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FLORA OF XEROTHERMIC SITES OF THE ZACHODNIOWOŁYŃSKA DOLINA BUGU SPECIAL AREA OF CONSERVATION (EASTERN POLAND): THE INFLUENCE OF HABITAT ON RARE GRASSLAND SPECIES

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Abstract - The aim of the investigation was to study the flora of grasslands within the Zachodniowołyńska Dolina Bugu Special Area of Conservation and to identify the types of habitats with the highest concentration of grassland species. In the years 2011-2012, floristic analyses covered the slopes of the valley of the Bug river, balks and places of shallow bedrock deposition, roadsides, as well as railway and earthwork sites. One hundred and fifty eight plant species belonging to 37 families were found. Though considered extinct in Polish flora, *Dianthus collinus* subsp. *glabriusculus* was discovered. Close to half of the recorded species (47%) were grassland taxa and 15% rare and/or protected plants, which make the studied area particularly valuable for the conservation of biodiversity. The fewest grassland plants occurred on habitats that are under the influence of agriculture, where the dominance of nitrophilous and herbicide resistant plant species was observed.

Key words: Agricultural intensification, agricultural landscape, conservation of biodiversity, *Dianthus collinus* subsp. *glabriusculus*, edge effects, grasslands, rare and protected plants, xerothermic habitats, Poland

INTRODUCTION

Central European grasslands are extrazonal communities developing on sites with specific microclimatic and edaphic conditions. The richest grassland species occur on soils rich in calcium carbonate, developed especially in the Cretaceous limestone and loess substrate (Ruprecht et al., 2007; Dúbravková et al., 2010; Piqueray et al., 2011). Apart from typical xerothermic plants, grasslands also consist of meadow and forest species, characterized by broad ecological amplitudes (Rupert et al., 2007; Dúbravková et al., 2010; Piqueray et al., 2011). Patches of steppe vegetation scattered in agricultural landscape generally have a secondary character. They have developed on difficult-to-cultivate, steep and warm slopes along river valleys or areas of shallow bedrock deposition, which were previously used as pastures or hay meadows (Karlík and Poschlod, 2009). In addition, scattered and less abundant patches of thermophilous species are often found on the slopes of ravines, fallows, abandoned vineyards and on balks (Smart et al., 2002; Matus et al., 2003; Ruprecht et al., 2007; Malatisszky et al., 2008; Woch, 2011; Babczyńska-Sendek et al., 2012), as well as along transport routes, sometimes also in sparse forests (McCollin et al., 2000; Tikka et al., 2001; Stenmark, 2011). The significant continental climatic conditions and presence of Cretaceous limestones and loess makes the Western Wolhynia Upland one of the areas with the highest number of the most valuable xerothermic grasslands in Poland. The far eastern geographical location determines the grasslands' share of species of the Pontic-

Pannonian type. Some of them have on this area the only stands in the country.

The Zachodniowołyńska Dolina Bugu Special Area of Conservation (Zachodniowołyńska Dolina Bugu Natura 2000 site), with an area of 1 556.1 ha, was established mainly to protect a region of the Bug River valley with its unique sites of oxbow lakes, humid meadows, riparian forests and steep loess slopes inhabited by grasslands (Barańska et al., 2010). Of the works concerning that region that have been published so far, the first was a description of plant communities of the proposed nature reserve by Fijałkowski (1957). Further information on the occurrence of rare plant species in the studied area is contained in several other works by Fijałkowski (1962, 1963, 1964, 1966) and Fijałkowski and Izdebski (1957), which were included in Flora of the Vascular Plants of Lublin (Fijałkowski, 1995) in a synthetic form. The vegetation of the studied areas was also mentioned in works addressing various botanical issues (Kucharczyk and Wójciak, 1995; Fijałkowski and Romer, 1999). Some plant associations found in the studied region have been described in the work by Trąba (2010). These areas are also sometimes mentioned on lists of stands of some species, e.g. *Echium russicum* (Dąbrowska et al., 1997; Chmielewski, 2007; Chmielewski et al., 2011), *Iris aphylla* (Dabrowska et al., 1998) and *Chamaecytisus albus* (Przemyski and Piwowarski, 2009). A full floristic study of all xerothermic habitats that takes into account the impact of the slope parts of the Bug valley on the frequencies of species, as well as their presence in other xerothermic habitats, such as balks, roadsides and facilely laid bedrocks, is lacking. The purpose of the research was the analysis of occurrence patterns of plant species within grassland sites, with a particular focus on rare xerothermic taxa and indication of places of their highest concentration.

MATERIALS AND METHODS

Research area

The studied area (50°48’25”N, 23°57’24”E) is located about 4.5 km east of the Hrubieszów city in the vicinity of the Czumów and Gródek villages (Fig. 1). According to the Kondradzki physicogeographical classification (2009), the research area is within the mezoregion of the Hrubieszów Basin, the western part of the macroregion Wolhynia Upland. Relative heights range within the limits of 200-240 m above sea level. In terms of geological formations, the upper Cretaceous sediments, on which small patches of tertiary formations occur, dominate. The entire surface is overlaid by quaternary formations of high thickness loess or loess-like sandy-silty formations (Kondracki, 2009).

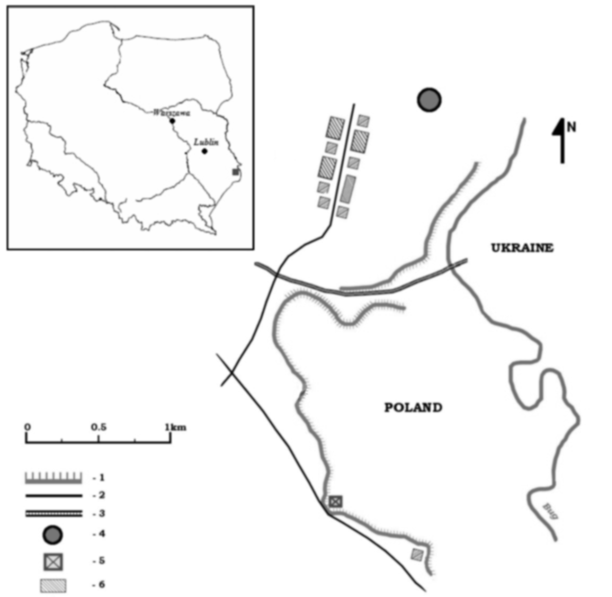

Fig. 1. Study site: 1 – scarps of the Bug River valley; 2 – roads; 3 – the railway line LHS; 4 – the medieval earthwork in Gródek; 5 – a observation tower; 6 – settlements.

Xerothermic grasslands have developed on substrates rich in calcium carbonate such as marl, limestone and loess, which are characterized by little rain absorption and low permeability of underground water. Therefore, the strongly drying-up and setting soils on the slopes during the summer are able to effectively saturate with water only during the long rain. Xerothermic habitats, situated on the steep, high scarps of the Bug River valley (ca. 4 km long), whose southern arm is attached to the Czumów village and northern arm to the Gródek village, prevail. The occurrence of xerothermic habitats in direct contact with the wetlands at the foot of the slopes on the Bug River flood plain and the farmlands located above is specific to them. The scarps are characterized by a large morphological variability. Exposition of the slopes is mainly southeast, and the inclination reaches 50°. On the south side, slopes are low and gradually increase to ca. 30 m, in the central part they lower, and then rise again, reaching their highest elevation about 35 m from Gródek. At the foot of the slopes the wide Bug River valley stretches, generally covered with the riparian forests "Królewski Kąt". Approximately 100 m from the studied sites are two hard roads (one local linking Hrubieszów to Dołhobyczów and a much smaller one running through the village of Gródek) and several smaller dirt roads. There is also a frontier crossing of the railway line LHS, which runs across the slopes of valley (Fig. 1).

Climate

The tested sites are under the influence of a temperate climate, with a significant impact of continental conditions. The climate is characterized by a long and warm summer and long and frosty winter, considerable insolation and the dominance of eastern winds. Sunny warm days are more frequent and cloudy and rainy days are rare in comparison to other regions of Poland. The annual average temperature is 7.2°C-7.3°C; the coldest month is January (-4.2°C) and the warmest July (17.7°C). The average annual amount of precipitation for the years 1956-1995 was 533 mm/yr. The driest months are January and February (25-30 mm/month), and the wettest are June and July (90 mm/month). Snow cover persists for 80-90 days per year. The duration of the vegetation period amounts to about 210-220 days; it usually begins in the first decade of April and ends in the third decade of October (Patkowski, 1999; Woś, 1999).

Plant cover

According to the geobotanical regionalization of Poland (Matuszkiewicz, 1993), the studied area lies in the Hrubieszów Subdivide, a part of the Wolhynia Divide. The potential natural vegetation of the study sites according to Matuszkiewicz (1995) are *Tilio-Carpinetum* (subcontinental colline lime-oak-hornbeam forest, Wolhynia-vicariant) and *Potentillo albae-Quercetum rosetosum gallicae* (thermophilous oak forest of upland-type). In particularly arid and warm sites, potential vegetation are communities belonging to the *Festucetalia valesiacae* order (the natural and semi-natural xero- and calciphilous grasslands).

Forms of protection

Since 1960 some of the most valuable parts of the slopes have been protected as a natural monument to a total area of 0.27 ha, and since 1997 as the Błonia Nadbużańskie ecological use area (Fijałkowski, 1996; Barańska et al., 2010). These areas have been also included in the Natura 2000 network as the Zachodniowołyńska Dolina Bugu Special Area of Conservation PLH060035. A plan to create a reserve on the site of the environmental use area was unsuccessful (Kucharczyk, 2004). Moreover, 2.46 ha of the area have been covered by the program of active conservation treatments (i.e. removal of shrubs, trees and their seedlings, mowing, controlled burning and pasturing, removal of the top layer of soil and *Echium russicum* reintroduction) (Barańska et al., 2010; Cwener and Chmielewski, 2010; Trąba, 2010).

Floristic research

In this investigation, the plant species composition of xerothermic habitats (20 ha in total) was investigated on several types of habitats: loess scarps of the valley of the Bug River: 1) the upper parts of scarps under the impact of agriculture (U); 2) the central part of scarps (S); 3) the lower parts of the slopes with contact with the meso- and hygrophilous biotopes of the valley bottoms (D); 4) the area of medieval earthwork in Gródek (Gr); 5) balks and places of shallow bedrock deposition (M); 6) roadsides (P).

The research was conducted from June to October 2011; supplementary lists were made in the

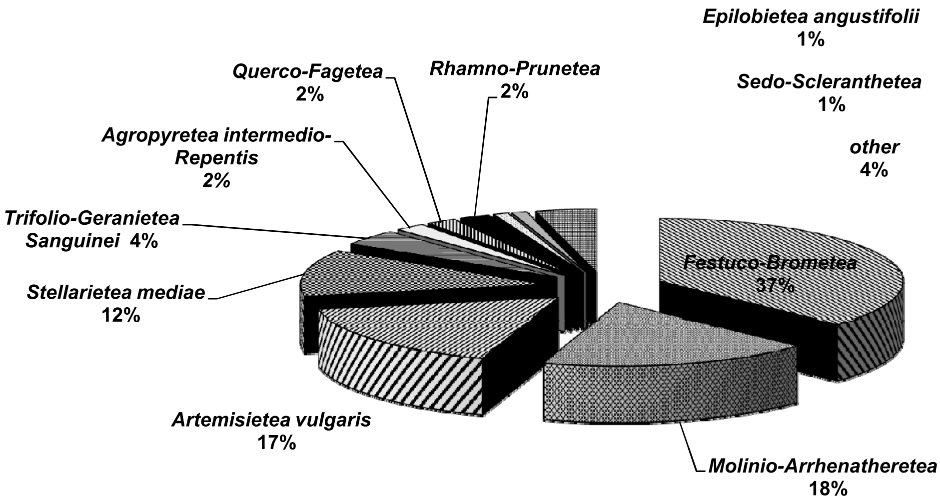

Fig. 2. Types of communities (%): other – *Alnetea glutinosae, Koeleria glauca-Corynephorus canescens* and *Thlaspietea rotundifolii* represented by 1 species (4% total).

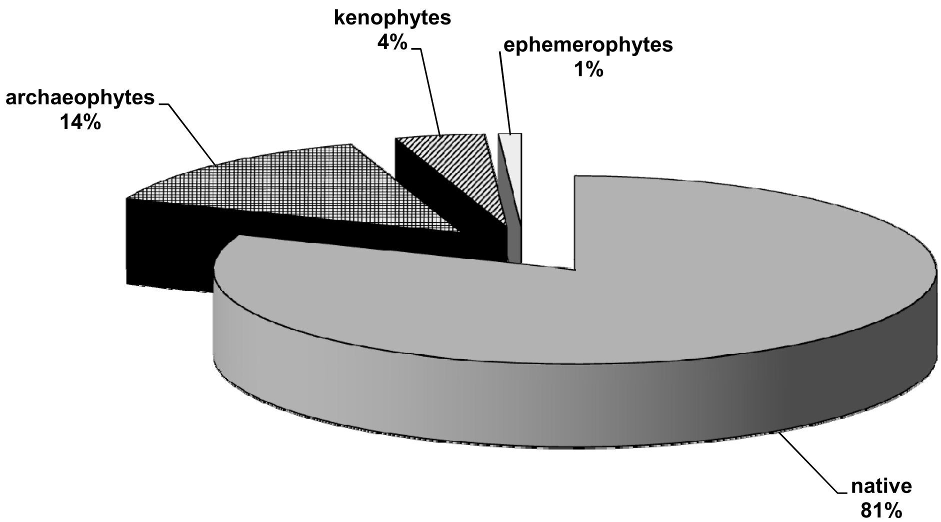

Fig. 3. Geographic-historical classification (%).

spring of 2012. The Latin plant nomenclature follows Rutkowski (2004). Protected and rare taxa were singled out based on the latest Ordinance of the Minister of the Environment for the protection of plant species (Ordinance of the Minister of the Environment of 05.01.2012 on the Protection of Plant Species) and posted in the Polish Red Book of Vascular Plants (RB) (Kaźmierczakowa and Zarzycki, 2001) and the Red List of Plants and Fungi in Poland (*CL*) (Mirek et al., 2006). While analyzing the flora, species frequency, share of geographical and historical groups, as well as share of life forms according to Rankiauer, were taken into account (Zarzycki et al., 2002; Rutkowski, 2007). In addition, communities of the most frequent occurrence were listed (Matuszkiewicz, 2006). For selected rare and protected species, short characteristics of their populations and sites of occurrence were included; the sites are also indicated

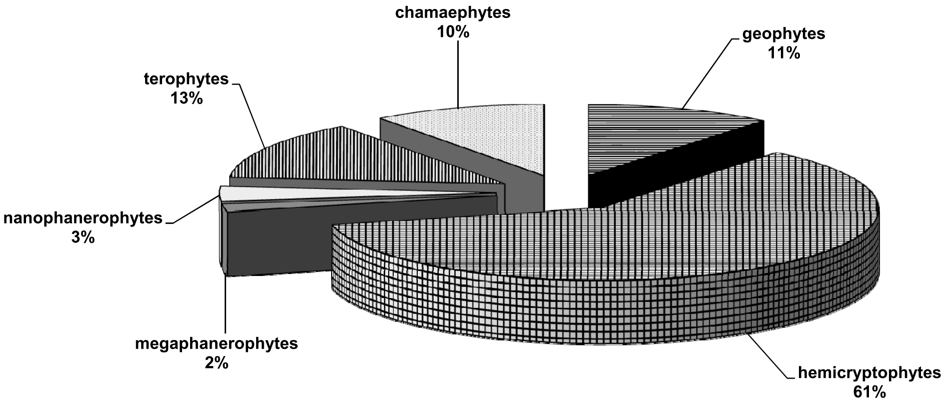

Fig. 4. Living forms from Raunkiaer (%).

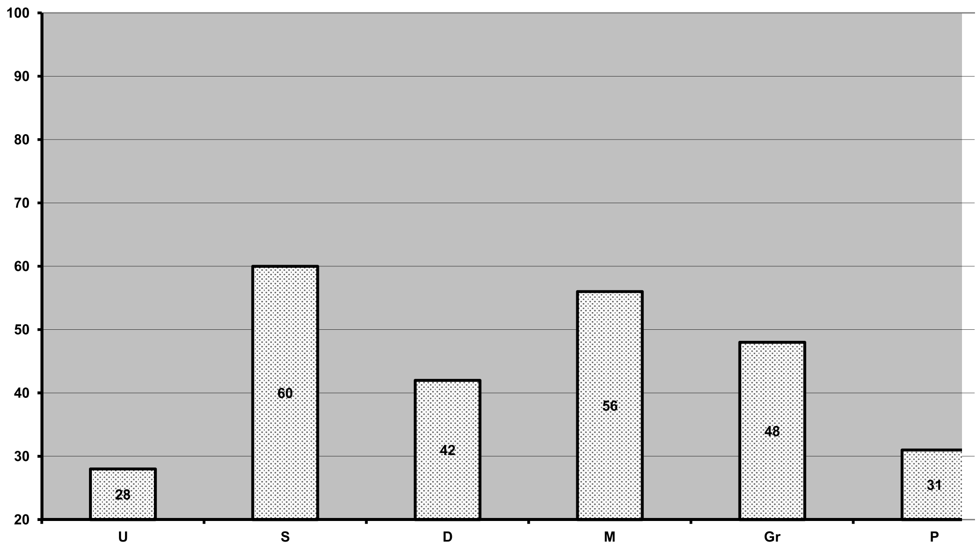

Fig. 5. The share of grassland species in several types of habitats (%): Loess scarps of the valley of the Bug river: U – upper parts of scarps being under the impact of agriculture; S – central part of scarps; D – the lower parts of the slopes contacting with the meso- and hygrophilous biotopes of the valley bottoms; Gr – the area of medieval earthwork in Gródek; M – balks and places of shallow bedrock deposition; P – roadsides.

on maps. Herb documentation has been deposited in the Herbarium of Vascular Plants of the Pedagogical University of Cracow (KRAP).

RESULTS

In the approximately 20 ha area of the studied Czumów and Gródek grasslands, 158 species of plants representing 37 families were reported (Table 1). The highest number of species belonged to Compositae (24 species) and Fabaceae (20), followed by Labiateae (14), Poaceae (9) and Rosaceae (9). Also numerous were Caryophyllaceae (8), Scrophulariaceae (7), Ranunculaceae (6), Boraginaceae (6), Cruciferae (6), Apiaceae (5) and Campanulaceae (5). Some families were represented by 2 or 3 species: Rubiaceae (3), Alliaceae (2), Asparagus (2), Dipsacaceae (2), Euphorbiaceae (2), Geraniaceae (2), Malvaceae (2), Orobanchaceae (2), Papaveraceae (2), Plantaginaceae (2), the Polygonaceae (2), Primulaceae (2) and Violaceae

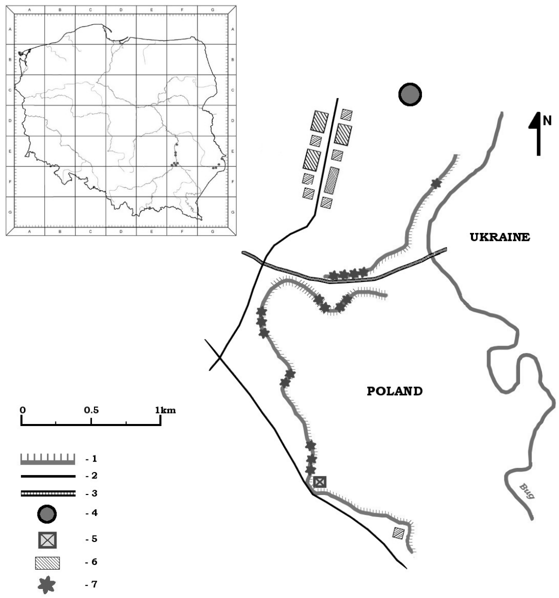

Fig. 6. Sites of occurrence on the study area and range in Poland of *Achillea setacea.*

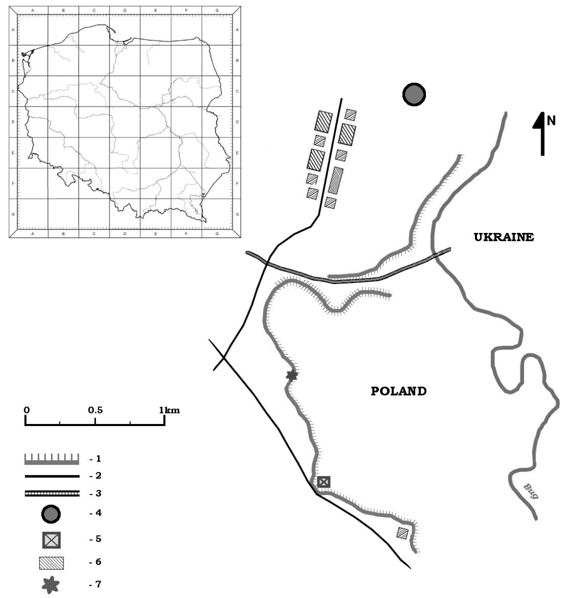

Fig. 8. Site of occurrence on the study area of *Dianthus collinus* subsp. *glabriusculus.*

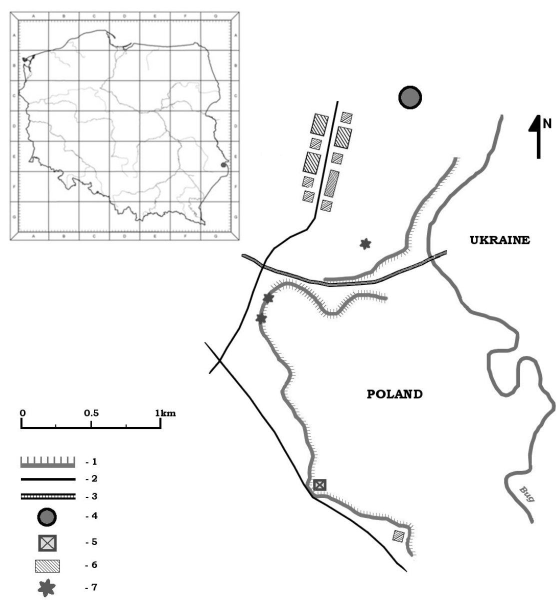

Fig. 7. Sites of occurrence on the study area and range in Poland of *Chamaecytisus albus.*

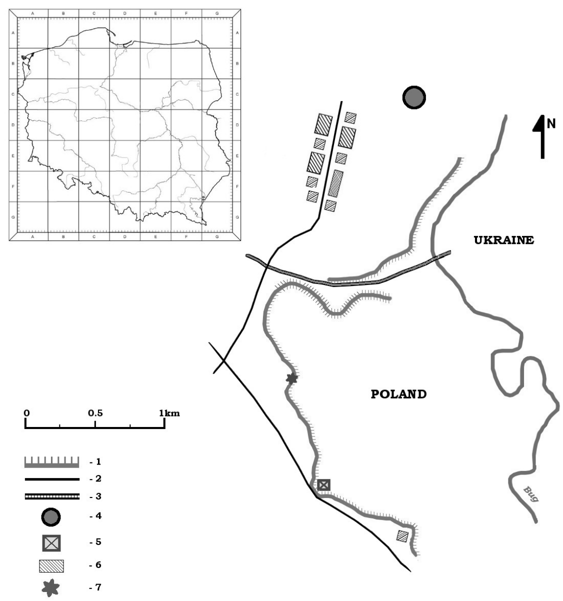

Fig. 9. Sites of occurrence on the study area and range in Poland of *Echium russicum*.

(2). Single species belonged to families: Apocynaceae, Chenopodiaceae, Convolvulaceae, Crassulaceae, Cucurbitaceae, Cyperaceae, Equisetaceae, Hypericaceae, Gentianaceae, Santalaceae, Solanaceae and Urticaceae.

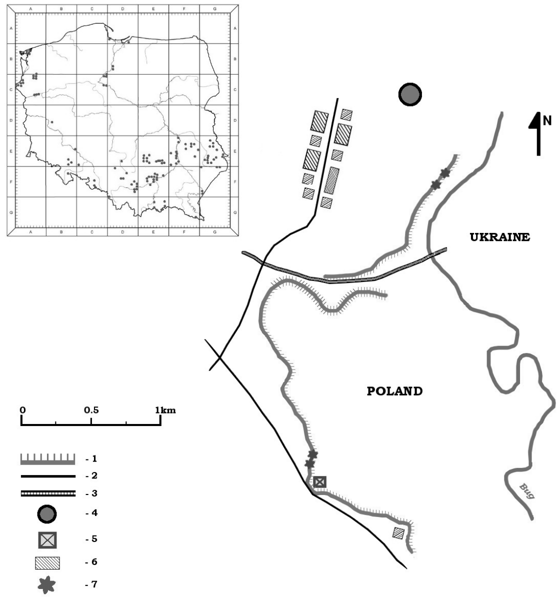

Fig. 10. Sites of occurrence on the study area and range in Poland of *Gypsophila paniculata.*

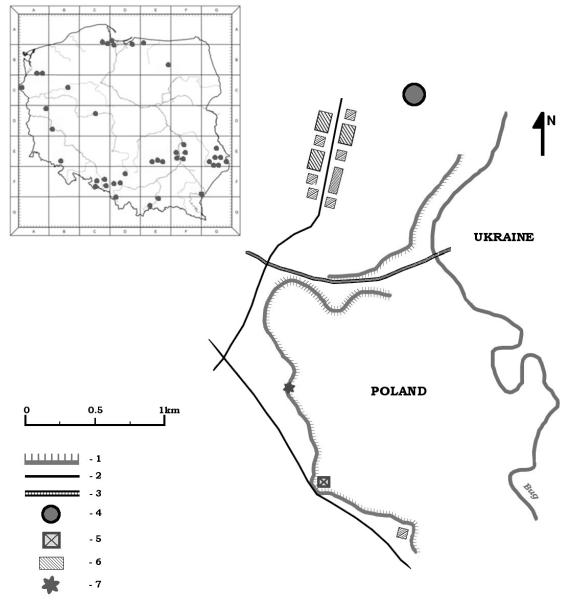

Fig 12. Sites of occurrence on the study area and range in Poland of *Orobanche elatior.*

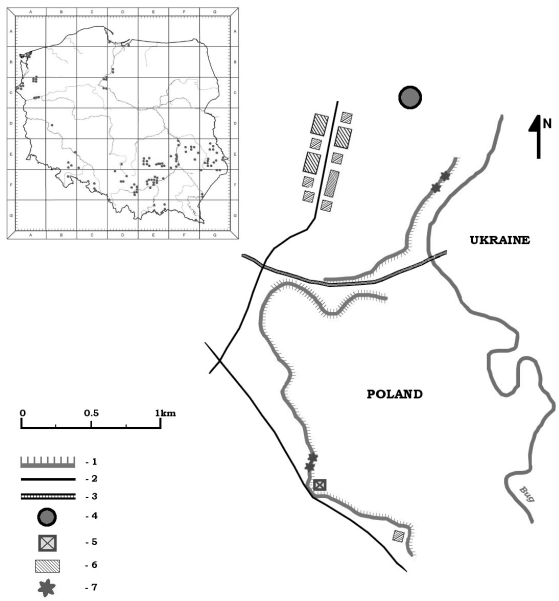

Fig. 11. Sites of occurrence on the study area and range in Poland of *Orobanche caryophyllacea.*

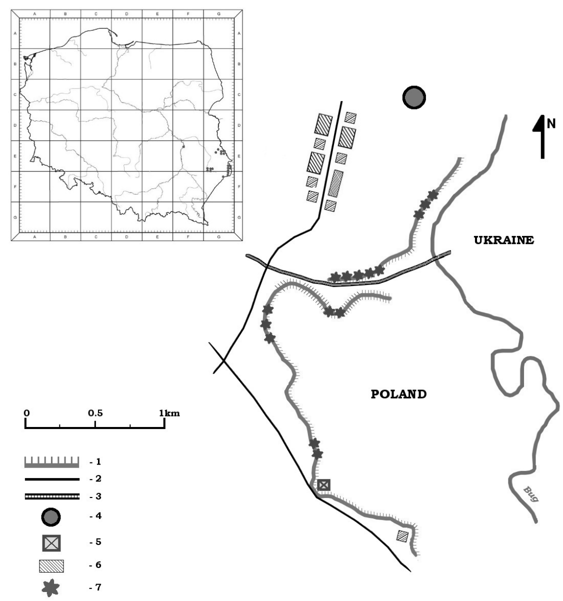

Fig. 13. Sites of occurrence on the study area and range in Poland of *Peucedanum alsaticum*

Most recorded species represented communities of *Festuco-Brometea* class (37%), as well as *Molinio-Arrhenatheretea* (18%), *Artemisietea vulgaris* (17%) and *Stellarietea mediae* (12). Some species belonged to the classes *Trifolio-Geranietea sanguinei* (4%), *Agropyretea intermedio-repentis* (2%), *Querco-*

Table 1. List of vascular plant species occurring in the study area.

Species	No of records	The most frequent habitat	Form	Status	Vegetation type	Remarks
Achillea millefolium	16	U, D, M, Gr, P	H	R	*Mol.-Arr.*	
Achillea pannonica	36	U, S, D, M, Gr, P	H	R	Fest.-Brom.	
Achillea setacea	17	S	H	R	*Fest.-Brom.*	RL
Acinos arvensis	17	S, D	H, T	R	*Fest.-Brom.*	
Adonis vernalis	14	S	H	R	*Fest.-Brom.*	SP, PCKR, RL
Alchemilla monticola	37	D	H	R	*Mol.-Arr.*	
Allium angulosum	3	U	G	R	*Mol.-Arr.*	RL
Allium oleraceum	26	S, U	G	R	*Fest.-Brom.*	
Alopecurus pratensis	37	S, D, M	H	R	*Mol.-Arr.*	
Anchusa officinalis	4	P	H	A	*Artem.*	
Anthericum ramosum	6	S	G	R	*Fest.-Brom.*	
Arctium lappa	4	P, U, M	H	R	*Artem.*	
Artemisia absinthium	11	S, U, P	Ch	A	*Artem.*	
Artemisia campestris	45	P, U, S	Ch	R	*Fest.-Brom.*	
Artemisia vulgaris	52	P, U, D	Ch	R	*Artem.*	
Asparagus officinalis	12	S	G	A	*Fest.-Brom.*	
Asperula cynanchica	9	U, S, D, M	H	R	*Fest.-Brom.*	
Aster amellus	20	S	H	R	*Fest.-Brom.*	SP
Astragalus cicer	14	D	H	R	*Trif.-Ger.*	
Astragalus danicus	27	S, D	H	R	*Fest.-Brom.*	
Avenula pratensis	48	S, Gr	H	R	*Fest.-Brom.*	
Ballota nigra	23	U, S	Ch, T	A	Artem.	
Bellis perennis	62	P, Gr, S	H	R	*Mol.-Arr.*	
Berteroa incana	17	P, Gr	H, T	R	*Artem.*	
Brachypodium pinnatum	68	U, S, D, P, Gr, M	H	R	*Fest.-Brom.*	
Calamagrostis epigejos	51	U, S, D, P, Gr, M	G, H	R	*Epil. ang.*	
Campanula bononiensis	34	S	H	R	*Fest.-Brom.*	SP
Campanula glomerata	3	D	H	R	*Fest.-Brom.*	
Campanula patula	4	D	H	R	*Mol.-Arr.*	
Campanula persicifolia	10	S	H	R	*Fest.-Brom.*	
Campanula sibirica	21	S	H	R	*Fest.-Brom.*	SP
Capsella bursa-pastoris	41	P, U, D, D, Gr	H, T	A	*Mol.-Arr.*	
Carduus acanthoides	21	P, S, U	H	A	*Artem.*	
Carex praecox	43	S, D, P	G, H	R	*Mol.-Arr.*	RL
Centaurea cyanus	18	U	T	A	*Stel. med.*	
Centaurea jacea	59	S, U, D	H	R	*Mol.-Arr.*	
Centaurea scabiosa	56	S, M, P, Gr	H	R	*Fest.-Brom.*	
Centaurea stoebe	42	S, P, Gr	H	R	*Fest.-Brom.*	
Cerastium arvense	15	P, G	Ch	R	*Agrop. int.-rep.*	

Table 1. *Continued*

Species	No of records	The most frequent habitat	Form	Status	Vegetation type	Remarks
Cerasus fruticosa	2	S, M	N	R	*Rham.-Prun.*	SP, PCKR, RL
Chamaecytisus albus	8	S, M	Ch, N	R	*Fest.-Brom.*	SP, PCKR, RL
Chamaecytisus ruthenicus	34	S	Ch, N	R	Fest.-Brom.	
Chelidonium majus	18	P	H	R	*Artem.*	
Chenopodium album	43	U, S	T	R	*Stel. med.*	
Cichorium intybus	14	U, P, Gr	H	A	*Artem.*	
Cirsium arvense	47	P, S, U, M, Gr	G	R	*Artem.*	
Clematis recta	7	S	H	R	*Trif.-Ger.*	SP
Conium maculatum	40	U, S, P	H, T	A	*Artem.*	
Consolida regalis	22	U	T	A	*Stel. med.*	
Convolvulus arvensis	53	U, P, D, S, Gr, M	G, H	R	*Agrop. int.-rep.*	
Coronilla varia	28	S, Gr	H	R	*Trif.-Ger.*	
Crataegus monogyna	9	S, M, U, D	N, M	R	*Rham.-Prun.*	
Crepis biennis	31	D, P, Gr	H	R	*Mol.-Arr.*	
Cruciata glabra	8	D, Gr	H	R	*Que.-Fag.*	
Dactylis glomerata	33	U, S, D, P, Gr, M	H	R	*Mol.-Arr.*	
Descurainia sophia	33	U, S	T	A	*Stel. med.*	
Dianthus carthusianorum	51	S, Gr	Ch	R	*Fest.-Brom.*	
D. collinus subsp. glabriusculus	1	S	Ch	R	*Fest.-Brom.*	PCKR, RL
Echinocystis lobata	18	D, U, P	T	K	*Artem.*	
Echium russicum	5	S	H	R	*Fest.-Brom.*	SP, PCKR, RL
Echium vulgare	7	U, P, S	H	A	*Artem.*	
Elymus hispidus	48	U, S, D, P, Gr, M	G	R	Agrop. int.-rep.	
Elymus repens	63	U, S, D, P, Gr, M	G	R	*Agrop. int.-rep.*	
Equisetum arvense	26	D	G	R	*Agrop. int.-rep.*	
Erigeron annuus	19	P, U, S, D	H	K	*Artem.*	
Eryngium planum	19	S, M	H	R	*Fest.-Brom.*	
Euphorbia cyparissias	47	U, S, D, P, M	H, G	R	*Fest.-Brom.*	
Euphorbia esula	22	U, S	H	R	*Fest.-Brom.*	
Falcaria vulgaris	51	P, S, Gr	H	R	*Fest.-Brom.*	
Fallopia convolvulus	44	U, P, S,	T	A	*Stel. med.*	
Festuca ovina	52	U, S, D, P, Gr, M	H	R	*Sed.-Scl.*	
Festuca rubra	54	U, S, D, P, Gr, M	H	R	*Mol.-Arr.*	
Ficaria verna	19	U, Gr	G	R	*Que.-Fag.*	
Filipendula vulgaris	38	S, Gr	H	R	*Fest.-Brom.*	
Fragaria vesca	18	U, P	H	R	*Epil. ang.*	
Galium aparine	69	U, S, D, P, Gr, M	T, H	R	*Artem.*	
Galium verum	43	P, U, D, S, Gr, M	H	R	*Fest.-Brom.*	
Gentiana cruciata	3	D	H	R	*Fest.-Brom.*	SP
Geranium phaeum	2	S	H	R	*Que.-Fag.*	

Table 1. *Continued*

Species	No of records	The most frequent habitat	Form	Status	Vegetation type	Remarks
Geranium pratense	13	D	H	R	*Mol.-Arr.*	
Glechoma hederacea	15	P, D	G, H	R	*Artem.*	
Gypsophila paniculata	6	U, S, D	Ch	R	*Sed.-Scl.*	SP
Hypericum perforatum	31	S, P, Gr	H	R	*Artem.*	
Inula ensifolia	18	D	H	R	*Fest.-Brom.*	
Knautia arvensis	42	S, D, Gr, P	H	R	*Fest.-Brom.*	
Lathyrus pratensis	19	U, S, D, Gr	H	R	*Mol.-Arr.*	
Lavatera thuringiaca	32	U, S, D, P, M	H	R	*Fest.-Brom.*	
Leonurus cardiaca	20	P, S, M	H	K	*Artem.*	
Linaria vulgaris	16	P, S, U	G	R	*Artem.*	
Lychnis flos-cuculi	22	D	H	R	*Mol.-Arr.*	
Malva sylvestris	2	P	H	A	*Artem.*	
Medicago falcata	61	S, P, Gr	H	K	*Trif.-Ger.*	
Medicago lupulina	34	U, P, S, D	H, T	R	*Artem.*	
Medicago sativa	7	S, Gr	H	K	*Mol.-Arr.*	
Melandrium album	42	P, G	T	R	*Artem.*	
Melilotus alba	27	P, S	H, T	A	*Artem.*	
Melilotus officinalis	6	U,S, D, P	H, T	A	*Artem.*	
Mentha arvensis	6	D	Ch, H	R	*Stel. med.*	
Myosotis arvensis	40	P, U, S, Gr	T, H	A	*Stel. med.*	
Nepeta pannonica	1	U	Ch, H	R	*Fest.-Brom.*	RL
Nonea pulla	1	S	H	R	*Fest.-Brom.*	
Ononis arvensis	8	M, S	N, H	R	*Fest.-Brom.*	PP
Onopordum acanthium	8	P, S, M, U	H	A	*Artem.*	
Origanum vulgare	40	U, D, S, Gr, M	Ch, H	R	*Trif.-Ger.*	
Orobanche caryophyllacea	4	S	G	R	*Fest.-Brom.*	SP
Orobanche elatior	1	D	G	R	*Fest.-Brom.*	SP
Oxytropis pilosa	2	S	H	R	*Fest.-Brom.*	SP
Papaver rhoeas	26	U, S	T	A	*Stel. med.*	
Peucedanum alsaticum	15	S	H	R	*Trif.-Ger.*	RL
Plantago lanceolata	21	S, D	H	R	*Mol.-Arr.*	
Plantago major	26	S, M, Gr, P	H	R	*Mol.-Arr.*	
Polygonum bistorta	27	D	G, H	R	*Mol.-Arr.*	
Potentilla reptans	13	P	H	R	*Mol.-Arr.*	
Primula veris	43	S, D, Gr	H	R	*Que.-Fag.*	PP
Prunella vulgaris	40	S, D, Gr	H	R	*Mol.-Arr.*	
Ranunculus acris	8	D	H	R	*Mol.-Arr.*	
Rhinanthus angustifolius	3	S	T	R	*Mol.-Arr.*	
Robinia pseudoacacia	9	U, D, S	M	K	*Rham.-Prun.*	

Table 1. *Continued*

Species	No of records	The most frequent habitat	Form	Status	Vegetation type	Remarks
Rosa canina	11	S, Gr	N	R	*Rham.-Prun.*	
Rubus caesius	49	D	N, Ch	R	*Artem.*	
Salvia nemorosa	5	P, S	H	R	*Fest.-Brom.*	
Salvia pratensis	59	S, D, Gr	H	R	Fest.-Brom.	
Salvia verticillata	33	S, D	H	R	*Fest.-Brom.*	
Sanguisorba officinalis	1	D	H	R	*Mol.-Arr.*	
Scabiosa ochroleuca	36	S, D, Gr, P	H	R	*Fest.-Brom.*	
Sedum maximum	2	S, P	G, H	R	*Fest.-Brom.*	
Senecio jacobea	40	S, M	H	R	*Fest.-Brom.*	
Sisymbrium officinale	23	P, S. Gr	T	A	*Stel. med.*	
Sisymbrium orientale	1	Gr	T	Ef	*Stel. med.*	
Sisymbrium volgense	1	Gr	H	K	*Stel. med.*	
Solanum dulcamara	10	D	Ch	R	*Alnet. glut.*	
Solidago virgaurea	23	S, D	H	R	*Thlas. rot.*	
Stachys officinalis	28	D	H	R	*Mol.-Arr.*	
Stachys recta	15	S	H	R	*Fest.-Brom.*	
Stellaria media	5	P	T	R	*Stel. med.*	
Symphytum officinale	23	D	H	R	*Alnet. glut.*	
Tanacetum vulgare	32	D, P, U	H	R	*Artem.*	
Taraxacum officinale	51	U, S, D, M, Gr, P	H	R	*Mol.-Arr.*	
Thesium linophyllon	42	S	G	R	*Fest.-Brom.*	
Thalictrum minus	52	P, S, M, Gr	H	R	*Trif.-Ger.*	
Thymus marschallianus	29	S, P, Gr	Ch	R	*Fest.-Brom.*	RL
Torilis japonica	1	Gr	T, H	R	Artem.	
Trifolium arvense	6	P	T	R	*Fest.-Brom.*	
Trifolium montanum	4	D	H	R	*Fest.-Brom.*	
Trifolium pratense	23	U, S, D, P	H	R	*Mol.-Arr.*	
Trifolium repens	28	U, S, D, P	H	R	*Mol.-Arr.*	
Urtica dioica	74	U	H	R	*Artem.*	
Verbascum chaixii subsp. austriacum	3	S	H	R	*Fest.-Brom.*	PCKR
Verbascum phlomoides	37	P, S	H	R	*Artem.*	
Verbascum phoeniceum	1	D	H	R	*Fest.-Brom.*	
Veronica chamaedrys	44	S, M, P	Ch	R	*Mol.-Arr.*	
Veronica spicata	12	S, M	Ch, H	R	*Fest.-Brom.*	
Vicia cracca	16	D	H	R	*Mol.-Arr.*	
Vicia tenuifolia	44	S, D	H, G	R	*Trif.-Ger.*	
Vincetoxicum hirundinaria	37	S, D	H	R	*Que.-Fag.*	
Viola arvensis	21	P, Gr, U	T	A	*Stel. med.*	
Viola hirta	14	U, S, D, P, M	H	R	*Fest.-Brom.*	
Viscaria vulgaris	2	S	Ch, H	R	*Fest-Brom.*	

Form – life forms from Raunkiaer: Ch – chamaephyte, G – geophyte, H – hemicryptophyte, M – megaphanerophyte, N – nanophanerophyte, T – therophyte; statute – geographic-historical classification in Polish flora: R – native species, K – kenophyte, A – archaeophyte, Ef – ephemerophyte; habitat – the most frequent habitat occupied in the study area: U – upper parts of scarps being under the impact of agriculture, S – central part of scarps, D – the lower parts of the slopes contacting with the meso- and hygrophilous biotopes of the valley bottoms, Gr – the area of medieval earthwork in Gródek, M – balks and places of shallow bedrock deposition; remarks – forms of protection and posted in red lists: SP – strictly protected, PP – partly protected, RB – Polish Red Book of Vascular Plants, CL – the Red List of Plants and Fungi in Poland.

Fagetea (2%), *Rhamno-Prunetea* (2%), *Epilobium angustifolium* (1%) and *Sedo-Scleranthetea* (1%). Some classes were represented by 1 species (4% total): *Alnetea glutinosae*, *Koeleria glauca-Corynephorus canescens* and *Thlaspietea rotundifolii* (Fig. 2). Most of the species found were native plants (81%). Among anthropophytes (19%), the most numerous were archaeophytes (plants that were introduced up to the end of the 15th century A.D.) (14%). The next groups of alien species were kenophytes (newcomers, after 15th century A.D.) (4%), and ephemerophytes (alien species, which were casually introduced into the territory) (1%) (Fig. 3). As far as Raunkiaer plant life forms are concerned, it was observed that hemicryptophytes predominated (72%). The second group comprised therophytes (16%), geophytes (13%) and chamaephytes (12%). The least numerous were nanophanerophytes (4%), megaphanerophytes (2%) and cryptophytes, represented by only one taxon (Fig. 4).

Close to half (47%) of the identified taxa belonged to the grassland species, the largest share being from the families Fabaceae (13 species), Labiateae (9), Compositae (6) and Poaceae (4). On the high slopes of the Bug River valley differences in the share of grassland species were observed, depending on the part. The highest share of xerothermic species was on the central part of scarps (S) – 60%. In these habitats, protected and/or rare plants (18 species) were the most numerous in comparison to other habitats. The lower parts of the slopes (D), touching the meso- and hygrophilous biotopes of the valley bottoms, had 42% of grassland plants and 4 rare and/or protected taxa. The upper parts of scarps (U), being under the impact of agriculture, were the poorest in grassland species, which accounted for only 28% of their flora. In this habitat, 2 protected taxa were found (Fig. 5).

Roadsides (P) also exhibited a small share of grassland species (31%). In these habitats, 67 species appeared: from the Red List only *Thymus marschallianus* was recorded. Balks and places of shallow bedrock deposition (M) had 56% of grasslands species, but in total only 34 species occurred there. In these habitats, 3 rare and/or protected species were found. On the medieval earthwork (Gr), 48 species occurred. Grassland taxa accounted for 46% of the flora, and 2 rare species occurred there (Fig. 5).

From among 158 taxa found in the xerothermic habitats of the Zachodniowołyńska Dolina Bugu Special Area of Conservation, 23 (15%) were rare and/or legally protected plants. Among 15 species protected in Poland, 13 were strictly and 2 partly protected. One species, *Dianthus collinus* subsp. *Glabriusculus*, has so far been considered as extinct in Poland. Six species are listed in the Polish Red Book of Vascular Plants (RB) and 11 in the Red List of Plants and Fungi in Poland (RL). Selected findings of rare and protected species are considered in the discussion.

DISCUSSION

Selected rare and protected plants

Achillea setacea is a taxon that is listed in the RB as critically endangered (E) and in the RL as declining – critically endangered (E). It is a Pontic-Pannonian-Irano-Turanian species with a range encompassing Albania, Austria, Bulgaria, Czech Republic, Germany, Greece, Hungary, Macedonia, Montenegro, Moldova, Romania, Russia (central and southern), Serbia, Slovakia, Spain, Switzerland and Ukraine (Tutin et al., 2010). The occurrence in Poland is restricted to sites on the slopes of the valleys of Vistula River near Sandomierz, Bug River and Huczwa River (Cwener and Sudnik-Wójcikowska, 2012). In the studied region, 17 stations of this species were recorded on the most xerothermic scarps of the Bug River valley (S) (Fig. 6).

Chamaecytisus albus is a strictly protected species, mentioned in the RB as rare and endangered (EN) and in the RL as rare – potentially at risk (R). It is an East-Mediterranean-Pontic plant found in Albania, Bulgaria, Greece, Hungary, Moldova, Montenegro, Romania, Serbia and Ukraine (Tutin et al., 2010). In Poland, it reaches its northern range border and is known only from the studied sites. The other sites, formerly reported in the literature, were not confirmed (Piękoś-Mirkowa and Mirek, 2006;

Przemyski and Piwowarski, 2009). There were seven specimens growing in the dry and sunlit eastern and southeastern exposure slopes of the Bug River valley as well as on balks (S, M). The plant also grew in a large dense patch (diameter ca. 20 m) on a small amid-field hill (M) with a western exposure (Fig. 7).

Dianthus collinus subsp. *glabriusculus* is recognized in the RB and RL as extinct (Ex) in Poland. The range of this Pannonian-North-Carpathian endemic includes the territories of Hungary, Moldova, Romania, Slovakia and Ukraine (Czerepanov, 1995; Tkachik, 1984; Jalas and Suominen, 1980; Tasenkevich, 1998; Tutin et al., 2010). It occurs in natural and semi-natural xerothermic habitats, mainly on loess soils (Malatissky, 2008). On Polish territory two stations located in the Przemyśl region were formerly known (Zając and Zając, 2001; Rutkowski, 2008). Within the studied area, one plant grew on an xerothermic elevation between erosive ravines on the slopes of the Bug River valley (S) (Fig. 8).

Echium russicum is a strictly protected species, listed in the RB as a rare and endangered (EN), and in the RL as a declining – critically endangered (E) species. It is a Pontic-Pannonian species occurring in the areas of Albania, Austria, Bulgaria, Czech Republic, Hungary, Montenegro, Moldova, the southwestern Russia, Romania, Serbia, Slovakia and Ukraine (Tasenkevich, 1998; Tutin et al., 2010). In Poland, it is a plant occurring only on three sites located in the southeast Lublin district (Cwener and Sudnik-Wójcikowska, 2012). On the investigated area, the species previously occurred naturally; the present stations originate from reintroduction (Cwener and Chmielewski, 2010). In 2011, 25 flowering specimens were recorded on southeastern and eastern exposed slopes of the Bug River valley (S) (Fig. 9).

Gypsophila paniculata is a strictly protected Pontic-Pannonian plant, occurring in Austria, Belarus, Bulgaria, Czech Republic, Hungary, Russia (southwest), Romania, Slovakia and Ukraine (Jalas and Suominen, 1980; Tasenkevich, 1998; Tutin et al., 2010). In Poland, it has a few natural stations. They are concentrated in the Podlasie Lowland and on the studied area. In other parts of the country they are probably of synanthropic origin, because they escaped from cultivations (Zając and Zając, 2001; Piękoś-Mirkowa and Mirek, 2006). The population on the studied area was small – 15 individuals on 6 sites, distributed mainly on the steep, dry and sunlit slopes of eastern and southeastern exposures as well as on western slopes of amid-field hills (S, U, D, M) (Fig. 10).

Orobanche caryophyllacea is a strictly protected species. It is a Middle European-Pontic-Pannonian-Irano-Turanian taxon with a range of Albania, Austria, Belarus, Belgium, Bulgaria, Czech Republic, England, France, Germany, Greece, Hungary, Italy, Luxembourg, Macedonia, Moldova, Montenegro, the Netherlands, Norway, Russia (central and southern), Romania, Serbia, Slovakia, Spain, Switzerland and Ukraine (Tasenkevich, 1998; Tutin et al., 2010). It is a rare plant in Poland; most of its stations are located in the highlands zone and in the lower Odra and Wisła River valleys (Cwener and Sudnik-Wójcikowska, 2012). On the studied area, it has not been listed yet. Four stations, located on xerothermic slopes of the Bug River valley, were discovered (S). (Fig. 11).

Orobanche elatior is a strictly protected species, listed in the RL as rare – potentially endangered (R). This is an Euro-Siberian-Irano-Turanian species found in Albania, Austria, Belarus, Belgium, Bulgaria, Czech Republic, Denmark, England, France, Greece, Hungary, Italy, Luxembourg, Montenegro, Macedonia, Moldova, the Netherlands, Norway, Romania, Russia (central and southern), Serbia, Slovakia, Spain, Switzerland and Ukraine (Tasenkevich, 1998; Tutin et al., 2010). In Poland it is found on scattered sites, mostly on the lowlands and in the highlands belt (Zając and Zając, 2001; Piękoś-Mirkowa and Mirek, 2006). In the Czumów-Gródek region, it was noted on several stations (Piwowarczyk et al., 2011). In the 2011 growing season, it was recorded on only one site shaded by bushes on a steep slope with southeastern exposure (D) (Fig. 12).

Peucedanum alsaticum is a Euro-Siberian species listed in the RL as vulnerable (V). It has a range covering the areas of Austria, Belarus, Bulgaria, Czech Republic, France, Germany, Hungary, Moldova, Romania, Russia (central and southern), Serbia, Slovakia and Ukraine (Tasenkevich, 1998; Tutin et al., 2010). Eastern Poland is the western limit of its range; a few stations are grouped in the Lublin district (Zając and Zając, 2001; Rutkowski, 2008). Fifteen sites were discovered on xerothermic slopes of the Bug River valley (S). (Fig. 13).

General floristic properties

The studied area is characterized by rich xerothermic flora, which provides nearly half of recorded species (47%). *Iris aphylla*, *Koeleria gracilis*, *Linosyris vulgaris*, *Orchis purpurea*, *Orchis militaris* and *Scorzonera purpurea* (Fijałkowski, 1957; Trąba, 2010) were not found at the studied sites. The reason for this may be the regression of these taxa from the investigated area or the seasonal variability of plant cover. In turn, *Allium angulosum*, *Dianthus collinus* subsp. *glabriusculus* and *Orobanche caryophyllacea* have not been recorded in this area so far.

The low share of anthropophytes in the studied flora (19%), among which species introduced in the earliest historical periods predominated (archaeophytes – 14%), is a common phenomenon taking place in various semi-natural ecosystems subjected to moderate anthropopression (Crawley, 1987; Pyšek, 1998; McCollin et al., 2000; Henderson and Naeth, 2005). The increased share of therophytes (16%) is associated with the prevailing extreme conditions on part of the studied areas and indicates early stages of succession (Grime, 1979; Tyler, 2003). Among plants of annual life strategy are most species that tolerate stress, which is especially important in xerothermic habitats (Madon and Médail, 1997). At the same time, the presence of phanerophytes reflects the process of overgrowing grasslands by thermophilous thickets. This process is characteristic for Central Europe and leads in further stages of the succession to the formation to deciduous forest communities (Brown and Southwood, 1987; Ruprecht et al., 2007).

Differences in the share of grassland plants in patches mainly depend on the degree of proximity of grasslands to other biotopes and an area of xerothermic habitats. The largest share of grassland species among all concerned habitats was observed in the central parts of xerothermic scarps of the Bug River valley (S) – 60%. In these habitats the majority of rare and protected plants (18 species) also occurred. The lower parts of the slopes (D) are under the influence of water oozing from the marshy bed of the valley, causing the share of xerothermic plants (42%) to decrease while the number of species of meso- and hygrophilous habitats increases. The upper parts of the scarps, being under the influence of cultivated fields, were poorest in grassland species (28 %). The impact of fertilization from the nearby arable fields on an impoverishment of the grasslands was also indicated by other researchers (Hejcman et al., 2009; Cwener and Chmielewski, 2010; Babczyńska-Sendek et al., 2012; Gaujour et al., 2012). In a belt of slopes, situated ca. 2-3 m below the farmlands and within a range of nitrate and phosphate runoff, a significant expansion of ruderal plants, such as *Artemisia vulgaris* and *Urtica dioica* was found. These habitats are also under the influence of herbicides, which negatively affect the species composition of grasslands (Rice and Stritzke, 1989; Tunnell et al., 2006). Herbicides most likely led to the prevalence of species relatively resistant to herbicides, such as *Calamagrostis epigejos* and *Elymus repens*. Such a phenomenon was also indicated by other authors (Bobbing and Wiliams, 1987; Gamrat, 2010). Unfavorable conditions also caused the low share of grassland plants (31%) on roadsides. However, the grassland plants growing on roadsides may be promoted by greater access to light as well as the strong warming up of field roads almost devoid of plant cover. These factors are pointed out as playing a crucial role (Saunders et al., 1991; Janišová, 2005).

Small and highly fragmented habitats of balks and places of shallow bedrock deposition (M) had a relatively high proportion (56%) of grassland plants. This may be connected to higher light intensity (Saunders et al., 1991; Janišová, 2005). However, due to their small size (no larger than 0.1 ha), the lowest number of species occurred there (34). An exponential relationship between low species diversity and the small area of island habitats was included in biogeography theory (MacArthur and Wilson, 1967). Therefore, the importance of amid-field habitats as reservoirs of valuable species is limited, which has also been confirmed in earlier studies (Smart et al., 2002; Gaujour et al., 2012).

Various objects created by human activities can act as sources of species for grasslands (Matus et al., 2003; Malatissky, 2008; Karlík and Poschlod, 2009; Woch, 2011; Babczyńska-Sendek et al., 2012; Woch et al., 2013). It turned out that on the studied area some anthropogenic habitats are quite favorable for the occurrence of grassland species. Relatively many species (46%) occurred on the earthwork (Gr). This small object (total area ca. 1 ha) has a number of steep slopes that significantly affects the habitat diversity. The importance of prehistoric objects as reservoirs of biodiversity has also been noted in other works (Moysiyenko and Sudnik-Wójcikowska, 2006; Celka, 2011; Suder, 2011). In addition, railway development contributed to the creation of favorable conditions for the expansion of grasslands on the slopes of embankments. Along the railway tracks, large patches of *Ononis arvensis* were recorded, and *Nonea pulla* grew only in this habitat. The railways cannot only be favorable habitats for thermophilous species, but can also facilitate their spreading (Tikka et al., 2001; Waldon et al., 2006; Stenmark, 2011). On the other hand, the proximity of routes is the most common cause of enrichment of grasslands with alien species (Fijałkowski and Izdebski, 1957; Pyšek et al., 1998; Kucharczyk, 2000). The development of the international railway LHS probably facilitated the occurrence of such anthropophytes as *Sisymbrium orientale* and *S. wolgense*. The presence of riverside thickets in the vicinity of grasslands has an impact on the increased frequency of the kenophyte *Echinocystis lobata,* intensively spreading along the rivers.

It has been stressed so far that the succession of shrubs and trees facilitated by the cessation of activities such as grazing and mowing, is the main threat to the grasslands (Pärtel et al., 1998; Piqueray et al., 2011). The negative effects that occurred in most areas of this type in Central and Eastern Europe due to the cessation of these activities as a result of economic change, or putting grasslands under strict protection, have been confirmed in many works (Barańska et al., 2010; Piqueray et al., 2011). The abandonment of grazing and mowing resulted in successive changes from grassland to shrub and forest communities. Accumulating organic matter accelerated this process, as well as favored colonization by nitrophilous species (Pärtel et al., 1998; Fijałkowski, 2003; Piqueray et al., 2011). On the other hand, during the period of no human activities, on the part of the grasslands a new equilibrium has developed – the process of termination of grassland species decline and there is no or only a slow succession of thicket communities (Karlík and Poschlod, 2009; Ruprecht et al., 2009). The reasons for this probably lies in the blocking of the germination of shrubs and trees through the shading of the ground by grassland communities and the accumulation of dry organic matter (Ruprecht et al., 2009; Barańska et al., 2010). Although the study area seems to be in such a situation, in some places the development of seedlings of *Crataegus monogyna*, *Rubus caesius*, and *Robinia pseudoacacia* was noticed. The latter species can be especially dangerous, because symbiotic bacteria living in the root nodules may significantly increase the content of nitrates in the substratum. In recent years, many papers indicated the problem of the loss of grasslands floristic diversity due to invasion of this tree species (Dzwonko and Loster, 1998; Barańska et al., 2010). This phenomenon is particularly serious in the countries located south of Poland (Pyšek et al., 1998; Matus et al., 2003; Ruprecht et al., 2009; Zagyvai et al., 2012). Therefore, the most valuable habitats of the Bug River scarps has been covered by an active protection program including mowing and maintaining extensive grazing (Barańska et al., 2010).

The findings of this study indicate that xerothermic grasslands located in the Zachodniowołyńska Dolina Bugu Special Area of Conservation are especially valuable. The biggest threat to them in the coming years will be the expansion of nitrophilous vegetation resistant to herbicides as a result of increasing intensification of agriculture. A low awareness of people concerning the protection of nature is also dangerous for the diversity of grasslands, as people dig up and take away some decorative species. Grasslands located within the attractive earthwork or near the newly built observation tower are usually trampled and littered. However, well-managed development of tourism can have a positive impact by increasing the sensitivity of people to the value of grasslands and the necessity of grassland protection.

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