















Protected species in grassland habitats of Ukraine

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Abstract. Based on the analysis of more than 17,000 vegetation plots (relevés), the participation of 261 protected species (254 vascular plants, six lichens, and one bryophyte) in 30 EUNIS grassland habitat types was revealed. Vegetation plots were assigned to the habitat types using the EUNIS-ESY expert system with further verification. We consider as protected species those listed in the current edition of the *Red Data Book of Ukraine, Resolution 6 of the Bern Convention, Annexes II and IV of the Habitat Directive*, and the *IUCN Red List* (only categories VU, EN, CR). The participation of protected species was studied according to the following three criteria: (1) the total number of protected species in the plots assigned to a certain habitat type, (2) the number of plots in which at least one protected species is present, and (3) the mean number of protected species per plots within each habitat type. True steppes (R1B) and meadow steppes (R1A) differed with a significant predominance of the total number of protected species. Arctic alpine calcareous grassland (R44) and Continental dry rocky steppic grassland and dwarf scrub on chalk outcrops (R15) had the largest proportion of plots with protected species and the highest mean numbers of protected species per relevé. Saline habitats, in particular Temperate inland salt marsh (R63) and Semi desert salt pan (R64), were characterized by the smallest number of plots with protected species. Among all species, *Gymnadenia conopsea*, *Stipa capillata*, *Colchicum autumnale* and *Gladiolus imbricatus* occurred in the largest number of studied habitat types. Based on the results of the analysis, appropriate ways of optimizing the protection of grassland habitats and protected species are proposed.

Keywords: *Annex II of the Habitat Directive, Annex IV of the Habitat Directive, EUNIS, IUCN Red List, Red Data Book of Ukraine, Resolution 6 of the Bern Convention*

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Introduction

Grassland habitats are extremely important, primarily as a source of numerous ecosystem services, and not only those resource-related, but also those related to the regulation and self-maintenance, e.g. thermoregulation, soil formation, countering soil and water erosion, carbon sequestration, etc., which contribute to increasing the sustainability of ecosystems to global climate change and natural disasters, and therefore to the sustainable development of society. In many European countries, grassland habitats are recognized as objects of special conservation interest and biodiversity hotspots (Grasslands..., 2018). Thus, European records of species richness according to the latest data are recorded in semi-dry grasslands and reach 106 species of vascular plants on 10.89 m² in Transylvania (Romania) and 119 species of vascular plants on 16 m² in Bukovyna (Ukraine) (Roleček et al., 2019). Such unique habitats are top priorities in the nature conservation policy of many countries, which provides for their inventory. In addition to a high level of species richness and biodiversity, grassland habitats shelter many rare species of plants and animals and are considered among the global biodiversity hotspots (Habel et al., 2013). The rarity of many of such species is caused by a very high level of transformation of grasslands due to their excessive exploitation, plowing, and change of land use modes, which leads to overgrowth of trees and shrubs. In addition, many representatives of the grassland flora, especially in dry grasslands, belong to local endemics. Comparison of different types of grassland habitats by the participation of protected species provides important information that allows prioritizing their protection and developing efficient management regimes. In this regard, we aimed to analyze the presence of protected plant species in the floristic composition of grassland habitats of Ukraine. In particular, we considered species listed in the current edition of the *Red Data Book of Ukraine* (Chervona..., 2009), *Resolution 6 of the Bern Convention* (Revised..., 2011), *Annexes II* (<https://eunis.eea.europa.eu/references/2325/species>) and *IV* (<https://eunis.eea.europa.eu/references/2326/species>) of the *Habitat Directive* (Council..., 1992), and species of the *IUCN Red List* (<https://www.iucnredlist.org/>) with categories "Vulnerable" (VU), "Endangered" (EN), and "Critically Endangered" (CR).

Materials and Methods

The data used in this study were vegetation plots from several phytosociological databases: Ukrainian Grassland Database (EU-UA-001) (Kuzemko, 2012, Kuzemko et al., 2020a), Eastern European Steppe Database (EU-00-030) (Vynokurov et al., 2020), "Vegetation of Bukovyna+" (EU-UA-009) (Budzhak et al., 2018), and "Halophytic and coastal vegetation database of Ukraine" (EU-UA-005) (Dziuba, Dubyna, 2021). Thus, we obtained a total dataset that included 23,746 relevés. Their territorial distribution in Ukraine and density are shown in Fig. 1.

The nomenclature of vascular plants was harmonized following the *The Euro+Med PlantBase – the information resource for Euro-Mediterranean plant diversity* (<https://www.europplusmed.org/>), which is used in the EUNIS-ESy expert system for habitat classification.

The EUNIS-ESy expert system (Chytrý et al., 2020), integrated into the JUICE software (Tichý, 2002), was used to assign the relevés to EUNIS habitat types. At the first stage of the analysis, 17,687 relevés were classified as group R (grassland habitats) and selected for further processing. As a result of several stages of verification, the grassland relevés were distributed among 28 habitat types. For the habitat types that were not identified using the expert system due to the lack of relevant data in the available dataset, we used additional relevés from literary and archival sources. For the snow-bed vegetation (R41), 28 relevés from the monograph "Vegetation of Ukraine. High mountain vegetation" (Malynovskiy, Krichfalushiy, 2000) were used. In addition, 26 relevés of the Mediterranean annual-rich dry grassland (R1F) authored by Ya.P. Dudukh were selected from the UkrVeg database (Iemeljanova, Kuzemko, 2016).

Thus, the data were divided into 30 clusters representing EUNIS habitat types of the third level of hierarchy (Table 1).

Results

In total, we revealed 261 species in the analyzed dataset, which we consider as protected species of grassland habitats. Vascular plants represent the majority (254 species) of protected species, while six species belong to lichens and one species to bryophytes (Table 2). They totally occupy 308 positions in red lists since some species are simultaneously included in different lists. In

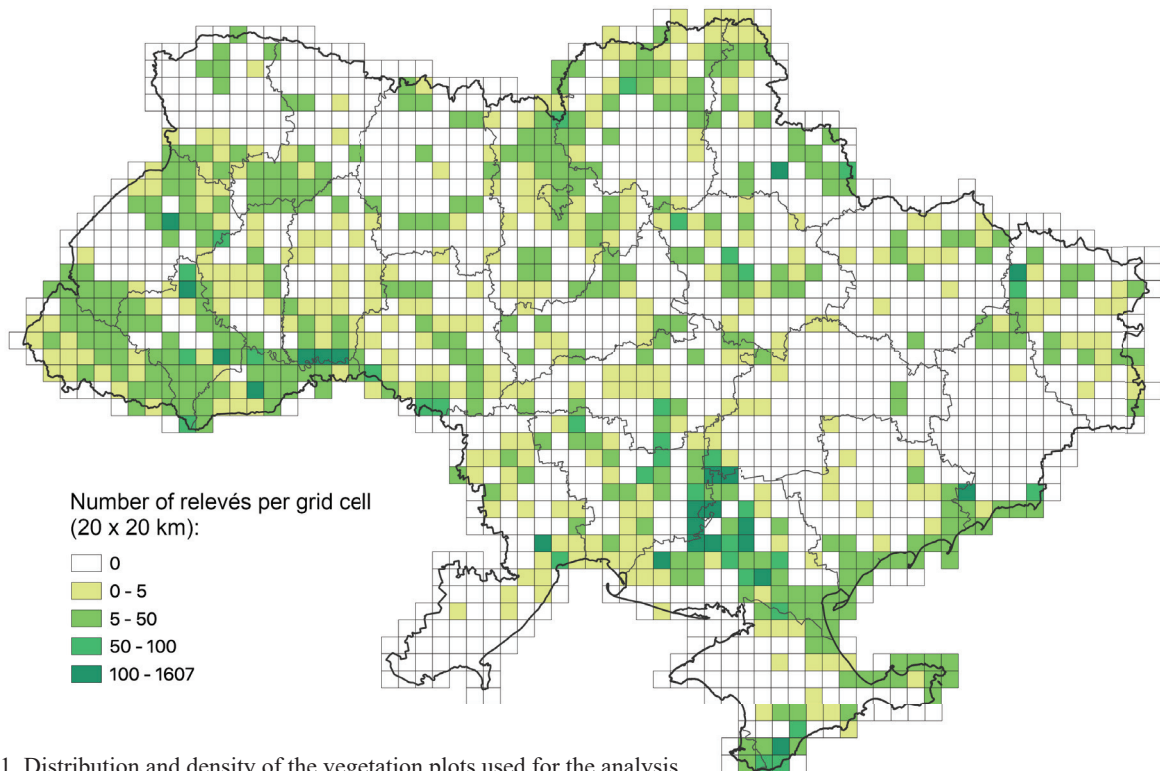


Fig. 1. Distribution and density of the vegetation plots used for the analysis

Table 1. Distribution of vegetation plots from the analyzed phytosociological dataset by EUNIS grassland habitat types

Cluster number	Code	Name	Number of plots
1	R11	Pannonian and Pontic sandy steppe	352
2	R12	Cryptogam and annual dominated vegetation on siliceous rock outcrops	80
3	R13	Cryptogam and annual dominated vegetation on calcareous and ultramafic rock outcrops	289
4	R15	Continental dry rocky steppic grassland and dwarf scrub on chalk outcrops	199
5	R16	Perennial rocky grassland of Central and South Eastern Europe	344
6	R18	Perennial rocky calcareous grassland of subatlantic submediterranean Europe	308
7	R1A	Semi dry perennial calcareous grassland	1755
8	R1B	Continental dry grassland true steppe	5531
9	R1C	Desert steppe	46
10	R1F	Mediterranean annual-rich dry grassland	26
11	R1M	Lowland to submontane, dry to mesic <i>Nardus</i> grassland	581
12	R1P	Oceanic to subcontinental inland sand grassland on dry acid and neutral soils	128
13	R1Q	Inland sanddrift and dune with siliceous grassland	88
14	R21	Mesic permanent pasture of lowlands and mountains	976
15	R22	Low and medium altitude hay meadow	2635
16	R23	Mountain hay meadow	175
17	R35	Moist or wet mesotrophic to eutrophic hay meadow	644
18	R36	Moist or wet mesotrophic to eutrophic pasture	1094
19	R37	Temperate and boreal moist or wet oligotrophic grassland	325
20	R41	Snow-bed vegetation	28
21	R43	Temperate acidophilous alpine grassland	58
22	R44	Arctic alpine calcareous grassland	197
23	R51	Thermophilous forest fringe of base rich soils	227
24	R55	Lowland moist or wet tall herb and fern fringe	115
25	R56	Montane subalpine moist or wet tall herb and fern fringe	104
26	R62	Continental inland salt steppe	238
27	R63	Temperate inland salt marsh	173
28	R64	Semi desert salt pan	655
29	R65	Continental subsaline alluvial pasture and meadow	49
30	X36	Depressions (pody) of the Steppe zone	315

particular, 250 species are listed in the current edition of the *Red Data Book of Ukraine* (Chervona..., 2009), 28 species – in *Resolution 6 of the Bern Convention*, 16 species – in *Annexes II and IV of the Habitats Directive*, and 14 species – in the *IUCN Red List* with categories "CR" – critically endangered" (1 species), "EN – endangered" (6 species), and "VU – vulnerable" (6 species). One species (*Centaurea pseudoleucolepis*) is currently listed in the *IUCN Red List* as extinct (Melnyk, 2011), although this information is incorrect, and recent studies proposed to reconsider its category (Onyshchenko et al., 2022; Vasyliuk et al., 2022).

The comparison of the habitat types by the total number of protected species (Fig. 2) showed a significant predominance of meadow (R1A) and true steppes (R1B) according to this criterion. It corresponds to the fact that about a third of the species protected in Ukraine at the national level by the *Red Data Book of Ukraine* are species of steppe habitats (Burkovskiy et al., 2013). Nonetheless, to some extent, this result could be influenced by the fact that the mentioned types are represented by the largest number of plots in the analyzed dataset (Table 1). Low and medium altitude hay meadow (R22) and Temperate and boreal moist or wet oligotrophic grassland (R37) also show a high proportion of protected species.

Since the results of the previous analysis largely depend on the number of plots representing a particular type, we also analyzed the proportion of plots with at least one protected species in the species composition (Fig. 3).

The results of this analysis differ from those of the previous one. The largest number of plots with protected species was recorded for the Continental dry rocky steppic grassland and dwarf scrub on chalk outcrops (R15) and Arctic alpine calcareous grassland (R44). For these types, almost all available relevés (98.9% and 95.9%, respectively) contain protected species. These types are followed by the Perennial rocky calcareous grassland of subatlantic submediterranean Europe (R18) due to the high number of Crimean endemics and subendemics, most of which are protected in Ukraine at the national level. True steppes (R1B), which are represented by the largest number of plots in the analyzed dataset, are slightly inferior to them, but at the same time, more than 77% of them contain protected species. Two other types, R23 Mountain hay meadow and R51 Thermophilous forest fringe of base rich soils, have almost the same proportion of relevés with protected species. The smallest number of relevés

with species from red lists was recorded for Oceanic to subcontinental inland sand grassland on dry acid and neutral soils (R1P) and Semi-desert salt pan (R64), for which protected species are represented in only 5.5 % and 4.1 % of relevés, respectively.

As another criterion to assess the participation of protected species in the grassland habitats of Ukraine, we used the arithmetic mean of protected species per relevé (Fig. 4).

The first position, as in the previous analysis, was occupied by Continental dry rocky steppic grassland and dwarf scrub on chalk outcrops (R15), while the second and third positions were shared by Arctic alpine calcareous grassland (R44) and Thermophilous forest fringe of base rich soils (R51). Two halophytic types (R63 and R64) and one psammophytic type (R1P) are characterized by the lowest values for this indicator, which resembles the results of the previous analysis.

Analyzing the habitat range of protected species, we found four species with the widest range: *Gymnadenia conopsea* occurs in 13 habitat types, *Stipa capillata* – in 12, *Colchicum autumnale* and *Gladiolus imbricatus* – in 11 types each. Other six species occur in 10 habitat types each: *Anacamptis morio*, *Anacamptis palustris* aggr., *Dactylorhiza maculata* aggr., *Epipactis palustris*, *Iris sibirica*, and *Stipa ucrainica*. At the same time, 72 species occur only within one habitat type.

Discussion

Our analysis demonstrated that among the dry grasslands (group R1), the habitats of chalk outcrops have the highest conservation value according to the total number of protected species. Among mesic grasslands (R2), such position belongs to the hay meadows of mountain regions, and among wet grasslands (R3) – to oligotrophic wet meadows. Remarkably, a high proportion of protected species characterizes all alpine and subalpine grasslands (R4). Among them, alpine grasslands formed on carbonate soils differ with the almost double number of protected species compared to other types. Fringe habitats (R5) host a high number of protected species due to the ecotone effect, but the proportion of such species is much lower for the Lowland moist or wet tall herb and fern fringe than for the other two types. Among halophytic habitats (R6), less saline and more humid habitats (i.e. R65) are characterized by a slightly higher proportion of protected species, which still remains low as compared to other groups.

Scientific (Latin) name (B = bryophyte; L = lichen)	Conservation status				Code of habitat type																				Total													
	RDBU	BC	HD	IUCN	R11	R12	R13	R15	R16	R18	R1A	R1B	R1C	R1F	R1M	R1P	R1Q	R21	R22	R23	R35	R36	R37	R41		R43	R44	R51	R55	R56	R62	R63	R64	R65	X36			
<i>Artemisia hololeuca</i>	*						69																														1	
<i>Asphodeline lutea</i>	*						1	13	2	1																												4
<i>Asplenium adianthum-nigrum</i>	*								2																													1
<i>Aster alpinus</i>	*																																					1
<i>Astracantha arnacantha</i>	*										1																											2
<i>Astragalus arenarius</i>	*									1																												5
<i>Astragalus cornutus</i> (<i>Astragalus cretophilus</i>)	*						5				11																										2	
<i>Astragalus dasyanthus</i>	*						2	1	6	86									1																		5	
<i>Astragalus excarpus</i>	*									1	14																										2	
<i>Astragalus glaucus</i>	*									1	3																										2	
<i>Astragalus monspessulanus</i>	*						4	25	32	33																											4	
<i>Astragalus ponticus</i>	*						1			4	1																										3	
<i>Astragalus reductus</i>	*										11	3																									2	
<i>Astragalus testiculatus</i>	*										1																										1	
<i>Astrodaucus littoralis</i>	*						3																														1	
<i>Betula humilis</i>	*																																				1	
<i>Betula klokovii</i>	*			*																																	1	
<i>Botrychium lunaria</i>	*														1				18	6																7		
<i>Botrychium multifidum</i>	*														1																						4	
<i>Bupleurum tenuissimum</i>	*																																				9	
<i>Catophaea wolgarica</i>	*										7																										1	
<i>Campanula carpatica</i>	*										1																										2	
<i>Campanula kladniana</i>	*																																				1	
<i>Campanula serrata</i>	*			*						14																											9	
<i>Caragana scythica</i>	*									3	94																										2	
<i>Carex buxbaumii</i>	*														4	1																					6	
<i>Carex davalliana</i>	*																																				4	
<i>Carex liparocarpos</i>	*																																				4	
<i>Carex pauciflora</i>	*																																				1	

Scientific (Latin) name (B = bryophyte; L = lichen)	Conservation status		Code of habitat type																				Total															
	RDBU	BC	HD	IUCN	R11	R12	R13	R15	R16	R18	R1A	R1B	R1C	R1F	R1M	R1P	R1Q	R21	R22	R23	R35	R36		R37	R41	R43	R44	R51	R55	R56	R62	R63	R64	R65	X36			
<i>Crocus pallasi</i>	*				1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	
<i>Crocus reticulatus</i>	*				8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	
<i>Crocus vernus</i> subsp. <i>vernus</i> (<i>Crocus heuffelianus</i>)	*				8	.	.	.	.	7	6	2	2	2	3	5	.	.	.	.	.	.	.	.	.	8		
<i>Cymbaria boryshenica</i> (<i>Cymbasasma boryshenica</i>)	*				83	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	
<i>Cypripedium calceolus</i>	*	**	*		1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2	
<i>Cystopteris montana</i>	*				1	
<i>Cystopteris sudetica</i>	*				1	
<i>Cytisus albus</i> (<i>Chamaecytisus albus</i>)	*				.	6	.	14	1	205	48	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
<i>Cytisus blockianus</i> (<i>Chamaecytisus blockianus</i>)	*				.	4	.	15	.	51	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
<i>Cytisus graniticus</i> (<i>Chamaecytisus graniticus</i>)	*				.	.	.	4	.	3	92	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
<i>Cytisus paczoskii</i> (<i>Chamaecytisus paczoskii</i>)	*				.	1	.	5	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
<i>Cytisus podolicus</i> (<i>Chamaecytisus podolicus</i>)	*				.	1	.	3	.	15	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
<i>Dactylorhiza cordigera</i>	*				5
<i>Dactylorhiza incarnata</i>	*				2	.	.	.	.	.	1	.	.	3	18	.	42	23	17	.	.	.	.	.	.	.	.	.	.	.	.	7	
<i>Dactylorhiza maculata</i> aggr.	*				1	.	.	.	.	.	.	.	3	64	4	4	6	11	.	.	.	.	.	.	.	.	.	.	.	.	.	10	
<i>Dactylorhiza majalis</i>	*				1	.	.	.	.	.	.	.	.	54	7	39	16	45	.	.	.	.	.	.	.	.	.	.	.	.	.	9	
<i>Dactylorhiza romana</i>	*				2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	
<i>Dactylorhiza sambucina</i>	*				1	.	.	23	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	
<i>Damasonium alisma</i>	*				3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	32	
<i>Daphne cneorum</i>	*				1	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	
<i>Delphinium elatum</i>	*				2
<i>Dianthus hypanicus</i>	*	*	*		.	1	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Dianthus superbus</i> subsp. <i>alpestris</i> (<i>Dianthus speciosus</i>)	*				1	.	.	.	.	.	.	.	.	1	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	
<i>Dictamnus albus</i>	*				.	1	.	4	.	5	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5

Scientific (Latin) name (B = bryophyte; L = lichen)	Conservation status				Code of habitat type																				Total											
	RDBU	BC	HD	IUCN	R11	R12	R13	R15	R16	R18	R1A	R1B	R1C	R1F	R1M	R1P	R1Q	R21	R22	R23	R35	R36	R37	R41		R43	R44	R51	R55	R56	R62	R63	R64	R65	X36	
<i>Orchis mascula</i>	*										2				7			1	35	3				1	1	1	1									8
<i>Orchis militaris</i>	*						1				2								2									5								4
<i>Orchis punctulata</i>	*			*							1																									2
<i>Orchis purpurea</i>	*										1																									1
<i>Ornithogalum boucheanum</i>	*										1																									1
<i>Paeonia tenuifolia</i>	*	*						38		14	16																									3
<i>Pedicularis exaltata</i>	*										7								9	8	1							3	1							6
<i>Pedicularis sceptrum-carolinum</i>	*																							2												1
<i>Pedicularis sylvatica</i>	*														21						2		1												3	
<i>Pinguicula alpina</i>	*																						1			9									3	
<i>Pinguicula vulgaris</i>	*														1								3	12												3
<i>Pistacia atlantica</i> subsp. <i>mutica</i> (<i>Pistacia mutica</i>)	*																																		1	
<i>Platanthera bifolia</i>	*									23					53				135	3	1		7		1	1	26									8
<i>Poa rehmannii</i>		*	*																1	1						3									3	
<i>Poa taurica</i>	*									3	6	1	3																							4
<i>Pontechium maculatum</i> (<i>Echium ruscicum</i>)	*									2	56	21							1								6									6
<i>Prangos trifida</i>	*									4	2																									2
<i>Primula minima</i>	*																								2	2										2
<i>Prunus klovkovi</i> (<i>Cerasus klovkovi</i>)	*											1																								1
<i>Psathyrostachys juncea</i>	*											1																								1
<i>Pseudobryum cinclidioides</i> (B)	*																				1		1													2
<i>Pseudorechis albida</i>	*													13				6								1										4
<i>Pulsatilla alpina</i> subsp. <i>alba</i> (<i>Pulsatilla scheerfelii</i>)	*																										2	1								2
<i>Pulsatilla patens</i>	*	*	*							5	1							3																		5
<i>Pulsatilla pratensis</i>	*							1	18	79	179							2																		9
<i>Pulsatilla halleri</i> subsp. <i>taurica</i>	*									66	3																									2
<i>Pulsatilla vulgaris</i> subsp. <i>grandis</i> (<i>Pulsatilla grandis</i>)	*	*	*						2	2	79	27						2																		6

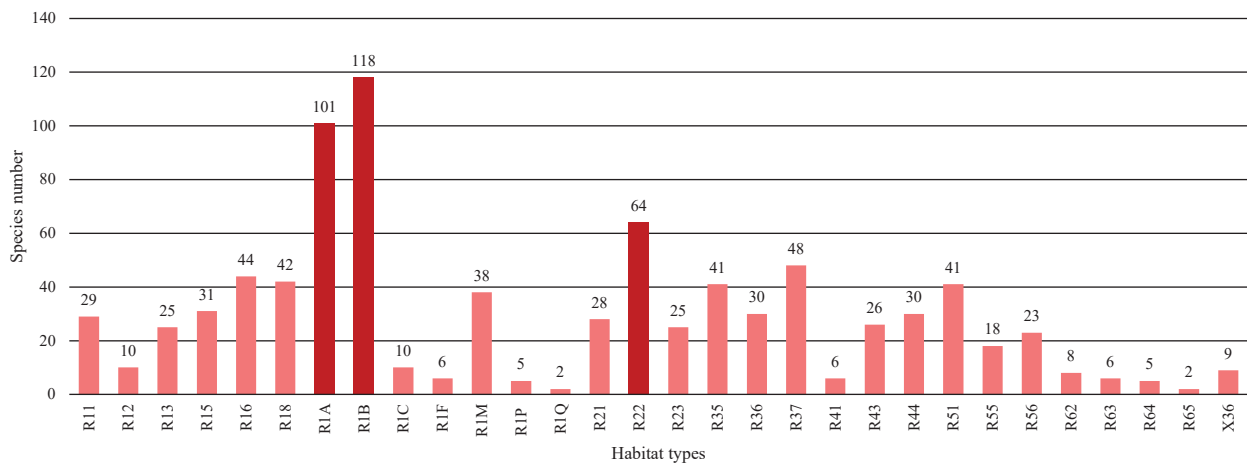


Fig. 2. The total number of protected species in the floristic composition for each habitat type. Dark red color represents the three highest values. The habitat codes correspond to those given in Table 1

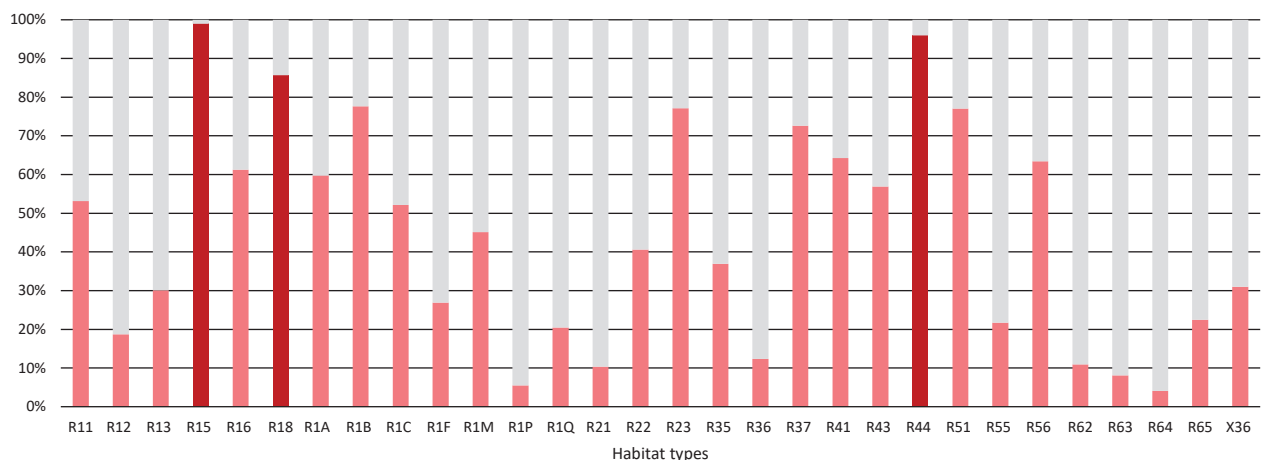


Fig. 3. The proportion of plots with at least one protected species in the species composition (red) to the total number of plots for each habitat type. The three highest values are indicated in dark red

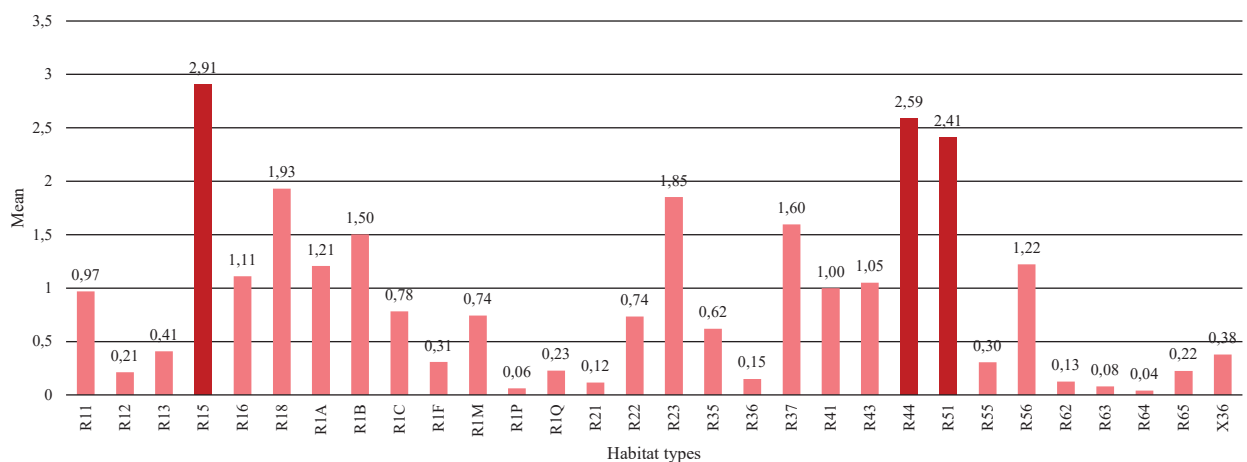


Fig. 4. The arithmetic means of protected species per relevé in the grassland habitats of Ukraine

In general, dry grasslands (group R1) have higher values of all three measurements used in the analysis (total number of protected species, proportion of plots with protected species, and arithmetic means of protected species per relevé) as compared to the mesic grasslands (R2) and wet grasslands (R3).

Salt marshes, mesic and wet pastures, as well as sandy grasslands of northern regions are characterized by the smallest proportion of protected species. At the same time, most of these habitats are generally characterized by low species richness. The main reason for this is their existence under extreme conditions, particularly with excessive salinity or trampling, or on soils that lack nutrients. Accordingly, the total species richness of habitats correlates with the richness of their protected fraction. However, other extreme habitats (e.g., grasslands on chalk outcrops, limestone outcrops, and Pontic sandy grasslands) are distinguished by a higher proportion of protected species. This indicates the possible role of climatic, edaphic and biogeographic factors in the formation of the flora of particular habitat types, including the rare elements in their floristic composition.

Among the reasons for the differences in the richness of protected species between different habitat types, there are also certain subjective reasons associated with selection of species for red lists. In particular, the compilation of species for the current edition of the *Red Data Book of Ukraine* was based on a rather subjective expert opinion. For example, all species of orchids (*Orchidaceae*) and all species of the genus *Stipa* L. occurring in Ukraine were included in the *Red Data Book of Ukraine* (Chervona..., 2009), regardless of the peculiarities of their distribution and population characteristics. However, recent studies showed that this decision should be revised, in particular for the widespread species *Stipa capillata* which occurs in the highest number of dry grassland relevés in databases, and even in synanthropic vegetation (Kuzemko et al., 2020b). Respectively, differences between habitats in the quantity and proportion of protected species can change significantly if objective (quantitative) criteria are used for formation of red lists. Such an analysis will be possible in the future in case of the preparation of a new edition of the Red Data Book of Ukraine based on updated quantitative methods of species selection.

The high number of species occurring only within one habitat type (72 species, which is almost one third of the total number of protected species) indicates their narrow ecological niche and high specialization.

The presence of protected species is an important basis for the implementation of practical measures aimed at the stabilization, preservation and restoration of grassland habitats. Such measures should primarily include:

inventory of localities of protected species of plants and animals (those listed in the *Red Data Book of Ukraine, Resolution 6 of the Bern Convention*) within the grassland habitats of Ukraine;

monitoring of the state of populations of rare and endangered plant species, with special attention to protected areas, including Emerald sites, using permanent monitoring plots, mapping and resurveying the species distribution patterns following the EU methodological approaches;

appropriate and scientifically justified management methods (organization of regulated grazing and haying, habitat restoration, reintroduction and/or repatriation of rare species, etc.) in a case when reduction in the number and/or area of populations of protected species is detected.






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Ethics Declaration

The authors declare no conflict of interest.

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Реферат. На основі опрацювання понад 17 тис. геоботанічних описів було проаналізовано участь 261 охоронюваного виду (254 види судинних рослин, шість видів лишайників, один вид мохоподібних) у 30 типах трав'яних біотопів системи EUNIS. Розподіл описів на типи було здійснено за допомогою експертної системи EUNIS-ESy з подальшою верифікацією. У якості охоронюваних ми розглядаємо види, занесені до діючого видання Червоної книги України, Резолюції 6 Бернської конвенції, Додатків II і IV Оселищної Директиви та Червоного списку МСОП (лише категорії VU, EN, CR). Участь видів раритетної фракції встановлювали за трьома критеріями: (1) абсолютною кількістю видів раритетної фракції у складі описів, віднесених до певного типу біотопу, (2) за кількістю описів, в яких присутній хоча б один вид раритетної фракції, (3) за середнім арифметичним охоронюваних видів на опис в межах певного типу біотопу. Справжні (R1B) і лучні (R1A) степи відрізнялися суттєвим переважанням за загальною кількістю охоронюваних видів. Аркто-альпійські луки на карбонатних субстратах (R44) і біотопи крейдяних відслонень (R15) мали найвищий вміст описів за участю охоронюваних видів і також характеризувалися найвищими показниками середнього арифметичного участі охоронюваних видів на опис. Галофітні біотопи, зокрема внутрішньоконтинентальні солончаки помірної зони (R63) і напівпустельні солончаки (R64) характеризувалися найнижчою участю охоронюваних видів. Серед усіх видів із охоронним статусом *Gymnadenia conopsea*, *Stipa capillata*, *Colchicum autumnale* і *Gladiolus imbricatus* відмічені у найбільшій кількості типів біотопів. Запропоновано шляхи оптимізації охорони трав'яних біотопів з урахуванням результатів проведеного аналізу.

Ключові слова: EUNIS, Додаток II Оселищної Директиви, Додаток IV Оселищної Директиви, Червоний список МСОП, Резолюція 4 Бернської конвенції, Червона книга України