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Flora and vegetation of the Dzhulaika Reserve in the Middle Dnipro (Dnieper) region of Ukraine

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Abstract. The botanical Dzhulaika Reserve, located in the middle part of the Dnipro (Dnieper) River valley, is a well-preserved area on the slopes of the Kremenchuk Reservoir in the forest-steppe zone of Ukraine. The taxonomic, biomorphological, and phytosociological structure of the plant communities was analysed, as well as the anthropophyte fraction, rare species, and habitats protected at the local, national, and international levels. The flora includes 657 species of vascular plants, of which 40 are protected at the regional level and 10 are included in the Red Data Book of Ukraine. The species composition, a brief description of vegetation, and lists of protected species and habitats are provided. The high floristic richness correlates with well-preserved vegetation, ranging from aquatic and wetland communities at the foothills to steppe and shrub-steppe communities and fragmented forests on the steep slopes of the Dnipro River. Taking into account the complete devastation of watersheds in the surrounding territories, this makes the study area a unique point of biodiversity in this part of Ukraine, so it requires appropriate protection measures and long-term monitoring.

Key words: rare species, Berne Convention, anthropophyte fraction, Kremenchuk Reservoir, forest-steppe zone

The paper is dedicated to the memory of Professor V. A. Solomakha, an outstanding Ukrainian scientist, a well-known specialist in the field of phytosociology, Doctor of Biological Sciences, laureate of M. Kholodny Prize of the National Academy of Sciences of Ukraine.

BIOGEOGRAPHY

1. Introduction

The primary tasks of nature conservation include ecosystem maintenance in a state of equilibrium, rewilding, and preservation of natural vegetation, which is destroyed at an incredible speed and on a large scale due to the increase in human impact. This increase is caused by the intensive economic use of land and the anthropogenic factors in general (Protopopova *et al.* 2002; Stojko & Koynova 2012).

As a result of active farming, the natural plant cover in the forest-steppe zone of Ukraine has been completely destroyed by ploughing. Most of the remaining fragments of natural vegetation have been preserved on steep slopes, in hard-to-reach places. Identification, study, and protection of such areas allow preserving their natural components, so that they can become centres for further renaturalization. An example is the botanical Dzhulaika Reserve on the slopes of the Kremenchuk Reservoir (Cherkasy region). This reserve, together with its surroundings covered with natural vegetation, is a very promising area for the creation of a larger protected area of national and European importance.

The purpose of our research was to inventory and analyse the structure of the flora and vegetation of the well-preserved Dzhulaika Reserve, representative of both the Middle Dnipro region and the central part of the Ukrainian forest-steppe zone.

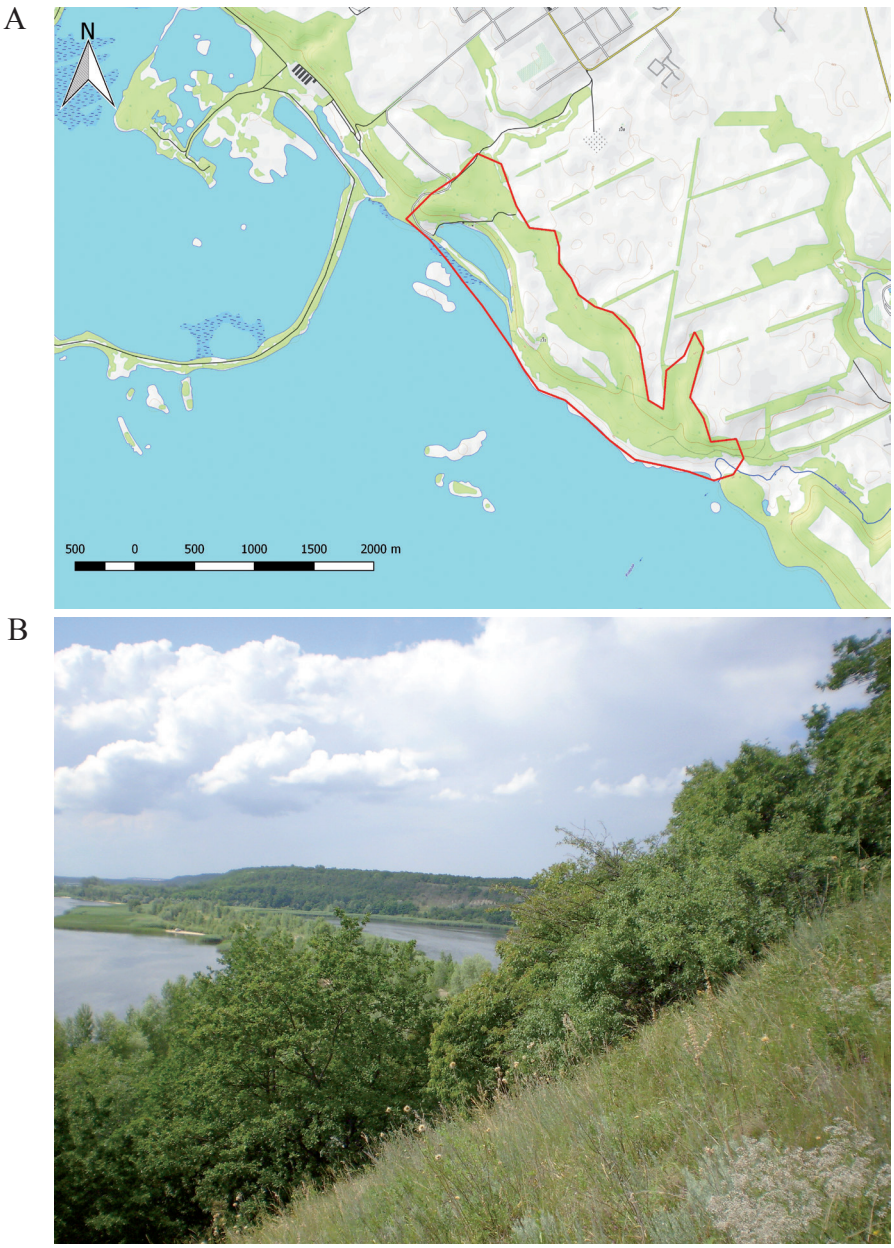

Fig. 1. Location (A) and landscape of the study area (B) – the Dzhulaika Reserve

2. Material and methods

2.1. Study area

The area is an array of coastal slopes located along the shores of the Kremenchuk Reservoir, between the villages of Prydniprovske and Kovrai in the former Chornobai district (now merged with the Zolotonosha district) of Cherkasy region. The central point of this area is 49°28'34.09"N, 32°22'14.24"E (Fig. 1A). The study area includes the botanical Dzhulaika Reserve (14 ha), which is an object of the Natural Reserve Fund of Ukraine. It was created by the decision of the Cherkasy Regional Council on 17 August 2004, for the protection and preservation of rare plant communities and species.

The study area belongs to the Zolotonosha-Chornobai physiographic region situated within the North Prydniprovsk Lowland of the Left-Bank Dnipro Forest-Steppe region within the Eastern European Plain (Popov *et al.* 1968; Marynych & Shyshchenko 2005). The total investigated area is about 231 ha – a promising territory for expanding the small Dzhulaika Reserve.

This is a hilly plain with a pronounced eroded topography, covered with steppe, shrub-steppe, and fragmented forests on the slopes, while wetlands at the lowest elevations, along the shores of the Kremenchuk Reservoir (Fig. 1B). The highest parts are located at 115-120 m a.s.l., which is a relative height of 35-40 m above the water level of the Kremenchuk Reservoir. The predominant soil types and subtypes are poorly developed chernozem-like soils, sometimes completely washed away, as well as grey forest soils and poorly formed soils on sandy deposits along the coast (Averchenko & Samoilenko 2018).

The climate is subcontinental: winters are mild with frequent thaws, and summer is warm. The average summer temperature is +19°C and the average temperature of the coldest month of January is -5.9°C (Lypynsky *et al*. 2003). Western winds bring precipitation.

2.2. Data collection and processing

The study is based on original data of our field research conducted in 2000-2020. The scientific names of taxa follow the Plants of the World Online (https://powo.science.kew.org/). We compiled a general list of plant species (Appendices 1-2) recorded in the study area at various times. By taxonomic structure, we understand the number and ratio of species of different taxonomic groups, usually at the level of families. The number of species included in the leading 10-15 families gives a clear idea of the structure of the flora of the study area. These data also characterize some regional regularities. The analysis of the biomorphological structure of the flora is based on Raunkiaer's (1937) plant life forms.

The groups of alien species were classified by Protopopova (1973, 1991) and Kornaś (1968, 1977). Plant species were analysed in respect of their time of introduction according to the classification of Kornaś (1968, 1977); the degree of naturalization according to the classification scheme of Schroeder (1969), modified by Protopopova and Shevera (2005, 2012); and the level of synanthropization and adventization (Faliński 1968; Jackowiak 1990, 1994).

Vegetation classes, their authorship, and diagnostic species correspond to the EuroVegChecklist (Mucina *et al.* 2016). The vegetation was studied using traditional geobotanical methods (sample plots of 25-500 m^2, depending on the type of vegetation). The biotope system, including protected habitats, is presented after Kuzemko *et al.* (2018) and Vasilyuk *et al*. (2019). Habitats of Resolution 4 of the Berne Convention are given after Vasilyuk *et al.* (2019), too.

Table 1. Leading plant families of the local flora and comparison with the taxonomic structure of the flora of Ukraine

Family	No. of species in this study	% of total species		Family ranking	
		local flora	Ukrainian flora	local flora	Ukrainian flora
Asteraceae	88	13.4	14.7	1	1
Poaceae	63	9.6	7.9	2	2
Fabaceae	40	6.1	6.3	3	3
Lamiaceae	36	5.5	4.7	4	7
Caryophyllaceae	35	5.3	4.9	5	6
Cyperaceae	29	4.4	3.2	6	10
Rosaceae	29	4.4	5.2	7	4
Scrophulariaceae	29	4.4	3.7	8	8
Brassicaceae	25	3.8	5.1	9	5
Ranunculaceae	23	3.5	3.0	10	11
Total	397 (out of 657)	60.4	58.7		

3. Results and discussion

3.1. Taxonomic structure of the flora

The flora of the study area includes 657 species of vascular plants belonging to 341 genera and 87 families. A complete list of species is given in Appendices 1-2. The top 10 plant families, ordered by number of species, make up 60.4% (397 species) of the total flora (Table 1).

The main part of the systematic spectrum of the flora of the studied region consists of families that determine the nature of the studied flora. The leading families are the Asteraceae, Poaceae, and Fabaceae. The high number of the Fabaceae, Lamiaceae, and Caryophyllaceae species is confined mainly to steppe vegetation on steep eroded slopes. The position of the Cyperaceae family indicates the presence of boreal features of the studied flora, and it is also connected with the presence of significant areas of wetlands near the border with the Kremenchuk Reservoir.

The genera with the largest numbers of species are: *Carex* (20), *Veronica* (14), *Trifolium* (9), and *Juncus* (9). In general, the list of the 10 richest families and dominant genera is typical of the Middle Dnipro region (Shevchyk *et al.* 2006).

3.2. Plant life-forms

The dominance of hemicryptophytes is typical of temperate latitudes and is associated with the predominance of herbaceous vegetation in the plant cover of the study area (Table 2).

Table 2. Proportions of species of various plant life-forms (according to Raunkiaer's system)

Plant life-forms	% of total species	No. of species
Hemicryptophytes	56.6	372
Therophytes	19.6	129
Geophytes	9.4	62
Chamaephytes	5.8	38
Nanophanerophytes	4.7	31
Phanerophytes	3.8	25
Total	100.0	657

3.3. Characteristics of the vegetation

In general, the plant cover of the Dzhulaika Reserve is characterized by sharp changes in the types of communities due to the eroded and dissected relief. On the one hand, this leads to fragmentation of individual types of vegetation, but on the other hand, it creates significant biodiversity and a unique combination of different, even contrasting habitats (Fig. 2).

If we consider a conditional altitudinal gradient in the form of a section across the Dzhulaika Reserve, then from the lowest altitudes at the border with the Kremenchuk Reservoir, occupied by open aquatic and wetland vegetation, they are quickly replaced by meadow-steppe, shrub-steppe, and fragmented forest vegetation on steep slopes.

Plant communities of the classes *Lemnetea minoris* (with *Lemna minor*, *L. trisulca*, *Spirodela polyrrhiza*) and *Potamogetonetea* (with *Potamogeton perfoliatus*, *Stuckenia pectinata*) expectedly cover the waters of the reservoir. In the stagnant waters of the lake, separated from the main part of the reservoir by a narrow spit, conditions are favourable for communities of the alliances *Stratiotion* and *Utricularion vulgaris* (with *Hydrocharis morsus-ranae*, *Utricularia vulgaris*).

Moving further along the altitudinal gradient, in the transition zone of the coastal and aquatic communities, where peaty and very rich soil is developed, communities of the alliance *Glycerio-Sparganion* occur. In the same altitudinal zone, but in much larger areas (up to 15 ha), communities of the alliances *Phragmition communis* and *Magnocaricion gracilis* are located, mainly dominated by *Phragmites australis*, *Typha angustifolia*, *Carex acuta*, and *C. acutiformis*.

In some years, when the water level in the reservoir decreased at the end of summer and autumn, debris of the alliance *Eleocharition soloniensis* (class *Isoëto-Nanojuncetea*) dominated by *Cyperus fuscus* and *Limosella aquatica* was found on outcrops.

Thin sandy deposits of secondary aeolian origin have formed on the spit separating the inlet from the reservoir. The deposits are covered by communities of the oligotrophic psammophytic alliance *Festucion beckeri* (class *Koelerio-Corynephoretea canescentis*), with a dominance of *Carex colchica* and *Artemisia campestris*.

A strip of fresh, moist soil is occupied by meadow vegetation. This biotope has an ecotone character and is found in some places. It is very rich in rare species, such as *Ophioglossum vulgatum*, *Epipactis palustris*, *Centaurium erythraea*, *Pyrola rotundifolia*, *Pyrola minor*, *Dactylorhiza incarnata*, and *Iris sibirica*. Usually in these conditions, communities of *Deschampsia cespitosa* (*Molinio-Arrhenatheretea*) are found, with a dominance of *Poa palustris* and *Alopecurus pratensis*.

Steep slopes usually have outcrops of loess loam and a very thin layer of chernozem-like soil, in some places completely washed away. Such habitats are occupied by meadow-steppe vegetation and the dominant species are *Elytrigia intermedia, Calamagrostis epigeios*, and *Festuca rupicola*. Such fragments of steppe vegetation are especially interesting due to the preservation of rare species, such as *Stipa capillata, Galatella villosa*, *Amygdalus nana*, and *Ephedra distachya* (Shevchyk *et al.* 2006; Didukh 2009). In some years, outbreaks of *Orobanche caryophyllacea* are typical for communities of meadow-steppe vegetation. Slopes with active erosion

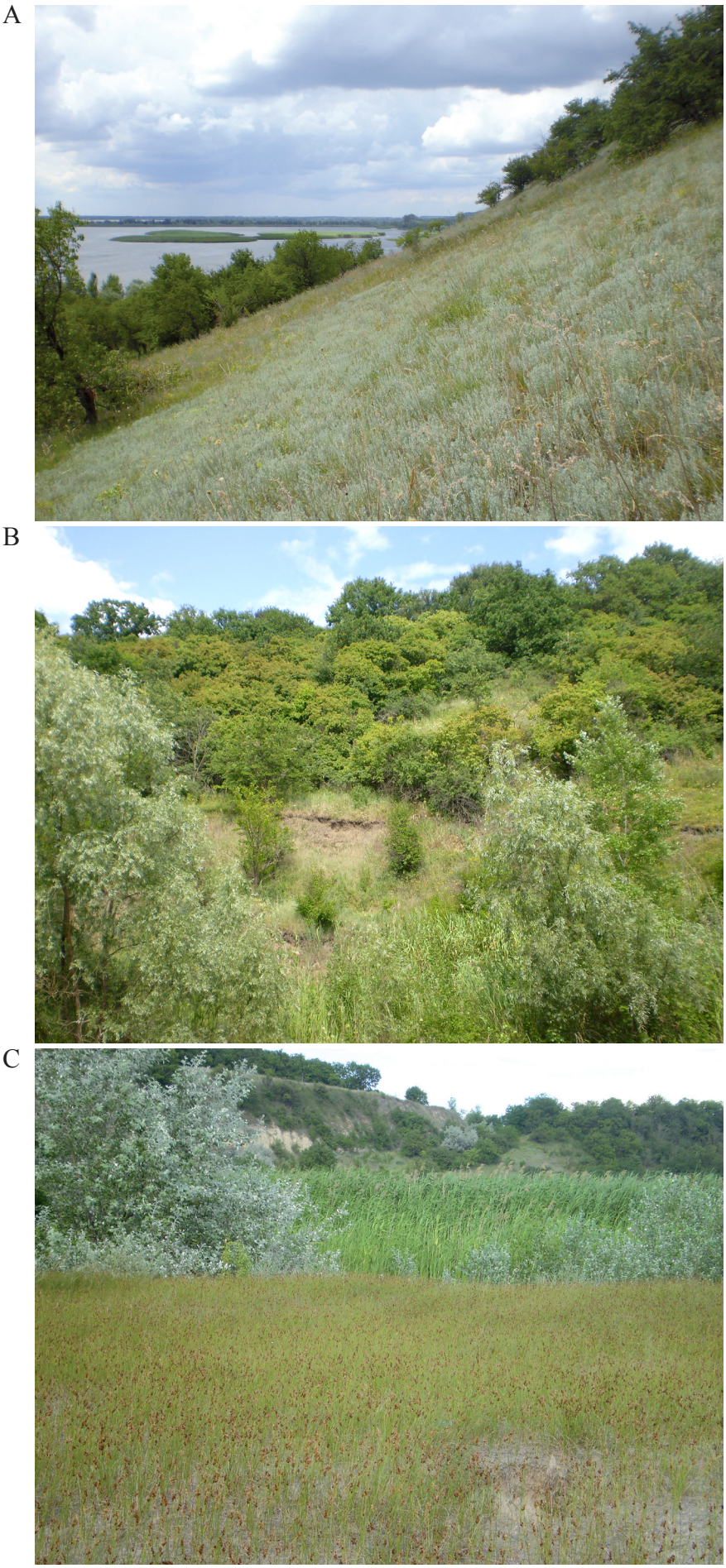

Fig 2. Steppe (A), forest-shrub (B), and wetland (C) vegetation in the Dzhulaika Reserve

and redisposition of sand represent successional stages dominated by *Artemisia marschalliana* and *Anisantha tectorum.*

In the lowlands, floodplain forests of the class *Salicetea purpureae* are common, dominated by *Salix alba* and *Populus nigra.* Large areas on the surface of gully cones of crushed stone, on gentle slopes and in the foothills of the reservoir are occupied by broad-leaved forests of the class *Carpino-Fagetea sylvaticae*. The most rugged and steep slopes (in total about 25 ha) are covered with planted *Robinia pseudoacacia*. The most advanced stages of shrub vegetation are represented by communities of the class *Crataego-Prunetea* (with *Acer tataricum*, *Cerasus fruticosa*, *Rhamnus cathartica*, *Prunus spinosa*, and *Ulmus minor*).

3.4. Phytosociological structure

Our analysis of phytosociological structure (Table 3) revealed the predominance of steppe species of the class *Festuco-Brometea* (17.4%), followed by the *Molinio-Arrhenatheretea* (14.3%). The relative dominance of these classes, as well as the third class of *Trifolio-Geranietea sanguinei*, is explained not by the prevalence of areas covered by plant communities of the mentioned classes, but by the floristic richness of the communities themselves, which are very diverse even in relatively small areas. The presence of two psammophytic classes *Koelerio-Corynephoretea canescentis* and *Sedo-Scleranthetea* is in accordance with a significant distribution of eroded slopes, although they are relatively poor in species (4.6% and 4.1%, respectively).

There are also patches of anthropogenic vegetation. The presence of species typical of the classes *Chenopodietea* and *Papaveretea rhoeadis* is explained by agricultural activities near the reserve on the side of the watershed. The distribution of species of other synanthropic classes is associated with roads and eroded areas along which anthropophytes quickly migrate. However, in general, the contribution of the latter is relatively small and the natural vegetation types predominate. An analysis of the representation of vegetation classes in the study area confirms the general conclusion about its high biodiversity and the need for its protection.

Table 3. Top 10 phytosociological classes and percentage contributions of their diagnostic species to the total number of species

Rank	Vegetation classes	% of total species
1	*Festuco-Brometea*	17.4
2	*Molinio-Arrhenatheretea*	14.3
3	*Trifolio-Geranietea*	9.0
4	*Carpino-Fagetea*	8.5
5	*Chenopodietea*	8.2
6	*Papaveretea rhoeadis*	7.3
7	*Phragmito-Magnocaricetea*	7.0
8	*Artemisietea vulgaris*	6.1
9	*Koelerio-Corynephoretea*	4.6
10	*Sedo-Scleranthetea*	4.1
Other classes		13.5
Total		100.0

3.5. Anthropophytes

We recorded 95 species of alien plants in the studied flora, which account for 14.5%. Archaeophytes (53 species) and kenophytes (42 species) are almost equally represented (Table 4). The ratio of native to invasive species is high (5.9 : 1), as compared to the same ratio in adjacent territories (Lukash 2009).

The level of synanthropization is low (synanthropization index 35.3). The allochthonous component of the flora is also small (adventization index 14.5), while the ratio of kenophytes to archaeophytes is quite high (modernization index 44.1), which may indicate the impact of nearby intensive agriculture.

3.6. Nature conservation value

The biotope diversity of the study area includes many habitats under Resolution 4 of the Berne Convention, which are priorities for protection in Europe as a whole (Table 5). There are also 50 species of vascular plants included in various lists of protected species (Appendices 1-2). Thus, the territory is of high conservation value, because of not only uniqueness and preservation but also environment-forming functions and the possible restoration of the flora and vegetation of the Middle Dnipro region.

Table 4. Proportions of native and alien species with division into various types of anthropophytes

Synanthropic categories	% of total species	No. of species
Non-synanthropic (native)	64.7	425
Apophytes (synanthropic native)	20.9	137
Archaeophytes (alien, introduced before 1500 AD)	8.1	53
Kenophytes (alien, introduced after 1500 AD)	6.4	42
Total	100.0	657

Table 5. Habitats of Resolution 4 of the Berne Convention in the study area. Conditional conservation values (H – high, M – medium, L – low) have been assigned, taking into account the occupied areas and the preservation of flora and vegetation

Habitat code and definition	Approx. area (ha)	Conservation value
C1.222 Floating *Hydrocharis morsus-ranae* rafts	0.1	H
C1.223 Floating *Stratiotes aloides* rafts	<0.1	L
C1.224 Floating *Utricularia australis* and *Utricularia vulgaris* colonies	1.5	H
C1.32 Free-floating vegetation of eutrophic waterbodies	0.1	M
C1.33 Rooted submerged vegetation of eutrophic waterbodies	1.0	M
C1.3411 *Ranunculus* communities in shallow water	<0.1	L
C2.34 Eutrophic vegetation of slow-flowing rivers	0.5	H
C3.51 Euro-Siberian dwarf annual amphibious swards (but excluding C3.5131 toad-rush swards)	0.1	L
E1.2 Perennial calcareous grassland and basic steppes	20.0	M
E1.9 Open non-Mediterranean dry acid and neutral grassland, including inland dune grassland	10.0	H
E3.4 Moist or wet eutrophic and mesotrophic grassland	0.5	L
F3.241 Central European subcontinental thickets	15.0	M
F3.247 Ponto-Sarmatic deciduous thickets	10.0	M
F9.1 Riverine scrub	<0.1	L
G1.11 Riverine *Salix* woodland	10.0	M
G1.22 Mixed *Quercus-Ulmus-Fraxinus* woodland of great rivers	1.0	M
G1.A1 *Quercus-Fraxinus-Carpinus betulus* woodland on eutrophic and mesotrophic soils	35.0	M
G1.A4 Ravine and slope woodland	40.0	M

4. Conclusions

To some extent, the richness and preservation of biodiversity in the Dzhulaika Reserve are ensured by the relatively long distance from populated areas, protection by a significant water barrier of the Dnipro River, location on steep slopes, and significant variability of habitats. To date, the protection regime of the reserve corresponds to the priority tasks of nature protection in this area. However, since there are very few similar preserved steppe areas in the Middle Dnipro region, the creation of other similar reserves in this region on the slopes of the Dnieper is a priority task, too, and monitoring of this nature reserve is needed. Considering that in the Middle Dnipro region, due to ploughing, hardly any steppes have been left, the study area as a whole represents unique plant diversity, combining species of very different classes of natural vegetation and being an interesting object for further research.

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Appendix 1. Vascular plant species protected at the national level according to the Red Data Book of Ukraine (Didukh 2009)

No.	Species	
	National level (Red Data Book of Ukraine)	
1	*Adonis vernalis* L.	+
2	*Astragalus dasyanthus* Pall.	+
3	*Dactylorhiza incarnata* (L.) Soó	+
4	*Epipactis palustris* (L.) Crantz.	+
5	*Iris sibirica* L.	+
6	*Jacobaea borysthenica* (DC.) B.Nord. & Greuter (syn. *Senecio borysthenicus* (DC.) Andrz. ex Czern.)	+
7	*Pulsatilla pratensis* (L.) Mill.	+
8	*Stipa capillata* L.	+
9	*Stipa pennata* L.	+
10	*Tragopogon ucrainicus* Artemczuk	+

Appendix 2. Vascular plant species protected at the regional level (Andrienko & Peregrym 2012)

No.	Species	Cherkasy	Poltava
1	*Alisma lanceolatum* With.	+	–
2	*Anemonoides sylvestris* (L.) Galasso, Banfi & Soldano (syn. *Anemone sylvestris* L.)	+	+
3	*Asparagus tenuifolius* Lam.	+	–
4	*Astragalus austriacus* Jacq.	+	–
5	*Astragalus varius* S.G. Gmel	+	–
6	*Athyrium filix-femina* (L.) Roth	–	–
7	*Avenula pubescens* (Huds.) Dumort. (syn. *Helictotrichon pubescens* (Huds.) Pilg.)	+	–
8	*Campanula persicifolia* L.	–	+
9	*Cardamine bulbifera* (L.) Crantz (syn. *Dentaria bulbifera* L.)	–	+
10	*Carex atherodes* Spreng.	+	–
11	*Carex disticha* Huds.	–	–
12	*Carex rhizina* Blytt ex Lindblom	+	+
13	*Centaurea borysthenica* Gruner	–	–
14	*Centaurea phrygia* subsp. *pseudophrygia* (C.A. Mey.) Gugler (syn. *Centaurea pseudophrygia* C.A. Mey.)	+	–
15	*Cleistogenes serotina* (L.) Keng (syn. *Cleistogenes bulgarica* (Bornm.) Keng)	+	–
16	*Clematis recta* L.	–	–
17	*Cyperus michelianus* (L.) Delile	+	–
18	*Dryopteris filix-mas* (L.) Schott	–	–
19	*Ephedra distachya* L.	+	+
20	*Eremogone procera* (Spreng.) Rchb. (syn. *Eremogone micradenia* (P.A.Smirn.) Ikonn.)	+	–
21	*Euphorbia esula* subsp. *esula* (syn. *Euphorbia kaleniczenkoi* Czern.)	+	–
22	*Galatella villosa* (L.) Rchb.f.	+	–
23	*Hieracium robustum* Fr.	+	–
24	*Hieracium virosum* Pall.	+	–
25	*Hyacinthella leucophaea* (K.Koch) Schur	+	+
26	*Iris pumila* L.	+	+
27	*Lysimachia thyrsiflora* L. (syn. *Naumburgia thyrsiflora* (L.) Rchb.)	–	+

28	*Minuartia setacea* subsp. *setacea* (syn. *Minuartia leiosperma* Klokov)	+	–
29	*Muscari neglectum* Guss.ex Ten	+	+
30	*Omalotheca sylvatica* (L.) F.W.Schultz & Sch.Bip. (syn. *Gnaphalium sylvaticum* L.)	–	+
31	*Pedicularis kaufmannii* Pinzger	+	+
32	*Phlomis herba-venti* subsp. *pungens* (Willd.) Maire ex DeFilipps (syn. *Phlomis pungens* Willd.)	+	–
33	*Potentilla alba* L.	+	+
34	*Prunus tenella* var. *tenella* (syn. *Amygdalus nana* L.)	+	+
35	*Prunus fruticosa* Pall. (syn. *Cerasus fruticosa* (Pall.) Borkh.)	+	+
36	*Psephellus sumensis* (Kalen.) Greuter (syn. *Centaurea sumensis* Kalen.)	–	+
37	*Pyrola rotundifolia* L.	+	+
38	*Salvia nutans* L.	+	–
39	*Scorzonera purpurea* L.	+	+
40	*Utricularia vulgaris* L.	–	+