, adequate to the character and scale of an offence.

The author of this article, in the environmental documentation prepared in line with the requirements of the RDP 2007-2013, repeatedly formulated protective recommendations that support the maintenance or revival of biodiversity at all levels of biological organisation: populational, biocoenotic and landscape. She took them into account, among others, in the plans of mowing and grazing, prepared for a farmer, adequately to the natural environment condition. The important populations of protected and threatened plant species and, also, phytocoenoses of threatened plant associations were covered by monitoring con-

-environmental Programme' included in the Rural Development Programme for 2007-2013] (Journal of Laws 2009.33.262).

Table 4
Requirements of Agri-environmental Programme 2007-2013[27], protecting biological and nutrient regulation processes of ecosystem services of extensive wet grasslands

Package.Variant	3	4.6, 5.6
Hay meadow management		
Season of mowing	1.06-30.09	15.06-30.09
Size of unmown area of meadow, each year different [%]	5-10	5-10
Height of mowing [cm] that does not damage meadow sward and soil surface	5-15	5-15
Removal or stacking of biomass two weeks after harvest or, in justified circumstances, later, soon after the cause of delay ceased	+	+
Ban on circular mowing from the outside to centre of a mowed area	+	+
Maximal number of harvests per year	2	2
Hay meadow* and pasture management		
Grazing periods in Wielkopolska, at the altitude ≤300 m a.s.l.	1.05-15.10	21.07-15.10
In floodplains, grazing not earlier than two weeks after water withdrawal; *Polish and Hucul horses all over the year	+*	+
Number of animals per area [DJP/ha]	≤0,3	≤1
Maximal strain on pasture [t/ha; DJP/ha]	≤5;10	≤5;10
Not mowing the leftover vegetation beyond the period of 1.08-30.09	+	-
*Haymeadow management as above	+	+
Other agro-technical treatments		
Ban on ploughing, rolling and resow	+	+
Ban on harrowing from 1.04-1.09	+	+
Ban on the construction and extension of drainage appliances, except for those used for natural values protection (does not apply to current conservation practices)	+	+
Ban on nitrogen fertilization in the areas fertilized by river mud and in other areas >60kg/ha/year	+	+
Ban on the use of plant protection products, except for selective and local eradication of persistent weeds, using appropriate equipment	+	+
Ban on the use of sewage and sewage sediments	+	+
Ban on the use of lime, if it affects negatively environment and package realization	+	-

ducted jointly with a farmer (e.g. J. Borysiak[28]). The objects of high natural value, like natural forests and thickets, ecotone tall herb communities and peatbog ecosystems, were distinguished as ecological sites (Package 4 or 5 Variant 10), while other objects were located on a ortophotomap, attached to the documentation, and introduced to a plan to preserve their proper condition over the declared 5 years of programme realization.

[28] J. Borysiak, B. Grabowska, T. Kubala, *Conservation of vegetation cover in the Głuszec stream valley in Poznań town (Poland) in the Agri-environmental programme 2007-2013*, "Biodiversity Research and Conservation" 2012 (in print).

A negative phenomenon is a low participation of Polish farms in the Agri-environmental Programme 2007-2013, partially related to the maintenance and improvement of permanent grasslands condition. The Report[29] from the realization of Rural Development Programme for 2007-2013 shows that up to the 31 December 2011, the lowest number of applications for payment allocation concerned the Packages 4 and 5. In the case of Package 4, the total area of supporting land qualified for agri-environmental payments will amount to 38,580.69 ha of permanent meadows and pastures falling to 3,105 farms (about 0.2% of a total number in Poland), financed for an overall sum of 49,990,817 PLN. The most popular was the Variant 4.1 'Protection of bird breeding habitats' (86.53% of funding used within the package). For Package 5, the total area of supporting land will amount to 66,305.82 ha, falling to 3,677 farms (also about 0.2% of the country's total number) and financed for an overall sum of 104,293,079 PLN. Also in the case of this package, the most popular was the ornithological Variant 5.1 (89.42%). Most attractive turned out to be the Package 3, which did not require documentation prepared by an authorised expert-botanist. In this case, the area of supporting land will amount to 252,452.35 ha, falling to 38,916 farms (2.5% of a total number) and financed for an overall sum of 238,691,388 PLN. It would be advisable to find a reason of farmers' reluctance to participate in the Packages 4-5 of Agri-environmental Programme. Perhaps, this results from the lack of relevant knowledge, as with such situation the author of this article often dealt with in practice.

Conclusions

Multi-functional microlandscapes of river valleys, shaped by the extensive agricultural use of wet seminatural grasslands, were presented. They are still widely spread in Wielkopolska. Furthermore, ecosystem services to human welfare, provided by the natural and seminatural vegetation of these microlandscapes, were determined. Also, the temporal and spatial gradients of human impact, resulting in vegetation degradation and reduction of ecological services, were discussed in connection with the dynamic economic development of the region and country. One of activities that restrains this phenomenon is the Agri-environmental Programme and its Packages 3-5, addressing the protection of species and natural habitats of a key importance for the preservation of regional and national biodiversity, including these (Packages 4 and 5) that are realized with the participation of expert-botanists. The legal package requirements and additional protective recommendations formulated by an expert-botanist specifically for an individual farm, allow not only to halt further progress in loss of

[29] Sprawozdanie z realizacji Programu Rozwoju Obszarów Wiejskich na lata 2007-2013. Sprawozdanie za 2011 r. Ministerstwo Rolnictwa i Rozwoju Wsi, http://www.minrol.gov.pl/pol/Wsparcie-rolnictwa-i-rybolowstwa/PROW-2007-2013/Monitoring-i-sprawozdawczosc--PROW-2007-2013 [Date of entry: 4.09.2012].

biodiversity, which is the base of essential ecosystem services, but also to increase species richness in local and regional biodiversity. Benefits of implementation the Packages 4 and 5 depend significantly on the expert's specialist knowledge. Such knowledge has to be particularly sound in the area of ecological dynamics of biotic and abiotic elements of natural environment, and, also, in autecology of plant and animal species. Additionally, it has to be supported by many years' practical experience.

Since 2004, in Poland (in the European Union since 1993), the Agri-environmental Programme has been a tool for sustainable management of agriculture extensification. Currently, the Programme's Packages 3-5 regulate drawing of natural resources from the environment and shape the dynamics of ecosystem services. Thus, ensure stability of multiple ecosystem processes and services of extensive seminatural grasslands. At present, the agri-environmental plan, based on the guidelines for the years 2007-2013, are realized. They should be continued in future, at least in the similar shape, to ensure long-term economic interests.