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Records of vascular plants at the old cemeteries of southern Ukraine

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Реферат

Скобель, Н., Загороднюк, Н., Мойсієнко, І. (2026) Знахідки судинних рослин старих цвинтарів, південна Україна

Передумови: Набір даних містить записи про знахідки та поширення видів судинних рослин в 20 геоботанічних описах у межах старих кладовищ Правобережного Злакового Степу (південь України). Дослідницькі експедиції 2023/2024 років «Моделювання рослинного різноманіття та взаємозв'язків між кількістю видів і площею степових анклавів на старих кладовищах Північного Причорномор'я (південь України)» були спрямовані на збір високоякісних даних про біорізноманіття об'єктів культурної спадщини - старих цвинтарів.

Нова інформація: Цей набір даних містить 1829 записів про знахідки 215 назв таксонів (199 судинних рослин, 16 мохоподібних), зафіксованих в 20 геоботанічних описах. Досліджені території представляють степи, з акцентом на клас Festuco-Brometea. Дослідження підкреслює важливість степів на старих цвинтарях як осередків біорізноманіття та привертає увагу до їхнього захисту в контексті змін землекористування та наслідків війни в Україні.

Ключові слова: *біорізноманіття; степи; просторовий масштаб; видове різноманіття; степ; Україна; судинні рослини;геоботанічний опис.*

Abstract

Background: The dataset contains records of vascular plant species occurrences and distribution in 20 vegetation plots within old cemeteries of the Right–Bank Dnipro Grass Steppe District (southern Ukraine). «Plant diversity and species-area relationships modelling of steppe enclaves within old cemeteries of Northern Prychornomoria region (Northern Black Sea Region) of southern Ukraine» are research expeditions in 2023/2024 aimed at collecting high-quality biodiversity data in cultural heritage sites — old cemeteries.

New information: This dataset contains 1829 occurrences of 215 taxa names (199 vascular plants, 16 bryophytes,) recorded in 20 vegetation plots. The sampled locations represent one of types of grasslands — steppes focused on class *Festuco-Brometea*. The study highlights the importance of steppes in old cemeteries as biodiversity hotspots and draws attention to the protection in the context of land-use changes and the consequences of the war in Ukraine.

Keywords: *biodiversity; grassland; spatial scale; species richness; steppe; Ukraine; vascular plants; vegetation plot.*

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Introduction

Anthropogenic activities have led to a significant loss of natural habitats over the last few centuries worldwide (Radić, Gavrilović 2020). Steppes once occupied about 40% of the territory of Ukraine (Korotchenko, Peregrym 2012), while, today, steppe remnants have survived in only 1–3% of the natural and semi–natural steppes (Burkovskyi et al. 2013).

Steppe flora in Ukraine is preserved mainly in protected areas, ravines, river terraces etc. (Burkovskyi et al. 2013). In the steppe zone of Ukraine, cultural herritage sites also serve as important refuges of steppe flora in Eastern Europe (Moysiyenko et al. 2014; Dayneko et al. 2023; Deák et al. 2024). Recently, studies in other countries have recognized the natural value of old cemeteries (Löki et al. 2019).

In our study, we define old cemeteries as cultural heritage sites established more than 100 years ago (Moysiyenko et al. 2021). In our previous studies, we found that the presence of typical steppe species such as *Festuca valesiaca* agg., *Koeleria macrantha*, *Stipa capillata* and a high proportion of natural non–synanthropic and protected species, compared to invasive species, indicates a comparatively high degree of preservation of steppe flora in its natural state in the old cemeteries (Moysiyenko et al. 2021).

The documentation of biodiversity within old cemeteries is urgent given the escalating threats of land-use change, neglect, and the ongoing impacts of war in the southern Ukraine. The data paper presents a comprehensive dataset of relevés. The data of biodiversity are essential for developing regional conservation strategies that integrate cultural heritage protection with biodiversity management and post-war recovery.

General description

Purpose: The aim of this research is to evaluate the species richness in vegetation plots of old cemeteries of the Right–Bank Dnipro Grass Steppe District and collecting high-quality biodiversity data.

Sampling methods

Description: The dataset contains co-occurrences of vascular plants. The study area is situated in the Right-Bank of Dnipro Grass Steppe District is in Northern Black Sea Region. The territory includes parts of Dnipropetrovsk, Kherson, Mykolaiv and Odesa administrative Regions. This area is situated in the south-western part of the Steppe Zone of Ukraine in one geobotanical zone using the national classification system namely fescue-feather grass steppes (or bunch-grass/grass steppes). The Right–Bank Dnipro Grass Steppe District is characterized by low precipitation, which decreases from north to south and west to east (400–450 mm per year) (Marynych, Shyshchenko, 2005). The average annual temperature exhibits a north–south gradient, with higher values observed in the southern regions and lower values in the northern regions (11.7 °–8.4 °C) (Karger et al. 2017). The average summer temperature is +30 °C, the average winter temperature is no more than +4 °C (Karger et al. 2017), with extreme temperatures of +40 °C in summer and –28 °C in winter (Karger et al. 2017). Soil resources of the Right–Bank Dnipro Grass Steppe District are represented by normal and southern chernozems and dark kastanozems in the southeast (Marynych, Shyshchenko, 2005).

The combined area of the 50 old cemeteries studied is 55.5 hectares. The area of the old cemeteries ranges from 0.1 to 32.5 hectares (median 3.1 hectares), aged from 100 years to 387 years (median 224 years) (for detaills see Skobel, Moysiyenko, 2026).

Sampling description: We have searched for old cemeteries in the bibliographical sources and open sources for research. The selection of old cemeteries in 2023-2024. The selection of old cemeteries was based on materials from the Google map

«Ancient Cemeteries of Ukraine» (Ukraine Incognita 2026) and cartographic materials and literature sources (Old Maps of Ukraine 2026; Malyna 2009 etc.). We carried out a visual analysis based on satellite images (Google Earth, 2026), with particular emphasis on the selection of cemeteries that were not overgrown and not covered with phanerophytes, as the natural steppe is zonally not associated with woody species (Krytskaya 1985). In order to carry out a study of the flora, we followed the following criteria, which could only be checked in the field: presence of bunch–grasses (or tussock grasses such as *Festuca*, *Koeleria*, *Stipa* etc.) and other characteristic steppe species from the class *Festuco–Brometea* (Mucina et al. 2016).

To obtain this dataset, we sampled 20 biodiversity plots which had 100m^2. The plots of larger size (100 m^2) which include smaller plots are marked as parent events in the Event Core. Sampling locations were chosen to cover different types of

Table 1. Overview of the investigated old cemeteries in the area of the Right-Bank of Dnipro Grass Steppe

#	Old cemeteries	Sampling data	Longitude	Latitude	Region	Area of old cemeteries	The establishment date of the village*	Number of vascular plant species per old cemeteries	Total species richness per vegetation plot	Species richness (vascular plants) per vegetation plot	Species richness (bryophytes) per vegetation plot
1.	Borysivka	2023-07-09	45.79236	29.63815	Odesa	1.88	1822	159	30	30	0
2.	Fedorivka	2024-05-25	46.74901	31.3165	Mykolaiv	9.75	1870	178	43	40	3
3.	Hlyboke	2023-07-09	45.72765	29.62113	Odesa	1.32	1800	164	37	33	5
4.	Inhulka	2024-05-23	47.20064	32.21772	Mykolaiv	2.21	1841	185	44	41	3
5.	Kamianka	2024-05-24	46.81567	31.67998	Mykolaiv	4.26	1802	198	43	40	3
6.	Kherson	2024-05-23	46.63589	32.58349	Kherson	2.41	1790	197	38	31	7
7.	Khrystoforivka	2024-05-23	47.27359	32.25278	Mykolaiv	1.20	1799	147	30	30	0
8.	Kostiantynivka	2023-07-03	47.10177	31.91595	Mykolaiv	2.46	1783	193	33	31	2
9.	Kozatske	2023-07-07	46.35353	30.04491	Odesa	3.14	1774	179	32	29	3
10.	Liubopil	2024-05-25	46.71740	31.09960	Odesa	1.88	1886	204	35	34	1
11.	Lymany	2023-07-09	45.66214	29.75014	Odesa	3.62	1812	203	51	43	8

#	Old cemeteries	Sampling data	Longitude	Latitude	Region	Area of old cemeteries	The establishment date of the village*	Number of vascular plant species per old cemeteries	Total species richness per vegetation plot	Species richness (vascular plants) per vegetation plot	Species richness (bryophytes) per vegetation plot
12.	Nova Dofynivka	2023-07-06	46.57513	30.91175	Odesa	3.83	1860	223	57	57	0
13.	Novo-bohdanivka	2023-07-04	46.87517	31.97336	Mykolaiv	1.47	1865	185	46	43	3
14.	Popazdra	2023-07-08	45.98511	30.30756	Odesa	0.81	1824	147	39	39	1
15.	Prylymanske	2024-05-26	46.41670	30.58567	Odesa	0.17	1793	114	45	44	1
16.	Pshonianove	2024-05-25	46.79642	31.12702	Odesa	0.10	1885	84	44	44	0
17.	Shestirnia	2024-05-23	47.55569	33.29087	Dnipro	2.25	1689	145	42	41	1
18.	Usatove	2024-05-26	46.52807	30.67237	Odesa	8.4	1775	215	42	42	0
19.	Velyka Korenykha	2023-07-04	46.93659	31.90835	Mykolaiv	2.72	1860	212	47	47	0
20.	Vypasne	2023-07-08	46.20308	30.25643	Odesa	2.73	1795	192	59	59	0

*date of the earliest probable burial

natural and seminatural open grassland habitats within the study area. In each plot, we recorded occurrences of vascular plants (shoot presence), all terricolous soil-growing bryophytes and lichens. For each 10m2 plot, several environmental and structural parameters were recorded: cover of vegetation layers and of litter, rocks, slope, aspect, inclination. Additionally, the complete 20 relevés with 7 nested-plot biodiversity series collected during expeditions following the EDGG methodology (Dengler et al. 2021) will available in the GrassPlot database (Dengler et al. 2018) by request.

Quality control: Some specimens of the vascular plants were collected as herbarium for determination and verification after the fieldwork. After digitizing the data, we harmonised the taxonomic information according to the nomenclature sources: for vascular plants — "Ukrainian Plant Trait Database: UkrTrait v. 1.0" (Vynokurov et al. 2024). for bryophytes — An annotated checklist of bryophytes of Europe, Macaronesia and Cyprus (Hodgetts et al. 2020). Then we used GBIF Backbone Taxonomy (GBIF species matching tool: https://www.gbif.org/tools/species-lookup) for the taxonomic check and implemented minor corrections of species names regarding misprints and problematic taxa to avoid misinterpretation. We additionally checked and verified the header data of vegetation plots (Event Core and GBIF Relevé Extension, Occurrence Extension) using OpenRefine (https://openrefine.

org/) and QGIS 3.38 (https://qgis.org) for quality control.

Step description:

1. Site selection, field research.
2. Identification of herbarium specimens of vascular plants, lichens, bryophytes.
3. Digitizing the field data forms.
4. Data checking and cleaning using OpenRefine (OpenRefine 2025).
5. Transformation of the dataset according to the Darwin Core standards (Wieczorek et al. 2012).
6. Taxonomic check, final quality control.

Geographic coverage

Description: The study area covered the Right-Bank of Dnipro Grass Steppe District, extending from Dnipopetrovsk, Kherson, Mykolaiv and Odesa administrative Regions, Southern Ukraine (Fig. 1).

Coordinates: 48.691 and 45.550 Latitude; 29.004 and 38.320 Longitude

Taxonomic coverage

Description: The dataset contains 1829 occurrences of 215 taxas names (199 vascular plants, 16 bryophytes) recorded in 20 vegetation plots during the during the project. The nomenclature of the dataset follows "Ukrainian Plant Trait Database: UkrTrait v. 1.0" — (Vynokurov et al. 2024), "An annotated checklist of bryophytes of Europe, Macaronesia and Cyprus" (Hodgetts et al. 2020) with minor edits.

The dataset includes 215 taxa name records (vascular plants, bryophytes), amongst them 36 taxas is determined to genus (30 bryophytes and six vascular plants). We used the taxonRank aggregate for some taxonomically problematic taxa and unclear determinations: *Festuca valesiaca* agg., *Festuca callieri* agg., *Festuca rupicola* agg. and *Syntrichia ruralis* agg.

Amongst all species records, the most common families of vascular plants are

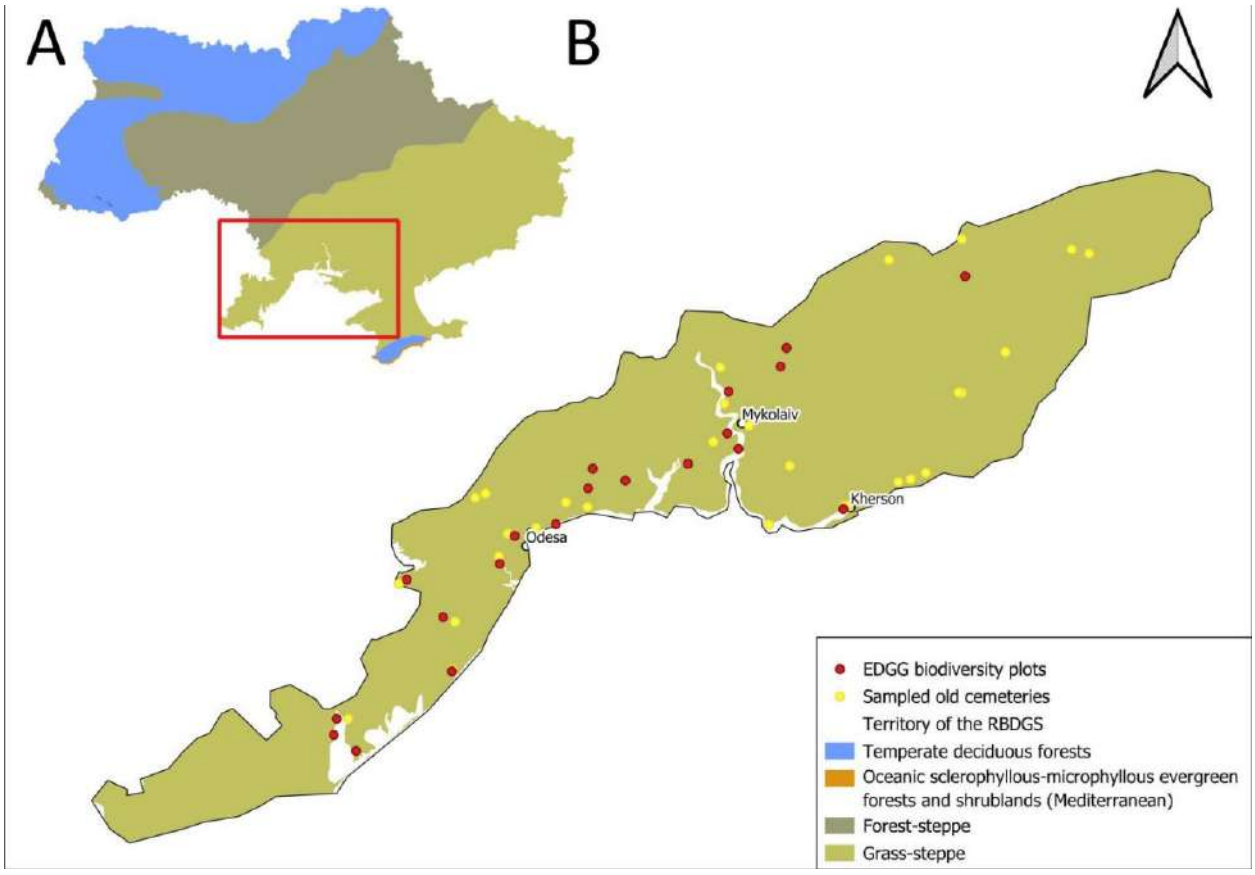

Figure 1. *Location of the study area within Ukraine according to climatic definitions of the world's terrestrial biomes (Loidi et al. 2022, 2023). The red polygon on the inset map of Ukraine indicates the geographical extent of the main ma. The study region – Right–Bank Dnipro Grass Steppe (RBDGS), country border, extracted from OpenStreetMap (openstreetmap.org).*

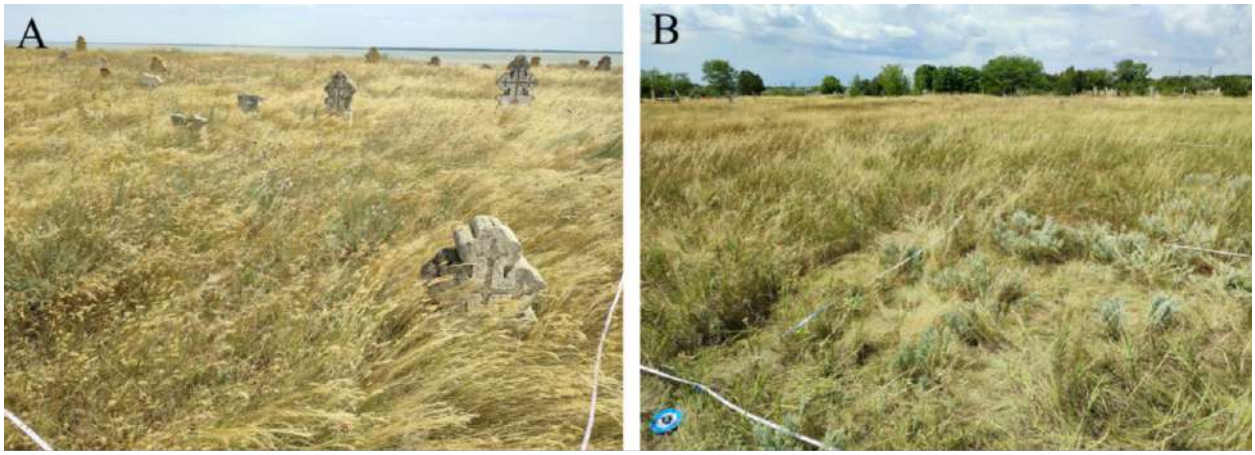

Figure 2. *Some old cemeteries of the Right–Bank Dnipro Grass Steppe District. Photos: N. Skobel. A — Hlyboke, B — Borysivka.*

Poaceae (418), *Asteraceae* (251), *Lamiaceae* (123), *Fabaceae* (115) and *Brassicaceae* (103).

The most common taxa of vascular plants at the species level are *Festuca valesiaca* agg. (44), *Agropyron pectinatum* (40), *Arenaria leptoclados* (40), *Artemisia austriaca* (36), *Poa angustifolia* (36), *Salvia nemorosa* (36), *Koeleria macrantha* (35), *Veronica arvensis* (35), *Bromus squarrosus* (33), *Medicago falcata* (33), *Securigera varia* (32), *Achillea setacea* (30), *Elytrigia intermedia* (29), *Kochia prostrata* (29), *Poa bulbosa* (29), *Stipa capillata* (28), and *Festuca callieri* agg. (26). The most common taxa of bryophytes are *Ptychostomum* sp. (13), *Weissia* sp. (13), *Barbula unguiculata* (11), *Weissia longifolia* (10) and *Tortula acaulon* (8).

Higher taxa included:

Rank	Scientific Name
Kingdom	Plantae

Temporal coverage

Data range: July 3, 2023, July 4, 2023, July 6, 2023, July 8, 2023, July 9, 2023, May 23, 2024, May 24, 2024, May 25, 2024, May 26, 2024

Usage licence

Licence: Attribution-NonCommercial 4.0 International (CC BY-NC 4.0)

Data resources

Alternative identifiers: https://doi.org/10.15468/bfuu93

Number of data sets: 1

Data set name: Records of vascular plants at the old cemeteries from the project «Plant diversity and species-area relationships modelling of steppe enclaves within old cemeteries of Northern Prychornomoria region (Northern Black Sea Region) of Southern Ukraine»

Character set: UTF-8

Resource link: https://www.gbif.org/dataset/c6ebbe9e-d151-475d-be35-d645d2ddb540

Data format: Darwin Core

Data format version:csv

Description: The dataset includes a table with 37 fields in Darwin Core terms and 1829 records in it (Skobel et al. 2025).

Data format version: 1.4

Column label	Column description
eventID (Darwin Core Event, GBIF Relevé Extension, Darwin Core Occurrence Extension)	An identifier for the Event (based on dataset name and relevé number)
samplingProtocol (Darwin Core Event)	The names of the methods or protocols used during an Event (Species Shoot Presence).

Column label	Column description
sampleSizeValue (Darwin Core Event)	A numeric value for a measurement of a sample in a sampling event (10, 100).
sampleSizeUnit (Darwin Core Event)	The unit of measurement of the size of a sample in a sampling event (square metre).
eventDate (Darwin Core Event)	The date-time or interval during which an Event occurred.
continent (Darwin Core Event)	The name of the continent in which the Location occurs. In our case, it is always Europe.
country (Darwin Core Event)	The name of the country or major administrative unit in which the Location occurs. In our case, it is always Ukraine.
countryCode (Darwin Core Event)	The standard code for the country in which the Location occurs. In our case, it is always UA.
stateProvince (Darwin Core Event)	The name of the administrative region of Ukraine in which the Location occurs.
county (Darwin Core Event)	The full, unabbreviated name of the next smaller administrative region than stateProvince (districts).
locality (Darwin Core Event)	The specific description of the place. The nearest village and name of cemetery or official name of cemetery.
verbatimElevation (Darwin Core Event)	The original description of the elevation (altitude, usually above sea level) of the Location. Measurement with R package 'evelator'.
decimalLatitude (Darwin Core Event)	The geographic latitude in decimal degrees.
decimalLongitude (Darwin Core Event)	The geographic longitude in decimal degrees.
geodeticDatum (Darwin Core Event)	The geodetic datum upon which the geographic coordinates are given. In our case, it is always WGS84.
coordinateUncertaintyInMeters (Darwin Core Event)	The distance (in metres) from the given decimalLatitude and decimalLongitude describing the smallest circle containing the whole of the Location (30 m).
georeferencedBy (Darwin Core Event)	The person who determined the georeference.
georeferenceProtocol (Darwin Core Event)	The description of the method used to determine coordinates (GPS).
aspect (GBIF Relevé Extension)	The compass direction that the relevé site faces (Note: -1 flat area).
inclinationInDegrees (GBIF Relevé Extension)	The inclination of relevé site in degrees.
coverTotalInPercentage (GBIF Relevé Extension)	The total cover (%) of all plants, rounded to the nearest hundredth.
coverShrubsInPercentage (GBIF Relevé Extension)	The cover (%) of shrubs, rounded to the nearest hundredth.
coverHerbsInPercentage (GBIF Relevé Extension)	The cover (%) of the herb layer, rounded to the nearest hundredth.
coverCryptogamsInPercentage (GBIF Relevé Extension)	The cover (%) of cryptogams, rounded to the nearest hundredth.
coverLitterInPercentage (GBIF Relevé Extension)	The cover (%) of litter, rounded to the nearest hundredth.

Column label	Column description
coverRockInPercentage (GBIF Relevé Extension)	The cover (%) of bare rock, rounded to the nearest hundredth.
basisOfRecord (Darwin Core Occurrence Extension)	The method in which data were acquired (HumanObservation).
occurrenceID (Darwin Core Occurrence Extension)	An identifier of a particular occurrence, unique within this dataset. We used the species occurrence numbers.
recordedBy (Darwin Core Occurrence Extension)	The persons who is responsible for recording the Taxon to the subject.
identifiedBy (Darwin Core Occurrence Extension)	The persons who is responsible for recording the Taxon to the subject.
scientificName (Darwin Core Occurrence Extension)	The original names according to 'Ukrainian Plant Trait Database: UkrTrait v. 1.0' and 'An annotated checklist of bryophytes of Europe, Macaronesia and Cyprus' , corrected for spelling mistakes using GBIF Species Matching tool.
kingdom (Darwin Core Occurrence Extension)	The full scientific name of the kindom in which the taxon is classified.
phylum (Darwin Core Occurrence Extension)	The full scientific name of the phylum or division in which the taxon is classified.
class (Darwin Core Occurrence Extension)	The full scientific name of the class in which the taxon is classified.
order (Darwin Core Occurrence Extension)	The full scientific name of the order in which the taxon is classified.
famile (Darwin Core Occurrence Extension)	The full scientific name of the family in which the taxon is classified.
taxonRank (Darwin Core Occurrence Extension)	The taxonomic rank of the most specific name in the scientificName.

Discussion

According to our counts, 199 vascular plant taxas were recorded across all vegetation plots. Richness values of the different taxonomic groups (complete vegetation, vascular plants, bryophytes, lichens) within 20 nested-plot series are shown in Table 2 (Skobel et al. 2025). Mean total species richness varied between two species in the smallest grain size (1 cm^2) and 40 species in the largest grain size (100 m^2). The richest plot at 100 m^2 (60 species of vascular plants) was located in Prylymanske (Odesa Region). The largest plot (100 m^2) accounts for 0.1% and 10.0% of the cemetery's total area (an average of 1.21%). The percentage of vascular plant species in a 100 m^2 plot out of the total number of species in the cemetery ranges from 15.7% to as high as 52.4% (on average, 23.9%) Mean species richness for bryophytes increased from 0 species in the smallest grain size to 3 species in the largest grain size. Most of the richest plots for bryophytes were recorded in Velyka Korenykha (0.1, 1, 10, 100 m^2 with 2, 3, 3 and 3 bryophytes species, respectively). Lichens were not found (Skobel et al. 2025). Compared to the EDGG Field Workshop data from the Ukrainian steppe (Moysiyenko et al. 2022), our study recorded lower mean richness across all scales, with the disparity most pronounced at larger grain sizes (Skobel et al. 2025).

The conservation significance is underscored by the presence of protected habitats and species. We recorded 2 ptorected habitats according to the Green Data Book of Ukraine (Didukh

Table 2. Descriptive statistics of the scale-dependent richness patterns across all sampled plots from Right-Bank of Dnipro Grass Steppe (Skobel et al. 2025).

Area (m^2)	n	All species			Vascular plants			Bryophytes			Lichens		
		mean	min	max	mean	min	max	mean	min	max	mean	min	max
0.0001	40	2.03	1	5	2.03	1	5	0.00	0	0	0.00	0	0
0.001	40	3.23	2	7	3.23	2	7	0.00	0	0	0.00	0	0
0.01	40	4.83	2	9	4.73	2	9	0.10	0	2	0.00	0	0
0.1	40	8.73	3	16	8.73	3	16	0.18	0	2	0.00	0	0
1	40	15.33	8	27	15.03	7	27	0.30	0	3	0.00	0	0
10	40	23.83	9	41	23.38	7	41	0.45	0	3	0.00	0	0
100	20	40.85	29	60	40.20	29	60	0.65	0	3	0.00	0	0

2009b) ((*Stipetum* (*capillatae*) *koeleriosum* (*cristatae*) and *Stipetum* (*ucrainicae*) *festucosum* (*valesiacae*)) and Perennial calcareous grasslands and basic steppes habitat of Resoiltion 4 of Berne Convention (1996).

Also we recorded (Skobel et al. 2025): 14 protected vascular plant species, according to the Red Data Book of Ukraine (Didukh 2009a) and regional red lists (Dnipropetrovsk Regional Council 2011; Odesa Regional Council 2011; Mykolaiv Regional Council 2012; Kherson Regional Council 2013):

- 5 species listed in the Red Data Book of Ukraine: *Astragalus henningii*, *A. borysthenicus*, *Stipa capillata*, *S. lessingiana*, *S. ucrainica*;
- 2 species included in the Regional Red List of Dnipropetrovsk Region : *Astragalus corniculatus*, *Potentilla recta*;
- 2 species included in the Regional Red List of Mykolaiv Region: E*phedra distachya*, *Iris pumila*;
- 5 species included in the Regional Red List of Odesa Region: *Allium guttatum*, *Arenaria leptoclados*, *Dianthus lanceolatus*, *Muscari neglectum*, *Phlomis hybrida*.

The presence of the endangered and protected vascular plant species within plots on old cemeteries of southern Ukraine of lower-than-average richness suggests that even less diverse steppe fragments are could have potential for the survival of steppes.

Conclusion

Despite this lower overall richness, the study area maintains high conservation value of old cemeteries. The harboring of two protected habitat types listed in the Green Data Book of Ukraine, one habitat of Resoiltion 4 of Berne Convention and 14 protected vascular plant species, underlining the importance of dry grasslands on old cemeteries of southern Ukeaine as refugia for threatened steppe flora.

Acknowledgements

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