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REVIEW

Diversity of agrocoenoses in the Lublin region, Poland

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Abstract

The Lublin region, one of the main agricultural regions in Poland, has very favorable conditions for agricultural production but the development of the agricultural sector has been very slow there. This is due, among other factors, to the extensive farming used on large areas and the fragmentation of fields with numerous fragments of natural ecosystems. In Lublin Province, cereals comprise the highest proportion of the crop structure, especially wheat, but farmers also often cultivate maize, oilseed rape, sugar beet, and legumes for consumption. The biological diversity of agricultural areas is enhanced by growing traditional plant species and varieties. Crop species are accompanied by segetal weeds, sometimes very expansive, sometimes rare and endangered by extinction. In recent years, the following have been the dominant weed species in the region's crop fields: *Galium aparine*, *Convolvulus arvensis*, *Papaver rhoeas*, *Viola arvensis*, and *Veronica persica*. However, there are several locations of occurrence of *Muscari comosum* (a strictly protected species) and the following unique species: *Adonis aestivalis*, *Anthemis tinctoria*, *Caucalis platycarpos*, *Galium tricornutum*, and *Thymelaea passerina*. In Lublin Province, there are many organic farms which contribute to the significant diversity of agricultural plant communities. In this review, we also indicate the biocoenotic role of weeds and their importance in the proper maintenance of agroecosystems and ecosystem services.

Keywords

agricultural areas; agrophytocoenoses; Lublin Province

Introduction

Agriculture is one of the main branches of the economy in Lublin Province, Poland. Agricultural lands occupy 55.2% of this region's total area and amongst the economically active people as many as 42.8% are involved in agriculture. Additionally, the Lublin region has very favorable environmental conditions for the development of this branch of the economy. In spite of such beneficial circumstances, the development of the agricultural sector has been very slow. This is partly due to the large fragmentation of agricultural holdings, which accounts for their low profitability. Small farms with extensive agronomic practices are, however, accompanied by numerous ecologically distinct units such as field margins, roadsides, midfield ponds, and tree stands, ditches and fallows. The specificity of such economic conditions has had a positive impact on the floristic diversity.

In the Lublin region, cereals account for the highest proportion of the crop structure, but in addition to crop plants, there are also many weeds in arable lands, some rare, which may have a different effect on the crop (unfavorable and beneficial). Increasing the diversity of the segetal flora also favors farming that follows the organic agriculture rules as well as growing traditional plant species and varieties. Large-area farms with intensive production, on the other hand, have a distinctly negative impact on the diversity of field communities, and at the same time they form phytocoenoses most exposed to anthropogenic pressure.

Characteristics of the Lublin region

Lublin Province is located in the eastern part of Poland, between the rivers Vistula and Bug. It occupies an area of >25 000 km^2 (8% of Poland's total area), within which agricultural land accounts for 70%. It is characterized by a low forest cover (23%), whereas areas of unfavorable farming conditions are a large proportion (38%) [1]. The Lublin region has few surface water resources but large groundwater resources. Its topography is diverse. Due to the fact that in this region there are many environmentally valuable areas, diverse landscapes, and a well-developed system of protected areas, it is one of the most interesting in Poland [2].

The Lublin region has a large stock of very good soils (37% of arable land) and good soils (22% of arable land), and therefore there are ideal conditions here for agriculture. The agricultural production space valuation ratio for this region is 74:1, higher by 7.5 points than the national average (66.6) [3,4]. In terms of heavy metal contents, the region's soils belong to the cleanest in Poland, and so offer great opportunities for healthy food production (e.g., organic foodstuffs). Nevertheless, there is also a high percentage of acidic and very acidic soils (51%) as well as of soils with very low or low availability of phosphorus (39%) and potassium (40%), which may lead to soil degradation [5].

Agricultural landscape of the Lublin region

In Lublin Province, agriculture is one of the main branches of the economy. Agricultural lands occupy 55.2% of this region's total area. The agricultural potential of this region is substantial because, from the point of view of agricultural production, it has favorable natural conditions and significant stocks of the high production requirements (land, labour, and capital). Among economically active people, 42.8% are involved in agriculture [1]. Nonetheless, the utilization of this potential is very low due to adverse organizational and economic conditions. In the opinion of Krasowicz and Kopiński [6], the problems here include primarily the following: insufficient development of the agri-food industry, numbers of farmers, little overall interest in the implementation of technological advances in plant and animal production, as well as a poorly developed infrastructure of rural areas. Furthermore, the Lublin region is characterized by large a fragmentation of farms which, in the opinion of Stalenga et al. [7], is favorable from the point of view of the implementation of environmentally-friendly agricultural practices. Out of >178 000 farms, the area of 53.5% is <5 ha [1]. According to Wrzeszcz [8], a larger farm area increases the possibility of using crop rotation, beneficially affects the soil organic matter balance, and offers the possibility of maintaining a proper nitrogen balance. A study carried out by Czubak [9] showed that the Lublin region is also characterized by one of the lowest labor productivity rates on account of a very high level of employment in agriculture. Currently, out of 714 000 people in the working age group in the Lublin region's villages, 306 000 are employed in agriculture, which accounts for 42.8% [1].

Evaluating some agricultural sustainability indicators for Lublin Province, Kwiatkowski et al. [10] pointed out that one of the most important elements of environmental impacts of agriculture is the crop structure, in particular the proportion of cereals in it, since cereals are the major crop in Poland. According to Majewski [11], their percentage should not be >66%, because a higher proportion leads to adverse economic (reduced productivity) and environmental effects (increased fertilization and crop protection and in consequence, soil degradation). In the Lublin region, this percentage is exceeded and this is considered to be negative from the environmental point of view (Tab. 1). Taking

Tab. 1 Some agricultural sustainability indicators for Lublin Province relative to the country as a whole in 2011 [10].

Indicator	Poland	Lublin Province		
		indicator value	relative to the country as a whole (Poland = 100)	rank among regions
Percentage of cereals in the crop structure (%)	72.8	75.7	104.1	3
Area of agricultural land in organic farms (ha)	376036	24717	6.5	7
Number of organic farms (pcs)	15234	1469	9.6	4
Percentage of agricultural land maintained in good agricultural culture (%)	87.0	95.2	109.4	3
Stocking rate (SD 100 ha^{-1})	45.7	30.7	67.2	11
Percentage of fallow land (%)	3.0	2.5	83.3	10
Percentage of drained arable land, meadows and pastures (%)	41.5	21.9	52.8	15
Consumption of mineral NPK fertilizers (kg ha^{-1} agricultural land)	126.6	115.4	91.1	11
Consumption of calcium fertilizers in kilograms of nutrient per hectare (kg ha^{-1} agricultural land)	36.8	40.3	109.5	7

into account other agricultural sustainability indicators, compared to the country as a whole, the Lublin region emerges well in terms of the number of organic farms (it ranks fourth) and the area of agricultural land maintained in good agricultural culture (it ranks third). The stocking rate in agricultural holdings and consumption of mineral fertilizers also look favorable from the environmental point of view [10,12].

Plant species grown under field conditions

Flora, fauna, and landscape associated with agriculture are important elements of biological diversity of rural areas. Crop fields occupy the largest area in the Lublin countryside landscape. Agricultural ecosystems or agrocoenoses (crop biocoenoses) are specific types of biocoenosis, which develop in agriculturally-used areas and are generally characterized by a significant reduction in terms of their species composition, compared to a natural biological community, and impaired self-regulation capacity resulting in susceptibility to diseases and pest invasion. The crop plant, which is accompanied by wild vegetation (weeds), usually unwanted, plays the dominant role in determining a crop biocoenosis [7,13].

In Lublin Province, cereals have the highest proportion in the crop structure. In 2014, the total cereal area was 791 000 ha, which accounted for 75.2% of the crop structure (Tab. 2). Among cereals, wheat has the largest cropped area. In this region, farmers also readily grow maize (77 000 ha) and oilseed rape (71 000 ha)., The Lublin region ranks first in the country among the Polish regions in terms of the crop area of legumes grown for consumption. Permanent grasslands account for 21% and orchards for only 3% of the region's total area. Animal production is poorly developed in this region. In terms of cattle production, the Lublin region ranks seventh in Poland and sixth in pig production [1].

The biological diversity of agricultural areas in the Lublin region is enhanced by growing traditional plant species and varieties as well as by keeping local livestock breeds which are a source of genetic variation. As a result of agricultural intensification, specialization and efforts to increase productivity, only a few farmers are still interested in maintaining old low-production cultivated varieties and livestock breeds due to

Tab. 2 The crop structure of more important crops in Lublin Province relative to Poland as a whole in 2014.

Crops	Poland (thousand ha)	Lublin Province (thousand ha)	Lublin Province in relation to the country (Poland = 100%)
Cereals in total	7485.0	790.8	10.6
Rape	951.1	71.0	7.5
Potato	267.1	20.9	7.8
Sugar beet	197.6	34.5	17.5
Corn in total	1219.0	76.8	6.3
Legumes in total	216.0	21.7	10.0
Legumes edible	53.0	19.0	35.8

their low profitability. Nevertheless, their lower level of usefulness is compensated by other positive traits, such as resistance to diseases, stress and extreme environmental conditions, longevity, adaptive capacity, low feed requirements, or the unique quality of products obtained [14]. Old traditional cultivated varieties, such as lentil and parsnip, and the livestock breeds Polish Konik, Biłgoraj Horse, Kopczyk Podlaski Horse, Whiteback cattle, as well as heather sheep (wrzosówki), świniarki sheep, and karnówki sheep have all been preserved in Lublin Province [15]. Preservation of the useful traits of varieties and breeds in danger of extinction is an important element of biological diversity protection. In recent years, consumer's interest in and requirement for healthy products, with special flavor and nutritional qualities, have been on the increase. Production of local breeds and varieties under extensive farming systems meets these expectations.

Species accompanying crop plants

Agricultural ecosystems are habitats for many plant species, invertebrates, birds, and other animals which are linked through a number of food chains and ecological relationships [16]. According to Gwiazdowicz [17], about 30% of the agricultural land in Poland serves as a refuge for endangered flora and fauna species. Agricultural activity may have various impacts on the biological diversity of agricultural land. Some agricultural practices pose a threat to this diversity (e.g., excessive mechanization and overuse of chemicals, development of agriculture in marginal areas, excessive livestock grazing, elimination of environmentally-friendly lands), whilst some others contribute to increased species richness of agricultural areas (e.g., extensive farming systems, sustainable production) [13,18].

During the post-war period, significant changes in the biological diversity of agro-phytocoenoses have occurred due to the very fast development of technology, industrialization of agriculture, introduction of new technologies, widespread herbicide use, and increasing field areas with simultaneous elimination of field margins. This process is dynamic, continuous, and permanent. These transformations affect both the species composition of the weed populations and their numbers. Individual weed species respond differently to the agricultural practices used; they can either disappear from crop fields or spread extensively and compete out other species. Taxa associated with specific, most frequently extreme habitats, with narrow ecological amplitude and herbicide-sensitivity, are the most vulnerable, but they can be replaced by ubiquitous weeds with high adaptive ability [19–24]. A study conducted by Fijałkowski [25] demonstrated that many common weed species that were found in the Lublin region during the period 1947–1967 maintained their numbers also in the period 1983–1993 (Tab. 3). Weeds that were most numerous in crop fields in both study periods, i.e., were characterized by the greatest abundance (numerical abundance – 5) and grew in many locations (number of locations – 5), are the following: *Apera spica-venti*, *Avena*

Tab. 3 Number of locations, abundance, and loss of abundance of common weed species in segetal habitats in the Lublin region during the period 1983–1993 [25].

Species	Number of locations	Abundance of species	Loss of abundance
Apera spica-venti (L.) P. Beauv.	5	5	5
Avena fatua L.	5	5	5
Chenopodium album L.	5	5	5
Echinochloa crus-galli (L.) P. Beauv.	5	5	5
Elymus repens (L.) Gould	5	5	5
Galinsoga ciliata (Raf.) S. F. Blake	5	5	5
Galinsoga parviflora Cav.	5	5	5
Matricaria maritima ssp. *inodora* (L.) Dostál	5	5	5
Poa annua L.	5	5	5
Setaria pumila (Poir.) Roem. & Schult.	5	5	5
Amaranthus retroflexus L.	5	5	4
Capsella bursa-pastoris (L.) Medik.	5	5	4
Equisetum arvense L.	5	5	4
Stellaria media (L.) Vill.	5	5	4
Cirsium arvense (L.) Scop.	5	5	3
Conyza canadensis (L.) Cronquist	5	5	3
Papaver rhoeas L.	5	5	3
Polygonum aviculare L.	5	5	3
Polygonum lapathifolium ssp. *lapathifolium* L.	5	5	3
Polygonum persicaria L.	5	5	3
Anagallis arvensis L.	5	5	2
Centaurea cyanus L.	5	5	2
Galium aparine L.	5	4	5
Convolvulus arvensis L.	5	4	4
Viola arvensis Murray	5	4	4
Lamium purpureum L.	5	3	4
Sonchus arvensis L.	5	3	4
Veronica arvensis L.	5	3	2
Lamium amplexicaule L.	5	2	3
Geranium pusillum Burm. F. ex L.	4	2	1
Veronica persica Poir.	2	1	2

Numerical abundance of species expressed as the number of individuals per location: “1” indicates 1–10 individuals; “2” – 10–20; “3” – 20–100; “4” 100–1000; “5” – >1000 individuals per location. Loss of abundance over the period 1983–1993 in relation to the abundance during the period 1947–1967: “1” – indicates species that lost 70–99% in the number of individuals or their total cover due to human management; “2” – 50–70%; “3” – 30–50%; “4” –10–30%; “5” – species that showed an insignificant (<10%) loss of abundance or its slight increase (up to 20%), especially due to field fertilization. Number of locations of individual species: “1” indicates the number of locations of 1–10; “2” – 10–100; “3” – 100–500; “4” – 500–1000; “5” – >1000 locations.

fatua, *Chenopodium album*, *Echinochloa crus-galli*, *Elymus repens*, *Galinsoga parviflora*, *G. ciliata*, *Matricaria maritima* ssp. *inodora*, *Poa annua*, and *Setaria pumila*. A large group of species reduced their numbers and frequency of occurrence compared to the period 1947–1967. *Geranium pusillum* showed the highest loss in abundance, by 70–99%. In the 1980's and 1990's, it occurred in 500–1000 locations and its abundance in these locations was from 10 to 20 plants. A decrease in abundance by 50–70% was also found in the case of *Anagallis arvensis*, *Centaurea cyanus*, *Veronica arvensis*, and *V. persica*. In the period 1983–1993, due to such a high loss in numbers, *V. persica* was a relatively rare weed species. The abundance of *Cirsium arvense*, *Conyza canadensis*, *Papaver rhoeas*, *Lamium amplexicaule* as well as *Polygonum aviculare*, *P. persicaria*, and *P. lapathifolium* ssp. *lapathifolium* all decreased by 30–50%. Ten species showed an insignificant (<10%) loss in abundance or a slight increase (up to 20%), largely due to field fertilization.

The evaluation of weed infestation of agrophytocoenoses carried out by Kapeluszny and Haliniarz [26] confirmed the findings of the study by Fijałkowski [25]. According to these authors, *Apera spica-venti* was the species that ranked highest among the expansive weeds in the period 1967–1985. The continuously increasing proportion of this weed in cereal crops is associated with its colonization of new habitats, the large proportion of cereals in the crop structure, the introduction of intensive short-stemmed varieties of cereals into cultivation, increased nitrogen fertilization, the long-term selective control of dicotyledonous weeds by herbicides, and the growing population of resistant biotypes [26–28]. Another highly expansive species is *A. fatua*, which started to colonize brown soils derived from loess, pseudo-rendzinas, and sandy soils with interbedded limestone. The expansion of its ecological amplitude and the colonization of new habitats can be related to the increasingly frequent occurrence of interspecific crosses, the so-called "fatuoids". Kapeluszny and Haliniarz [26] included the following in their list of other expansive species found in the Lublin region area: *Elymus repens*, *Echinochloa crus-galli*, *Setaria pumila*, *Viola arvensis*, *Galium aparine*, *Amaranthus retroflexus*, *Agrostis stolonifera* ssp. *stolonifera*, *Chenopodium album*, *Galinsoga parviflora*, and *G. ciliata*.

The present study conducted over the periods 1997–2003 (186 relevés) and 2005–2015 (237 relevés), revealed successive transformations in the structure of weed infestation of crop fields (Tab. 4). Compared to the years 1997–2003, during the second study period 13 species increased their constancy in agrophytocoenoses of the Lublin region. *Galium aparine* was most frequently found in crop fields and in the period 2005–2015 it was already a constant species (S = V). *Apera spica-venti*, *Convolvulus arvensis*, *Papaver rhoeas*, and *Viola arvensis* increased their constancy, from class III to IV. The increase in constancy of *Veronica persica* increased from S = II to S = IV and deserves special attention. In the study by Fijałkowski [25], this species occurred in small numbers but Kapeluszny and Haliniarz [26] did not mention it in their group of expansive weeds. Currently, this species is included in the list of segetal invasive species [29]. *Anagalllis arvensis*, *Conyza canadensis*, *Geranium pusillum*, and *Galinsoga parviflora* increased their constancy from S = I to S = III. The degree of phytosociological constancy of 12 species remained at the same level in both study periods. Among those weeds, the following three were most frequently found/noted in agrophytocoenoses: *Centaurea cyanus*, *Chenopodium album*, and *Elymus repens*. Only two taxa decreased their frequency of occurrence in crop fields, i.e., *Matricaria maritima* ssp. *inodora* and *Capsella bursa-pastoris*.

A common phenomenon in rural areas is the migration of species inhabiting other habitats to crop fields. Meadow species from the *Molinio-Arrhenatheretea* class and ruderal species from the *Artemisietea* class have the largest proportion in agrophytocoenoses [30]. Large areas of fallow and wasteland as well as tillage reductions are the main factors that promote the penetration of ruderal weeds [31,32]. In agrophytocoenoses, the following species occur most frequently: *Artemisia vulgaris*, *Lactuca serriola*, *Daucus carota*, *Taraxacum officinale*, *Medicago lupulina*, *Sisymbrium officinale*, and *Descurainia sophia* [30,32]. The migration of ruderal weeds to crop fields, on the one hand, increases weed infestation of crops, whilst on the other, it has a positive effect on increased biological diversity of agrophytocoenoses [30].

Increased biodiversity of rural areas is a priority objective of integrated plant protection [33]. The fragmentation of fields which form a mosaic-like landscape with numerous field margins, strips of midfield tree stands and fragments of natural ecosystems in the

Tab. 4 Degrees of constancy (S) of common weed species of segetal habitats in 1997–2003 and 2005–2015 in the Lublin region (original data).

Species	S	
	1997–2003	2005–2015
Amaranthus retroflexus L.	II	III
Anagallis arvensis L.	I	III
Apera spica-venti (L.) P. Beauv.	II	IV
Avena fatua L.	II	III
Capsella bursa-pastoris (L.) Medik.	III	II
Centaurea cyanus L.	III	III
Chenopodium album L.	III	III
Cirsium arvense (L.) Scop.	II	III
Convolvulus arvensis L.	III	IV
Conyza canadensis (L.) Cronquist	I	III
Echinochloa crus-galli (L.) P. Beauv.	II	II
Elymus repens (L.) Gould	III	III
Equisetum arvense L.	I	II
Galinsoga ciliata (Raf.) S. F. Blake	I	II
Galinsoga parviflora Cav.	I	III
Galium aparine L.	IV	V
Geranium pusillum Burm. F. ex L.	I	III
Lamium amplexicaule L.	I	I
Lamium purpureum L.	I	I
Matricaria maritima ssp. *inodora* (L.) Dostál	IV	III
Papaver rhoeas L.	III	IV
Poa annua L.	I	I
Polygonum aviculare L.	II	II
Polygonum lapathifolium ssp. *lapathifolium* L.	I	I
Polygonum persicaria L.	I	I
Setaria pumila (Poir.) Roem. & Schult.	II	III
Sonchus arvensis L.	II	II
Stellaria media (L.) VILL.	II	II
Veronica arvensis L.	II	III
Veronica persica Poir.	II	IV
Viola arvensis Murray	III	IV

form of field ponds, peat bogs, wetlands, etc., largely contributes to the preservation of rich diversity in the Lublin region. The traditional farming system used on large areas, in particular extensive farming, the use of a small amount of chemicals in agricultural production (fertilizers, pesticides), and tillage technologies that cause soil degradation to a small extent (heavy equipment), are all also of great importance. According to Hyvönen et al. [34] and van Elsen [35], farming that follows the organic agriculture rules [in the Lublin region there are about 2000 organic farms (about 40 000 ha of land)], is a method to achieve a high level of ecosystem benefits and also satisfactory yields [36]. In a short time, this results in increased species diversity of the segetal flora, though usually the restoration of rare, particularly valuable species requires more time.

A study conducted by Staniak et al. [37] in selected agricultural holdings in Lublin Province showed greater richness of the segetal flora in organically grown winter crops than under the conventional system (Fig. 1). The average number of weed species in a cereal crop grown in organic farms was found to be higher (16) than in conventional farms (11) as well as the number of individuals per unit area was higher (respectively, 385 and 284 plants m^{-2}). Moreover, more monocotyledonous than dicotyledonous species were found both under the organic and conventional systems (Tab. 5).

In turn, the research carried out by Kapeluszny and Haliniarz [38] in selected agricultural holdings in Lublin Province revealed a fourfold higher level of weed infestation of spring cereals and twice higher weed infestation of winter crops in organic fields compared to conventional ones. The *Vicietum tetraspermae* Krusem. et Vlieg. association was dominant in these crops. Furthermore, 10 species considered to be rare or endangered were found to occur in fields of organic farms, whereas they were not found in conventional fields. In organic farms, three species – *Papaver rhoeas*, *Viola arvensis*, and *Consolida regalis* – were a constant element (S = V), while four species were classified in constancy class IV. In the other group of farms, there were no constant species and only three included in constancy class IV [39].

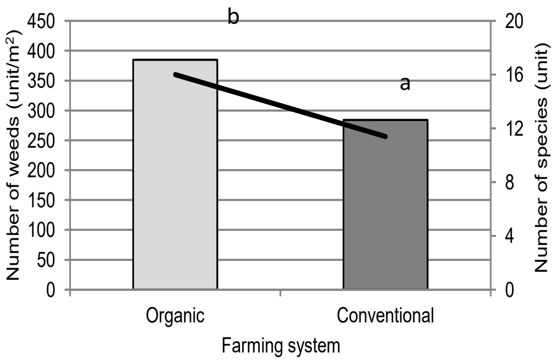

Fig. 1 The average number of weeds per 1 m^2 and number of species in the winter cereals depending on the method of farming [37]; values marked a different small letter differ significantly at the $p < 0.05$ level.

Tab. 5 Dominant species in selected ecological and conventional farms of the Lublin region (%) [37].

Dominant species	Ecological system	Conventional system
Monocotyledonous		
Anthoxanthum aristatum Boiss.	5.3	6.5
Apera spica-venti (L.) P. Beauv.	5.4	7.3
Echinochloa crus-galli (L.) P. Beauv.	3.7	7.3
Elymus regens (L.) Gould	10.3	4.4
Setaria pumila (Poir.) Roem. & Schult	23.4	13.4
Juncus bufonius L.	2.6	21.3
Dicotyledonous		
Anthemis arvensis L.	2.9	1.3
Centaurea cyanus L.	0.9	2.2
Polygonum lapathifolium L. ssp. *lapathifolium*	4.6	0.1
Rumex acetosella L.	4.7	1.1
Scleranthus annuus L.	4.3	1.2
Viola arvensis Murr.	2.5	5.5

The biocenotic role of weeds

Species associated with crop communities are a special group of plants. In recent decades, it has emerged that plants that are not related to natural ecosystems but grow in heavily anthropogenically transformed areas where natural succession is consciously restricted, are also endangered and threatened with extinction. Besides crop plants, in arable lands there also weeds that compete with crops but which, apart from causing impaired growth of the crop plants (competition for water, nutrients, and light), impeded harvest and a deterioration in some quality parameters of the agricultural produce, may also positively affect crops if they occur in low intensity. For example, they are a source of soil humus, protect against erosion, and stimulate the growth of soil bacteria, whilst some affect the growth of other plants (allelopathy). They are also a source of food for pollinators that determine yields of insect-pollinated crops (oilseed rape, buckwheat, horticultural and fruit crops). Pollinating insects produce benefits globally that are estimated to be valued at >US$ 100 billion per year [40].

Complete elimination of weeds from agricultural ecosystems may have adverse effects due to disruption of the food chain balance between animals, plants, and soil organisms. In intensive monocultural crops, a higher incidence of some pest-borne diseases is frequently observed with the elimination of weed infestation. On the other hand, greater species diversity of weeds favors the occurrence of beneficial animal species, including predators of pests and parasites, e.g., ladybirds. Weed species that are important from the point of view of the occurrence of beneficial invertebrates include in particular the following: *Rumex obtusifolius*, *Stellaria media*, *Polygonum aviculare*, *Poa annua*, *Cirsium arvense*, *Senecio vulgaris*, *Sinapis arvensis*, *Marticaria maritima* ssp. *indora*, *Chenopodium album*, and *Galium aparine* (Fig. 2). These weed species are frequently encountered in the Lublin region area [13,41–43]. Furthermore, some weed species are a valuable raw material for the production of herbal medicines (e.g., valerian), culinary herbs, or used in cosmetics. The flora accompanying crops is often very attractive and beautifies the Polish countryside, forming a colorful aesthetic element. The following belong to the most attractive weeds of field crops which are often found in the Lublin region: *Papaver rhoeas*, *Centaurea cyanus*, *Agrostemma githago*, *Consolida regalis*. They are a leading motif in paintings and on ornaments [44].

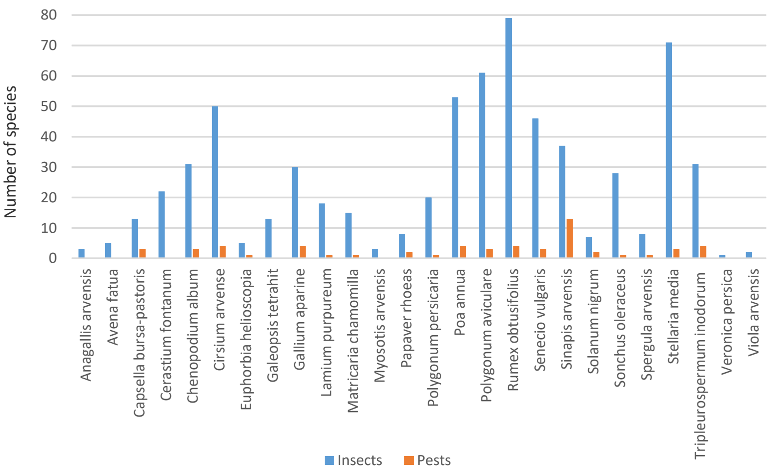

Fig. 2 The number of beneficial insect species and pests occurring on various weed species [43].

Endangered weed species

Among segetal species in Poland, about 100 belong to different categories of endangerment [45]. In the group of these plants, calciphilous species have the highest proportion [46]. In the Lublin region, rendzinas occupy >3% of the region's area and occur in the following mesoregions: Działy Grabowieckie (Grabowicec Interfluves), Pagóry Chełmskie (Chełm Hills), Padół Zamojski (Zamość Depression), Grzęda Sokalska (Sokal Ridge), Grzęda Hrubieszowska (Hrubieszów Ridge), Wzniesienia Urzędowskie (Urzędów Heights). These areas are poorly industrialized and extensive farming is often used in fields. This favors the occurrence of weeds sensitive to herbicides and intensive farming, which includes species considered to be rare and endangered at the regional and national levels. Nevertheless, many species have disappeared irretrievably from our fields. The study of Fijałkowski [25] showed that during the post-war period until 1993, most of the rare species decreased their abundance by 90% (Tab. 6). Among those

Tab. 6 Number of locations, abundance, and loss of abundance of rare weed species in segetal habitats in the Lublin region during the period 1983–1993 [25].

	Number of locations	Abundance of species	Loss of abundance
Adonis aestivalis L.	2	5	1
Agrostemma githago L.	5	3	1
Anagallis foemina Mill.	3	4	1
Anthemis tinctoria L.	3	2	3
Camelina sativa (L.) Crantz	2	1	2
Caucalis platycarpos L.	2	2	1
Chaenorhinum minus (L.) Lange	2	3	1
Euphorbia exigua L.	4	3	3
Fumaria vaillantii Loisel.	3	3	1
Galium tricornutum L.	4	3	2
Lathyrus tuberosus L.	4	3	3
Muscari comosum (L.) Mill.	2	1	1
Neslia paniculata (L.) Desv.	3	1	1
Sherardia arvensis L.	5	3	2
Stachys annua (L.) L.	4	4	1
Thlaspi perfoliatum L.	5	3	2
Thymelaea passerina (L.) Coss. & Germ.	3	1	3
Valerianella dentata (L.) Pollich	3	2	1
Veronica agrestis L.	3	2	2
Veronica polita Fr.	5	5	3

species, *Veronica polita* occurred in greatest numbers during the period 1983–1993. In 1998, Fijałkowski and Nycz [47] published a list of 95 species with different degrees of endangerment, in which the following 12 species were classified as extinct or probably extinct: *Adonis flammea*, *Alopecurus myosuroides*, *Bromus arvensis*, *Cuscuta epilinum*, *Geranium molle*, *Kickxia elatine*, *Misopales orontium*, *Myosotis discolor*, *Ornithogalum umbellatum*, *Orobanche lutea*, *O. ramose*, and *Saxifraga tridactylites*. When conducting their research during the period 2005–2010, Haliniarz and Kapeluszny [24] found 29 species from the list of Fijałkowski and Nycz [47] to be present in agrophytocoenoses of the Lublin region. *Consolida regalis*, *Veronica agrestis*, *Bromus secalinus*, and *Lathyrus tuberosus* occurred in greatest numbers, but these taxa were classified as species of indeterminate status in the region. The following weeds were classified as threatened with extinction: *Melandrium noctiflorum*, *Stachys annua*, *Thlaspi perfoliatum*, *Conringia orientalis*, *Muscari comosum*, *Erysimum cheiranthoides*, and *Anthemis tinctoria*.

The analysis made under this study, conducted during the periods 1997–2003 and 2005–2015, revealed that in recent years as many as five species classified as rare increased their constancy in crop fields of the Lublin region (Tab. 7). In both study periods, *Fumaria vaillantii* exhibited the highest degree of constancy (respectively, S = II and S = III). Over the period 2005–2010, *Anagallis foemina*, *Chaenorhinum minus*, *Euphorbia exigua*, and *Sherardia arvensis* were also encountered more frequently. On the other hand, 10 species maintained their phytosociological constancy at an unchanged level. During the other study period, all rare weeds found in the period 1997–2003 were recorded. When carrying out this study, no species classified by Fijałkowski and Nycz

Tab. 7 Degrees of constancy (S) of rare weed species of segetal habitats in 1997–2003 and 2005–2015 in the Lublin region (original data).

Species	1997–2003	2005–2015
Adonis aestivalis L.	I	I
Agrostemma githago L.	I	I
Anagallis foemina Mill.	I	II
Anthemis tinctoria L.	I	I
Camelina sativa (L.) Crantz	I	I
Caucalis platycarpos L.	I	I
Chaenorhinum minus (L.) Lange	I	II
Euphorbia exigua L.	I	II
Fumaria vaillantii Loisel.	II	III
Galium tricornutum L.	I	I
Lathyrus tuberosus L.	II	II
Muscari comosum (L.) Mill.	I	I
Neslia paniculata (L.) Desv.	II	II
Sherardia arvensis L.	I	II
Stachys annua (L.) L.	I	I
Thlaspi perfoliatum L.	I	I
Thymelaea passerina (L.) Coss. & Germ.	I	I
Valerianella dentata (L.) Pollich	I	I
Veronica agrestis L.	I	I
Veronica polita Fr.	I	I

[47] as extinct or probably extinct (Ex) were found, but based upon information provided by individual farmers, *Alopecurus myosuroides* accompanies crops in the Lublin region more and more frequently. It should be stressed that in this region there are several permanent locations of occurrence of *Muscari comosum*, a strictly protected species [48]. Moreover, the following unique species: *Adonis aestivalis*, *Anthemis tinctoria*, *Caucalis platycarpos*, *Galium tricornutum*, *Thymelaea passerina*, can be found on heavy rendzinas of the Lublin region.

Cwener et al. [46] published the "Red list of vascular plants for the Lublin region", in which many segetal species were included. These authors estimated that in crop fields, calciphilous plant species in cereal crops are most endangered and the flora of these habitats should be afforded special protection.

Conclusion

The Lublin region has very favorable conditions for agricultural production and is one of the main agricultural regions in Poland. According to the Institute of Soil Science and Plant Cultivation, the agricultural production space valuation ratio is higher by 7.5 points than the national average, which ranks the Lublin region third in Poland. Despite very favorable environmental conditions in this region, the level of fragmentation of individual farms found here is one of the highest in Poland. Cereals are predominant in the crop structure of these farms, especially wheat. The Lublin region is among the leaders in Poland in the cultivation of edible legumes and sugar beet. As experienced in the whole country, changes in production technologies have resulted in significant changes in the floristic diversity of agrophytocoenoses. In recent years, the following have been the dominant weed species in the region's crop fields: *Galium aparine*, *Convolvulus arvensis*, *Papaver rhoeas*, *Viola arvensis*, *Veronica persica*. In spite of the fact that during the post-war period the abundance of many weed species has significantly decreased, many taxa considered to be rare or endangered at the national level can be found in Lublin Province. Fragmented farms with extensive agronomic practices are accompanied by high diversity of segetal communities and will probably remain similar to today's level over the next several decades.

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Streszczenie

Różnorodność agrocenoz Lubelszczyzny

Lubelszczyzna jest jednym z głównych regionów rolniczych w Polsce, posiadających bardzo korzystne warunki do produkcji rolniczej. Rozwój sektora rolnego zachodzi tu jednak bardzo powoli, co jest spowodowane, między innymi, ekstensywnym gospodarowaniem na znacznych obszarach, a także rozdrobnieniem gospodarstw. W województwie lubelskim w strukturze zasiewów dominują zboża, a zwłaszcza pszenica, ale często uprawia się również kukurydzę, rzepak, buraki cukrowe oraz strączkowe jadalne. Gatunkom rolniczym towarzyszą chwasty segetalne, czasem bardzo ekspansywne, a czasami rzadkie i zagrożone wyginięciem. W ostatnich latach gatunkami chwastów dominującymi na polach uprawnych regionu były: *Galium aparine*, *Convolvulus arvensis*, *Papaver rhoeas*, *Viola arvensis* i *Veronica persica*. Występuje kilka stanowiska unikalnych gatunków, takich jak: *Muscari comosum* (objęty ścisłą ochroną), *Adonis aestivalis*, *Anthemis tinctoria*, *Caucalis platycarpos*, *Galium tricornutum* i *Thymelaea passerina*. Na Lubelszczyźnie jest wiele gospodarstw ekologicznych, w których często uprawia się stare, tradycyjne gatunki i odmiany roślin uprawnych, wzbogacające różnorodność agrocenoz. W tej pracy wskazujemy także na biocenotyczną rolę chwastów oraz ich znaczenie w prawidłowym utrzymaniu agroekosystemów (usługi ekosystemowe).