DOI: 10.21570/EDGG.PG.65.25-34

Research Article

Plant diversity of steppe enclaves within old cemeteries of the Northern Black Sea Region (Southern Ukraine): first results of an ongoing project

Nadiia Skobel[1,2*], Nataliia Velychko[1], Iwona Dembicz[2] & Ivan Moysiyenko[1]

[1]Department of Botany, Kherson State University, Universytetska str. 27, 73000 Kherson, Ukraine; skobel2015@gmail.com (N. Skobel), nata.sergiivna.03@gmail.com (N. Velychko), ivan.moysiyenko@gmail.com (I. Moysiyenko)

[2]Department of Ecology and Environmental Conservation, University of Warsaw, ul. Żwirki i Wigury 101, 02-089, Warsaw, Poland; iwona.dembicz@uw.edu.pl

*) Corresponding author

Palaearctic Grasslands 65 (2025): 25-34

Abstract: We conducted our study in the Northern Black Sea Region of Ukraine. We inventoried the flora of 50 old cemeteries, mainly focusing on well-preserved old cemeteries with steppe vegetation of the class *Festuco-Brometea* and established, at the old cemeteries, 20 nested plots of seven grain sizes from 1 cm^2 to 100 m^2 ("EDGG biodiversity plots"). We focused on the evaluation of species richness, the presence of protected species, the potential of old cemeteries as refuges for steppe vegetation, and on the species richness of steppe plant communities in the old cemeteries. This article includes the results of the previous investigations carried out in 2007-2024. The species list includes 688 species of vascular plants recorded at the 50 old cemeteries. In addition, a subset of 204 species was recorded within the biodiversity plots. We summarize the scale-dependent richness values and compare them with data from another study within the steppe area (the EDGG 15th Field Workshop). The flora of old cemeteries includes 66 protected species with different conservation statuses: 3 species are listed in Resolution 6 of the Bern Convention, 16 species in the Red Data Book of Ukraine and 49 species in the Regional Red Lists of the Dnipropetrovsk, Kherson, Mykolaiv and Odesa administrative regions. We propose a series of measures for the future preservation and conservation of old cemeteries in Ukraine.

Keywords: cultural heritage sites; flora; nested series; protected species; steppe; Ukraine; vascular plants.

Nomenclature: Vynokurov et al. (2024) for vascular plants, Mucina et al. (2016) for syntaxa.

Abbreviations: EDGG = Eurasian Dry Grassland Group.

Submitted: 4 April 2024; Accepted: 11 August 2025

Scientific Editor: Denys Vynokurov. Linguistic Editor: Lorna Marcham

Introduction

Anthropogenic activities have led to a significant loss of natural habitats in the world over the last few centuries (Radik & Gavrilovic 2020), also in Ukraine (Burkovskyi et al. 2013). Steppe habitats suffered the greatest losses in the XIX and XX centuries (Burkovskyi et al. 2013). Previously, steppes occupied about 40% of the modern territory of Ukraine (Korotchenko & Peregrym 2012), while today steppe remnants have survived on only 1-3% of the natural and semi natural steppes of Ukraine (Korotchenko & Peregrym 2012; Burkovskyi et al. 2013).

Steppe flora is preserved mainly in protected areas, ravines, gullies, river terraces and sea cliffs (usually due to steep slopes, which make ploughing with agricultural machinery impossible) (Burkovskyi et al. 2013). Cultural heritage sites, such as burial mounds (kurgans), old settlements and old cemeteries, could also serve as sites for the preservation of biodiversity, given their status as sacred places (Löki et al. 2019a). In the steppe zone of Ukraine, kurgans and old settlements serve as important refuges of steppe vegetation in Eastern Europe, where intensive landscaping and agriculture have largely eliminated most of the natural steppe vegetation (Dayneko et al. 2020; Moysiyenko et al. 2022). Recently, studies in other countries have recognized the natural value of old cemeteries and other cultural heritage sites (Vickery et al. 2009; Löki et al. 2019a, 2019b).

Nevertheless, at the time of writing, there is no official historical database of old cemeteries in Ukraine. Despite their significance for biodiversity preservation, old cemeteries have not been subjected to a survey in Ukraine before. In contrast, in the European Union and neighbouring territories, there is a project to increase awareness and preserve the heritage of European old cemeteries (Significant Cemeteries 2024). Research of the old cemeteries as complex objects of both cultural and natural importance is a new approach in Ukraine. The study of the flora of old cemeteries has been the subject of our in-depth research. In our study, we define old cemeteries as cultural heritage sites established more than 100 years ago (Moysiyenko et al. 2021).

Prior to the 20th century, stone crosses were used as grave markers in southern Ukraine. Over time, these crosses have fallen and deteriorated (History of villages of the Ukrainian SSR 1953), becoming overgrown with vegetation and disappearing. As a result, areas within old cemeteries without new burials may exist today as uncultivated flat areas, where typical steppe vegetation remains (Skobel et al 2022a, 2022b, 2023a, 2023b).

Figure 1. Some old cemeteries of the Right-Bank Dnipro Grass Steppe. A - Chervonyi Tik, B - Inhulka, C - Kamianka, D - Kostiantynivka, E - Nerubaiske, F - Shestirnia. Photos: N. Skobel.

In our previous research, 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; Skobel & Moysiyenko 2022). The aim of the research is to evaluate the species richness, analyze the presence of protected vascular plant species, and provide insight into threats to protected species of 50 old cemeteries located within the Right-Bank Dnipro Grass Steppe District and the significance of their active conservation. In this study we present some preliminary results of investigation at the 50 old cemeteries.

Study area

We investigated 50 old cemeteries located within the Right-Bank Dnipro Grass Steppe District (the western bank of Ukraine, southern Ukraine). This territory, according to the geobotanical zoning of Ukraine and adjacent areas (Didukh & Sosonko 2003), belongs to the Pontic Steppe Province of Ukraine (Figures 1, 2, Table 1). The territory includes parts of the Northern Black Sea Region (Barbarych 1977) i.e. Dnipopetrovsk, Kherson, Mykolaiv and Odesa administrative regions (47.96-44.80° N, 34.80-28.96 °E).

This area is situated in the south-western part of the Steppe Zone of Ukraine, in fescue-feather grass steppes (or bunchgrass/grass steppes) (Moysiyenko et al. 2022), according to the national geobotanical zone classification system (Barbarych 1977). The steppe physiognomy in the region is determined by the prevalence of fescue-feather grass steppes with *Festuca* and *Stipa* species, also with a good amount of xerophytes (Lavrenko et al. 1991).

The climate is continental and is characterized by snowless winters and hot, dry summers (Mordkovych 2014). 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 tem-

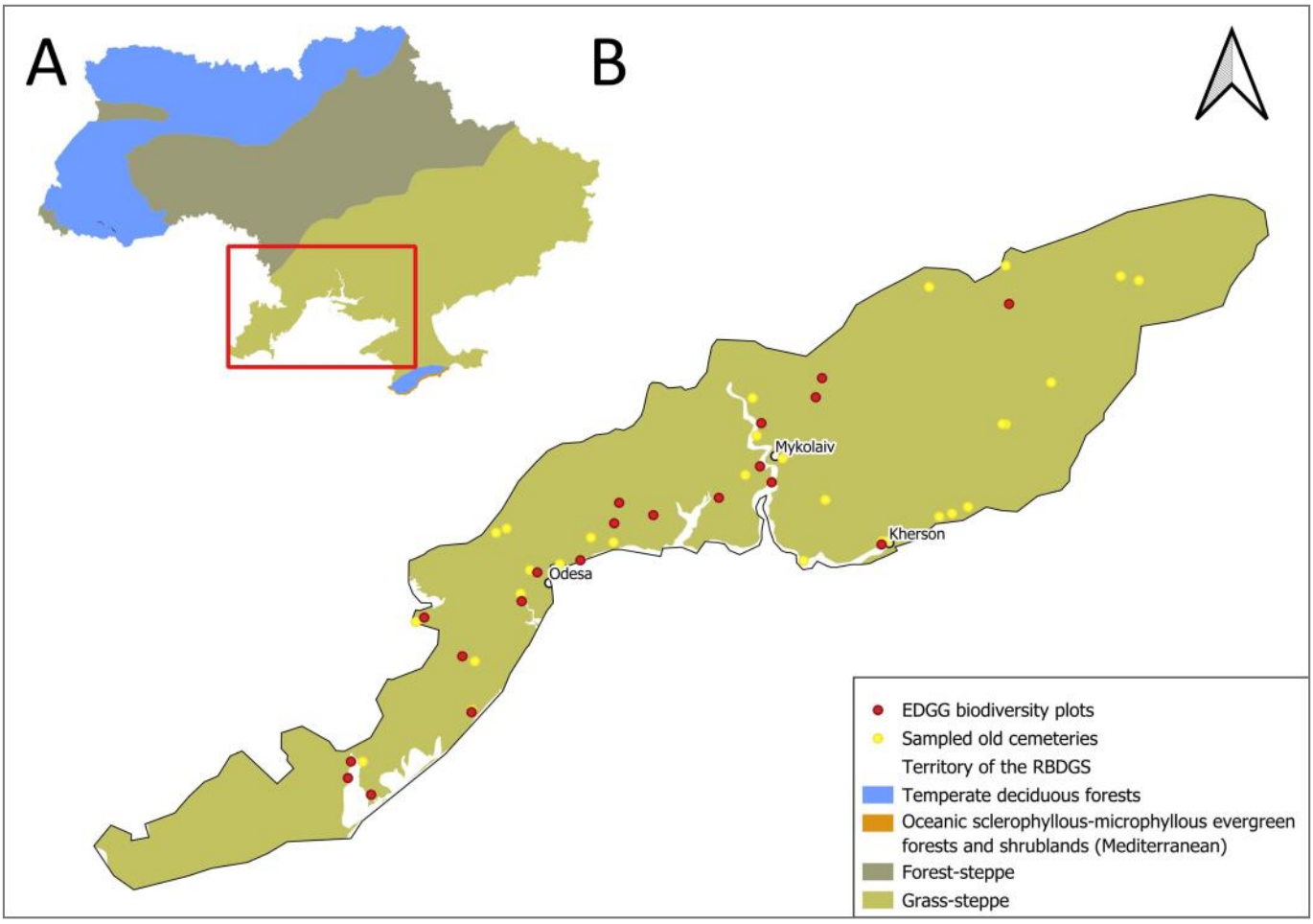

Figure 2. Location of the study area within Ukraine (A) according to climatic definitions of the world's terrestrial biomes (Loidi et al. 2022, 2023). The red rectangle on the inset map of Ukraine indicates the geographical extent of the main map (B). The study region - Right-Bank Dnipro Grass Steppe, country border, extracted from openstreetmap.org.

peratures 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 territory is characterized by a relatively flat surface. Ravines are present in all the administrative regions (Marynych & Shyshchenko 2005), but not in the vicinity of old cemeteries. Old cemeteries located in the Odesa (Hlyboke) and Mykolaiv (Yelysavetivka) regions are characterized by wind erosion of the coast and landslides (Marynych & Shyshchenko 2005). In the north-east of the Right-Bank Dnipro Grass Steppe District, near Chervonyi Tik, there are granite outcrops (Marynych & Shyshchenko 2005).

Today, nearly every human settlement in Ukraine, whether city or village, has old cemeteries. The combined area of the 50 old cemeteries studied is 55.5 hectares (Table 1). 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).

Table 1. Studied old cemeteries of the Right-Bank Dnipro Grass Steppe. Old cemeteries marked with an asterisk (*) are those with established biodiversity plots.

№	Site location	Region (Oblast)	Latitude	Longitude	Establishment date of the village (*date of the earliest probable burial)	Area [ha]
2	Borysivka*	Odesa	45.792525	29.637213	1860	2.00
3	Buldynka	Odesa	46.662591	30.970278	1803	1.88
4	Cemetery near Kurgan Balakshova	Kherson	47.098420	33.253836	1855-1865	0.67
5	Cemetery Zabalkivske	Kherson	46.636648	32.582764	1870	9.75
6	Chervonyi Tik	Dnipropetrovsk	47.660932	33.910625	1927	1.50
7	Ekonomiia Ivanivka	Kherson	47.097128	33.273068	1822	2.21
8	Fedorivka	Mykolaiv	46.749047	31.316719	1800	1.32
9	Hlyboke*	Odesa	45.727587	29.619549	1841	2.73
10	Inhulka	Mykolaiv	47.200287	32.217219	1802	4.26
11	Jewish cemetery c. Bilhorod-Dnistrovskyi	Odesa	46.183482	30.325645	1855-1865	0.35
12	Jewish cemetery c. Kherson	Kherson	46.648517	32.586413	1860	2.82
13	Kamianka	Mykolaiv	46.815796	31.679462	1790	2.41
14	Kherson Memorial Cemetery	Kherson	46.649444	32.613333	1780h	15.6
15	Khrystoforivka	Mykolaiv	47.273123	32.252789	1799	1.20
16	Korolivske	Mykolaiv	46.903175	31.826942	1926 (*1860)	0.31
17	Kosivka	Odesa	45.993698	30.311768	1834	0.70
18	Kostiantynivka*	Mykolaiv	47.102464	31.915738	1783	2.46
19	Kozatske*	Odesa	46.354418	30.044033	1774	3.14
20	Kryzhanivka	Odesa	46.559707	30.797625	1775	0.75
21	Liubopil	Odesa	46.717086	31.100161	1886	1.88
22	Lymany*	Odesa	45.662276	29.750728	1812	3.62
23	Mykolaivskyi Nekropol	Mykolaiv	46.967107	32.034375	1795	32.5
24	Nerubaiske	Odesa	46.536969	30.632117	1795	4.67
25	Nova Dofynivka*	Odesa	46.575880	30.912262	1860	3.83
26	Novobohdanivka (big cemetery)*	Mykolaiv	46.874752	31.972625	1865	1.47
27	Novobohdanivka (small cemetery)	Mykolaiv	46.876910	31.973002	1920	0.70
28	Odradove	Odesa	46.681123	30.443640	1637	0.87
29	Poniativka	Kherson	46.743071	32.903220	1780	1.10
30	Popazdra*	Odesa	45.985272	30.307722	1824	0.81
31	Posad- Pokrovske	Kherson	46.807617	32.271652	1789	3.48
32	Prylymanske	Odesa	46.416696	30.585638	1793	0.17
33	Pshonianove	Odesa	46.796467	31.127069	1850	0.10
34	Sebyne	Mykolaiv	47.197869	31.867054	1792	0.89
35	Shestirnia	Dnipropetrovsk	47.555680	33.290566	1689	2.25
36	Shyroke	Dnipropetrovsk	47.700544	33.272559	1787	8.94
37	Skobeleve	Mykolaiv	47.620095	32.847386	1875	1.55
38	Stanislav	Kherson	46.572933	32.150254	1697	6.80
39	Starokozachie	Odesa	46.336391	29.998868	1824	3.48
40	Sychavka	Odesa	46.644083	31.095152	1801	1.95
41	Tiahynka	Kherson	46.780492	33.062809	1778	700
42	Tokarivka	Kherson	46.754950	32.974147	1780	2.60
43	Trapivka	Odesa	45.791889	29.703639	1829	2.12
44	Tryfonivka	Kherson	47.257042	33.524622	1863	3.27
45	Usatove	Odesa	46.528096	30.670819	1775	8.40
46	Ust-Kamianka	Dnipropetrovsk	47.644582	34.011166	1754	0.58
47	Velyka Korenykha*	Mykolaiv	46.936568	31.907024	1860	0.34
48	Velykyi Dalnyk	Odesa	46.445883	30.579972	1795	2.72
49	Vypasne*	Odesa	46.203091	30.256395	1795	1.32
50	Yelysavetivka	Odesa	46.697052	30.501878	1856	0.45

Methods

Our research is based on data sampled from 2007-2024. We have searched for old cemeteries in bibliographical sources and open sources for research. The selection of old cemeteries in 2023-2024 for the research was based on ongoing materials from the Google map "Ancient Cemeteries of Ukraine" (Ukraine Incognita 2024) and data on the dates of foundation of human settlements (History of villages of the Ukrainian SSR 1953; Schubert Maps 1965; Malyna 2009). The area and boundaries of the old cemeteries were determined using Google Earth and include the entire area of the old cemeteries, including the area of new burials if the old cemetery was extended (Google Earth 2024). We carried out a visual analysis based on satellite images, with particular emphasis on the selection of cemeteries that were not overgrown and not covered with phanerophytes. In order to carry out a study of the flora of the area in question and of the presence of steppe refugia in the old cemeteries, we followed the following criteria, which could only be checked in the field:

- Presence of protected species (Didukh 2009; Dnipropetrovsk Regional Council 2011; Odesa Regional Council 2011; Mykolaiv Regional Council 2012; Kherson Regional Council 2013).
- Presence of bunch-grasses (or tussock grasses such as Festuca, Koeleria, Stipa etc.) and other steppe species from the class *Festuco-Brometea* (Mucina et al. 2016).
- High proportion of native species in comparison to alien species (Protopopova 1991).

In total we inventoried the flora of 50 old cemeteries during 2007-2024 and established 20 nested-plot series (EDGG (Eurasian Dry Grassland Group) Biodiversity Plots) in 2023-2024 with seven grain sizes from 1 cm^2 to 100 m^2 (Dengler et al. 2016, 2021). Floristic surveys in old cemeteries were conducted three times during the growing season: in spring, summer, and autumn. The list of flora includes only spontaneous species of vascular plants.

Plot selection for the nested-plot series was conducted within each study site in quasi-homogeneous stands of the recognizable vegetation type of *Festuco-Brometea* (Mucina et al. 2016), considering both site conditions and floristic composition. These sites have been chosen free of anthropogenic impact (cultural maintenance, new graves, etc.) on the old parts of old cemeteries in the flat steppe areas, with a buffer zone radius of at least 100 meters in diameter to minimize anthropogenic impact. In some cases, nested-plot series were established with old stone crosses incorporated into the study design (Hlyboke, Nova Dofynivka). These areas have already been devoid of human activity, except for old stone crosses, without repeated burials.

For all nested plots environmental and structural parameters were recorded in situ, including cover of vegetation layers and of litter, dead wood, stones and rocks, gravel, open soil, slope, aspect, inclination, maximum microrelief, soil depth, maximum and mean height of vegetation layers and land use. Soil samples were also collected (for details see Dengler et al. 2016, 2021). Various soil parameters will be analyzed by N.S. in University of Warsaw using EDGG protocols. For each nested plot, we calculated species richness of all vegetation layers.

First results and discussion

Vascular plants

688 vascular plant species were recorded in the flora of 50 old cemeteries. Total species richness ranged from 84 (Pshonianove) to 242 (Nerubaiske). The mean number of vascular plant species per old cemeteries was 174. The flora of the investigated old cemeteries represents 13.5% of the flora of Ukraine, which includes 5,100 species (Mosyakin & Fedoronchuk 1999), 33.9% of the flora of Northern Black Sea Region, which includes 2,025 species (Moysiyenko 2013). After final checking, the number may be slightly amended. 204 species (among them, 14 protected species) were recorded within the biodiversity plots.

Protected species of vascular plants

We recorded 66 protected vascular plant species (Figure 3), according to Resolution 6 of the Bern Convention (Revised Annex I 1998), the Red Data Book of Ukraine (Didukh 2009) and regional red lists (Dnipropetrovsk Regional Council 2011; Odesa Regional Council 2011; Mykolaiv Regional Council 2012; Kherson Regional Council 2013):

- 3 species listed in Resolution 6 of the Bern Convention: *Iris hungarica, Jurinea cyanoides, Paeonia tenuifolia*.
- 16 species listed in the Red Data Book of Ukraine: *Adonis vernalis, A. wolgensis, Astragalus borysthenicus, A. dasyanthus, A. henningii, Betula borysthenica, Cymbochasma borysthenica, Iris hungarica, Ornithogalum boucheanum, O. refractum, Paeonia tenuifolia, Stipa capillata, S. lessingiana, S. ucrainica, Tulipa schrenkii, T. biebersteiniana*.
- 25 species included in the Regional Red List of Dnipropetrovsk Region: *Alcea pallida, Allium paniculatum, A. rotundum, Amygdalus nana, Anemone sylvestris, Astragalus corniculatus, Convallaria majalis, Convolvulus lineatus, Dianthus guttatus, Ephedra distachya, Goniolimon besserianum, Haplophyllum suaveolens, Inula oculus-christi, Iris pumila, Kohlrauschia prolifera, Linaria biebersteinii, Muscari neglectum, Ornithogalum kochii, Padus avium, Potentilla recta, Rosa corymbifera, Salvia austriaca, Sedum sexangulare, Sempervivum ruthenicum, Senecio borysthenicus, Thymus* x *dimorphus*.
- 17 species included in the Regional Red List of Kherson Region: *Amygdalus nana, Bellevalia sarmatica, Centaurea trichocephala, Convallaria majalis, Dianthus andrzejowskianus, Elytrigia pseudocaesia, Ephedra distachya, Fraxinus excelsior, Iris halophila, Limonium*

platyphyllum, Linaria macroura, Muscari neglectum, Peucedanum ruthenicum, Prangos odontalgica, Quercus robur, Veronica capsellicarpa, Vinca herbacea.

- 9 species included in the Regional Red List of Mykolaiv Region: *Amygdalus nana, Anemone sylvestris, Astragalus pallescens, Convallaria majalis, Ephedra distachya, Iris pumila, Limonium platyphyllum, Polygonatum multiflorum, Sempervivum ruthenicum*.
- 17 species included in the Regional Red List of Odesa Region: *Allium guttatum, Anemone sylvestris, Arenaria leptoclados, Asyneuma canescens, Bellevalia sarmatica, Convallaria majalis, Dianthus lanceolatus, Helichrysum arenarium, Iris halophila, Iris pumila, Kohlrauschia prolifera, Muscari neglectum, Ornithogalum kochii, Phlomis hybrida, Salvia nutans, Sedum sexangulare, Valeriana officinalis*.

Species richness patterns

According to our preliminary counts, 204 vascular plant species 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. 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 m2 (60 species of vascular plants) was located in Prylymanske (Odesa Region).

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.

When our results were compared to those from a previous EDGG Field Workshop in the steppe zone (Moysiyenko et al.

Figure 3. Protected species of the Right-Bank Dnipro Grass Steppe. Photos: A - *Adonis vernalis*, B - *Ornithogalum boucheanum*, C - *O. refractum*, D - *Stipa capillata*. Photos: N. Skobel.

2022), mean richness was lower in our data, especially in the larger grain sizes. For example, at the grain size 10 m^2, mean species richness was 20 species for complete vegetation (same for only vascular plants) in comparison with the mean richness obtained in the FW (28 for complete vegetation, 24 for vascular plants). The mean number of bryophytes was also generally lower in our study, especially for the larger grain sizes, while lichens did not occur (Moysiyenko et al. 2021).

14 protected species were recorded in the plots:

- 5 species listed in the Red Data Book of Ukraine: *Astragalus henningii, Astragalus borysthenicus, S. 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: *Ephedra distachya, Iris pumila*.
- 5 species included in the Regional Red List of Odesa Region: *Allium guttatum, Arenaria leptoclados, Dianthus lanceolatus, Muscari neglectum, Phlomis hybrida*.

Problems of preservation and conservation of biodiversity at the old cemeteries in southern Ukraine

Old cemeteries have challenges in preserving biodiversity, which are the elimination of these sites, re-purposing of the land, reburials and absence of a management plan. According to current legislation, specifically, the "Instructions on the Procedure for Burial, Maintenance of Cemeteries, and Organization of Ritual Services in Settlements of Ukraine KDI -204/12 Ukraine 182-91," the use of a closed cemetery or a separate plot in an active cemetery for secondary burials may be permitted after 20 years. The closure of cemeteries is allowed no earlier than 20 years after the last burial (Cabinet of Ministers of Ukraine 1999). In most of these old cemeteries, we recorded reburials. The natural vegetation cover and protected species could be damaged and destroyed after these reburials.

The presence of species listed in the Red Book of Ukraine and regional red lists provides a basis (according to current Ukrainian law) for the creation of nature conservation areas (Verkhovna Rada Ukrainy 1992). In our opinion, old abandoned cemeteries could be designated as natural monuments. Designation of natural monuments is carried out without expropriating land plots and other natural objects from their owners. Natural monuments are individual unique natural formations with special environmental, scientific, aesthetic, educational, and cultural significance. Designation aims to preserve them in their natural state (Verkhovna Rada Ukrainy 1992).

Moreover, the presence of species listed in Resolution 6 of the Bern Convention provides a rationale for establishing an Emerald Network site in old cemeteries - for protecting sections of old cemeteries from new burials and reburials, and for implementing a management plan at old cemeteries. The cemeteries of the south of Ukraine lack management plans. Usually management plans are present in other countries, such as plans for single cemeteries in Canada (History of Notre-Dame-des-Neiges 2024), and in the United Kingdom (Richmond Old Cemetery 2018). The lack of management plans has resulted in the accumulation of litter in most of these cemeteries. We propose to preserve the steppe flora of old cemeteries by means of orderly management. In particular, mowing and cutting of tree and shrub vegetation will be most appropriate. We have noticed grazing and burning in the old cemeteries, but we do not believe it is ethical to use the latter techniques as management recommendations on these cultural heritage sites.

It is suggested that active conservation intervention in natural burial sites should only take place if the protection of the site cannot be ensured otherwise. This strategy is also fa-

Table 2. Descriptive statistics of the scale-dependent richness patterns across all sampled plots from Right-Bank Dnipro Grass Steppe.

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

vourable in view of the limited capacity of policy makers to manage conservation issues (Löki et al. 2019a). We support this idea. Since preservation and spirituality are closely intertwined, it is believed that the involvement of local communities and the restoration of deteriorated sacred and spiritual traditions, contributes to the preservation of natural flora (Löki et al. 2019a, 2019b). Involving communities is essential for the effective and respectful conservation of both natural and cultural values of burial places (Löki et al. 2019a). For old cemeteries, it is reasonable to implement a gentle informational campaign on more 'nature-friendly' burial care. For example, information boards/signs could be installed with information about protected species growing in these locations. Such approaches are already used in global practice (Löki et al. 2019a).

It is pertinent to highlight that there is a movement in Ukraine aimed at preserving the historical cultural heritage of the old cemeteries, implemented by NGO Ukraine Incognita within the framework of the "Ancient Cemeteries of Ukraine" project (Ukraine Incognita 2024). In the future, for some particularly valuable sites, it will be possible to introduce comprehensive protection that will contribute to the preservation of natural, historical and cultural values. Such an approach to cultural heritage sites in Ukraine has already been proposed for burial mounds (Sudnik-Wójcikowska et al. 2012).

Conclusions and outlook

Our preliminary results emphasise the species richness and protected species richness of the vascular flora of old cemeteries. These old cemeteries could have an important role in the preservation of steppe phytodiversity. Though relatively small individually, collectively they could contribute significantly to the preservation of the steppes in southern Ukraine. As soon as the vegetation data are ready, they will be integrated in the GrassPlot database (Dengler et al. 2018; Biurrun et al. 2019) and via this to the European Vegetation Archive (EVA; Chytrý et al. 2016) and the global plot database "sPlot" (Bruelheide et al. 2019) to allow the best possible use. Moreover, the floristic information has been published in the worldwide GBIF database (GBIF 2024; Skobel & Moysienko 2024; Skobel et al. 2024). The scale-dependent richness patterns in the steppe patches of old cemeteries will be used to explore issues related to island effects such as the influence of spatial isolation and size on plant diversity, as in Dembicz et al. (2016).

Author contributions

N.S., I.M. and I.D. planned the research and led the writing, N. S. prepared the map, I.M., N.S. and N.V. participated in the field sampling. All authors checked, improved and approved the manuscript.

Acknowledgments

This investigation was supported by an IAVS Special grant to support the research of Ukrainian members: "Plant diversity and species-area relationships modelling of steppe enclaves within of Northern Prychornomoria Region (Northern Black Sea Region) of Southern Ukraine". We would like to express our deep appreciation to the members of the expedition teams Barbara Sudnik-Wójcikowska, Maria Zachwatowicz, Maryna Zakharova, Viktoria Dzerkal, Kateryna Kalashnik, Olena Shchepeleva, Emilia Heinzel and Dmytro Krasko for his assistance with data cleaning. Finally, we also thank the reviewers for a critical evaluation of our manuscript, their relevant comments and suggestions.

References

Academy of Sciences of the Ukrainian SSR (ed.). 1953. *Istoriia mist i sil Ukrainskoi RSR: V 26 t*. [*History of Cities and Villages of the Ukrainian SSR: In 26 vols*]. Main Editorial Office of the Ukrainian Soviet Encyclopedia of the Academy of Sciences of the Ukrainian SSR, Kyiv, UA. [In Ukrainian]

Barbarych, A.I. (ed.) 1977. *Geobotanichne rayonuvannia Ukrainskoi RSR* [Geobotanical zoning of Ukrainian SSR]. Naukova Dumka, Kyiv, UA. [In Ukrainian]

Biurrun, I., Burrascano, S., Dembicz, I., Guarino, R., Kapfer, J., Pielech, R., García-Mijangos, I., Wagner, V., Palpurina, S., (…) & Dengler, J. 2019. GrassPlot v. 2.00 – first update on the database of multi-scale plant diversity in Palaearctic grasslands. *Palaearctic Grasslands* 44: 26–47.

Bruelheide, H., Dengler, J., Jiménez-Alfaro, B., Purschke, O., Hennekens, S.M., Chytrý, M., Pillar, V.D., Jansen, F., Kattge, J., (...) & Zverev, A. 2019. sPlot – A new tool for global vegetation analyses. *Journal of Vegetation Science* 30: 161–186.

Burkovskyi, O.P., Vasyliuk, O.V., Yena, A.V., Kuzemko, A.A., Movchan, Y.I., Moysiyenko, I.I. & Sirenko, I.P. 2013. *Ostanni stepy Ukrayiny: buty chy ne buty?* [*The last steppes of Ukraine: to be or not to be?*]. Geoprint, Kyiv, UA. *[In Ukrainian]*

Cabinet of Ministers of Ukraine. 1999. *Instruktsiia pro poriadok pokhovannia, utrymannia kladovyshch i orhanizatsiiu rytualnoho obsluhovuvannia v naselenykh punktakh Ukrainy KDI-204/12 Ukraina 182-91* [*Instructions on the procedure for burial, maintenance of cemeteries, and organization of ritual services in settlements of Ukraine KDI-204/12 Ukraine 182-91*]. URL: https://zakon.rada.gov.ua/go/v0126303-91 [Accessed 10 November 2025]. [In Ukrainian]

Chytrý, M., Hennekens, S.M., Jiménez-Alfaro, B., Knollová, I., Dengler, J., Jansen, F., Landucci, F., Schaminée, J.H.J., Aćić, S., (...) & Yamalov, S. 2016. European Vegetation Archive (EVA): an integrated database of European vegetation plots. *Applied Vegetation Science* 19: 173–180.

Cimetière Notre-Dame-des-Neiges (ed.). 2024. *History of Notre-Dame-des-Neiges.* URL: https://www.cimetierenotredamedesneiges.ca/en/about/history [accessed 27 August 2024].

Dayneko, P., Moysiyenko, I., Dembicz, I., Zachawatovicz, M. & Sudnik-Wójcikowska B. 2020. Ancient settlements in Southern Ukraine: how do local and landscape factors shape vascular plant diversity patterns in the last remnants of grass steppe vegetation? *Tuexenia* 40: 459–478.

Dembicz, I., Moysiyenko, I.I., Shaposhnikova, A., Vynokuorv, D., Kozub, Ł. & Sudnik-Wojcikowska, B. 2016. Isolation and patch size drive specialist plant species density within steppe islands: a case study of kurgans in southern Ukraine. *Biodiversity and Conservation* 25: 2289–2307.

Dengler, J., Boch, S., Filibeck, G., Chiarucci, A., Dembicz, I., Guarino, R., Henneberg, B., Janišová, M., Marcenò, C., (…) & Biurrun, I. 2016. Assessing plant diversity and composition in grasslands across spatial scales: the standardised EDGG sampling methodology. *Bulletin of the Eurasian Dry Grassland Group* 32: 13−30.

Dengler, J., Wagner, V., Dembicz, I., García-Mijangos, I., Naqinezhad, A., Boch, S., Chiarucci, A., Conradi, T., Goffredo, (...) & Biurrun, I. 2018. GrassPlot – a database of multi-scale plant diversity in Palaearctic grasslands. *Phytocoenologia* 48: 331–347.

Dengler, J., Biurrun, I. & Dembicz, I. 2021. Standardised EDGG methodology for sampling grassland diversity: second amendment. *Palaearctic Grasslands* 49: 22–26.

Didukh, Y.P. (ed.) 2009. *Chervona knyha Ukrainy. Roslynnyi svit* [*Red Data Book of Ukraine. Plant Kingdom*]. Globalkonsaltyng, Kyiv, UA. [In Ukrainian]

Didukh, Y.P. & Sosonko Yu, R. 2003. Heobotanichne rayonuvannya Ukrayiny ta sumizhnykh terytoriy [Geobotanical zoning of Ukraine and adjacent territories]. *Ukrainian Botanical Journal* 60(1): 6–17. [in Ukrainian]

Dnipropetrovsk Regional Council. 2011. *Pro zatverdzhennya Chervonykh spyskiv tvaryn ta roslyn Dnipropetrovs'koyi oblasti* [*Approval of the List of Species of Animals and Plants under Special Protection in the Territory of Dnipopetrovsk Region and their Regulations*]. Decisions of the session of the Dnipopetrovsk Regional Council № 219-10/VI since 27.12.2011. Dnipro, UA. [In Ukrainian]

European Commission. 1998. *Revised Annex I of Resolution 6 of the Bern Convention listing the species requiring specific habitat conservation measures (year of revision 2011)*. URL: https://eunis.eea. europa.eu/references/2443/species [accessed 31 May 2024]

GBIF. 2024. *Global Biodiversity Information Facility*. URL: https://www.gbif.org/uk/ [accessed 31 May 2024].

Google Earth. 2024. *Google Earth*. URL: https://earth.google.com/web/ [accessed 31 May 2024].

Karger, D.N., Conrad, O., Böhner, J., Kawohl, T., Kreft, H., Soria-Auza, R.W., Zimmermann, N.E, Linder, H.P. & Kessler, M. 2017. Climatologies at high resolution for the Earth land surface areas. *Scientific Data* 4: e170122

Kherson Regional Council. 2013. *Chervonyi spysok Khersonskoi oblasti* [*Red List of Kherson Region*]. Decisions of the XXVI session of the Kherson Regional Council of the VI convation № 893 since 13.11.2013. Kherson, UA. [In Ukrainian]

Korotchenko, I. & Peregrym, M. 2012. Ukrainian steppes in the past, at present and in the future. In: Werger, M. & van Staalduinen, M. (eds.) *Eurasian steppes. Ecological problems and livelihoods in a changing world* [Plant and vegetation 6], pp. 173–176. Springer, Dordrecht, NL.

Lavrenko, E.M., Karamysheva, Z.V. & Nikulina, R.I. 1991. *Stepy Eurazii* [*Steppes of Eurasia*]. Nauka, Leningrad, RU. [In Ukrainian]

Loidi, J., Navarro-Sánchez, G. & Vynokurov, D. 2022. Climatic definitions of the world's terrestrial biomes. *Vegetation Classification and Survey* 3: 231–271.

Loidi, J., Navarro-Sánchez, G. & Vynokurov, D. 2023. A vector map of the world's terrestrial biotic units: subbiomes, biomes, ecozones and domains. *Vegetation Classification and Survey* 4: 59–61.

Löki, V., Deák, B., Lukács, A.B., Molnár, V.A. 2019a. Biodiversity potential of burial places – a review on the flora and fauna of cemeteries and churchyards. *Global Ecology and Conservation* 18: 1–14.

Löki, V., Molnár, V.A., Süveges, K., Heimeier, H., Takács, A., Nagy, T., Fekete, R., Lovas-Kiss, Á., Kreutz, K.C., (…) & Tökölyi, J. 2019b. Predictors of conservation value of Turkish cemeteries: a case study using orchids. *Landscape and Urban Planning* 186: 36–44.

Malyna, V.V. 2009. *Kamiani khresty v Ukraini*. XVIII – XX st. [*Stone crosses in Ukraine. XVIII – XX centuries*.]. Artil «Khudozhniy mahazyn», Mykolayiv, UA. [in Ukrainian]

Marynych, O.M. & Shyshchenko, P.G. 2005. *Fizychna geografia Ukrainy* [*Physical geography of Ukraine*]. Znyannia, Kyiv, UA. [In Ukrainian]

Mordkovych, V.H. 2014. *Stepnyye ekosistemy* [*Steppe ecosystems*]. Geo, Novosibirsk, RU [In Russian]

Mosyakin, S.L. & Fedoronchuk, M.M. 1999. *Vascular plants of Ukraine. A nomenclatural checklist.* M.G. Kholodny Institute of Botany, Kyiv, UA, 345 pp.

Moysiyenko, I.I. 2013. Florystychne bahatstvo ta systematychna struktura flory Pivnichnoho Prychornomoria [Floristic diversity and taxonomic structure of the flora of the Pivnichne Prychornomoria (Northern Black Sea Coastal Plain)]. *Chornomorsky Botanical Journal* 9(1): 41–56. [in Ukrainian]

Moysiyenko, I.I., Skobel, N.O., Sudnik-Wójcikowska, B., Dembicz, I., Zachwatowicz, M., Zakharova, M.Ya. & Dzerkal, V.M. 2021. Old cemeteries as refuge of the steppe flora in Southern Ukraine. *Chornomorsky Botanical Journal* 17(3): 194–217.

Moysiyenko, I., Vynokurov, D., Shyriaieva, D., Skobel, N., Babitskyi, A., Bednarska, I., Bezsmertna, O., Chusova, O., Dengler, J., (…) & Dembicz, I. 2022. Grasslands and coastal habitats of Southern Ukraine: First results from the 15th EDGG Field Workshop. *Palaearctic Grasslands* 52: 44–83.

Moysiyenko, I., Sudnik-Wójcikowska, B., Dembicz, I., Zachwatowicz, M. & Skobel, N. 2023. The first dataset of vascular plant species occurrences on kurgans in Southern Ukraine. *Biodiversity Data Journal* 10: 1–26.

Mykolaiv Regional Council. 2012. *Pro zatverdzhennia Pereliku vydiv roslyn, yaki pidliahaiut osoblyvii okhoroni na terytorii Mykolaivskoi oblasti, ta Polozhennia pro noho* [*List of plant species that are subject to special protection on the territory of Myko-*

laiv Region and their Regulations]. Decisions of the Mykolaiv Regional Council, Mykolaiv, UA. [In Ukrainian]

Mucina, L., Bültmann, H., Dierßen, K., Theurillat, J.-P., Raus, T., Čarni, A., Šumberová, K., Willner, W., Dengler, J., (…) & Tichý, L. 2016. Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science* 19 (suppl. 1): 3–264.

Odesa Regional Council. 2011. *Pro zatverdzhennia Pereliku vydiv tvaryn i roslyn, yaki pidliahaiut osoblyvii okhoroni na terytorii Odeskoi oblasti, ta Polozhennia pro noho* [*On Approval of the List of Species of Animals and Plants under Special Protection in the Territory of Odesa Region and their Regulations*]. Decisions of the session of the Odesa Regional Council № 90-VI since 18.02.2011. Odesa, UA. [In Ukrainian]

Protopopova, V.V. 1991. *Sinantropnaya flora Ukrainy i puti ee razvitia* [*Synantropic flora of Ukraine and ways of its development*]. Naukova Dumka, Kyiv, UA. [In Russian]

Radic, B. & Gavrilovic, S. 2020. Natural Habitat Loss: Causes and Implications of Structural and Functional Changes. In: Leal Filho, W., Azul, A., Brandli, L., Lange Salvia, A. & Wall, T. (eds.) *Life on Land. Encyclopedia of the UN Sustainable Development Goals*, pp. 1-14. Springer, Cham, CH.

Richmond Old Cemetery. 2018. *Richmond Old Cemetery: management plan 2017-2027*. Borough Richmond upon Thames, London, UK.

Schubert Maps. 1965. *Etomesto – old maps online*. URL: http://www.etomesto.ru/shubert/ [accessed 10 November 2025].

Significant Cemeteries. 2024. *Significant cemeteries*. URL: https://www.significantcemeteries.org/p/significant-cemeteries.html [accessed 10 November 2025].

Skobel, N. 2022. *Stari tsvyntari mista Khersona yak refuhiumy stepovoyi flory* [*Old cemeteries of city Kherson as refuge of steppe flora*]. Master thesis. Kherson State Unviersity, UA [in Ukrainian]

Skobel, N. & Moysiyenko, I. 2022. Stari tsvyntari mista Khersona yak refuhiumy stepovoyi flory [Old cemetereies of city of Kherson asrefugeof steppe flora]. *Chornomorski Botanical Journal* 18(1): 52–70. [In Ukrainian]

Skobel, N. & Moysiyenko, I. 2024. Records of vascular plants at the old cemeteries in the Right-Bank Dnipro Grass Steppe District (Southern Ukraine). Kherson State University. Occurrence dataset accessed via GBIF.org on 2024-12-30.

Skobel, N., Moysiyenko, I., Sudnik-Wójcikowska, B., Dembicz, I., Zachwatowicz, M., Zakharova, M., Dzerkal, V. & Marushchak, O. 2022a. Vascular plants of Lower Dnipro Region (Southern Ukraine). Kherson State University. Occurrence dataset.

Skobel, N., Moysiyenko I., Sudnik-Wójcikowska, B., Dembicz, I. & Zachwatowic, M. 2022b. Factors influencing for the steppe flora and recommendation for subsequent protecting and conservation in of Kherson province (Southern Ukraine). 30th Conference of the European Vegetation Survey. Bratislava, Slovakia, May 9 – 13, 2022: 55.

Skobel, N., Moysiyenko, I., Sudnik-Wójcikowska, B., Dembicz, I., Zachwatowicz, M., Zakharova, M., Marushchak, O. & Dzerkal, V. 2023a. Vascular plants of in the Lower Dnipro Region (Southern Ukraine). *Biodiversity Data Journal* 11: e99004.

Skobel, N., Velychko, N., Schepeleva, O. & Moysiyenko, I. 2023b. Grass-step of the Right-Bank of Dnipro Grass steppe zone as refuge of steppe flora. *18th Eurasian Grassland Conference*. Szarvas, Hungary, September 25 – 28, 2023: 65.

Skobel, N., Zagorodniuk, N. & Moysiyenko, I. 2024. 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». Kherson State University. Sampling event dataset.

Sudnik-Wojcikowska, B. & Moysiyenko, I. 2012. *kurgany na „Dzikich Polach" – dziedzictwo kultury i ostoja ukraińskiego stepu*. [*Kurgans in the 'Wild Field' – a cultural heritage and refugium of the Ukrainian steppe*]. Wydawnictwa Uniwersytetu Warszawskiego, Warsawa, PL.

Ukraine Incognita. 2024. *Starovynni tsvyntari Ukrainy iz kamianymy kozatskymy ta davnoukrainskymy khrestamy* [*Ancient Cemeteries of Ukraine with Stone Cossack and Ancient Ukrainian Crosses*]. URL: https://ukrainaincognita.com/mista/karta-starovynnykh-tsvyntariv-z-kam-ianymy-kozatskymy-khrestamy [In Ukrainian] [accessed 10 November 2025]

Verkhovna Rada Ukrainy. 1992. Pro pryrodno-zapovidnyi fond Ukrainy: Zakon Ukrainy vid 16.06.92 r. № 2457-XII [On the nature reserve fund of Ukraine: Law of Ukraine dated 16.06.92 No. 2457-XII]. URL: https://zakon.rada.gov.ua/laws/show/2456-12 (date of application 29.02.2020). [In Ukrainian] [accessed 10 November 2025].

Vickery J.A., Feber R.E. & Fuller R.J. 2009. Arable field margins managed for biodiversity conservation: a review of food resource provision for farmland birds. *Agriculture, Ecosystems & Environment* 133: 1–13.

Vynokurov. D., Borovyk, D., Chusova, O., Davydova, A., Davydov, D., Danihelka, J., Dembicz, I., Iemelianova, S., Kolomiiets, G., (…) & Kuzemko, A. 2024 Ukrainian Plant Trait Database: UkrTrait v. 1.0. *Biodiversity Data Journal* 12: e118128.