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ECOLOGICAL CHARACTERISTICS OF RARE AND ENDANGERED SPECIES IN THE DIVYCHKY EMERALD NETWORK AREA (CENTRAL UKRAINE)

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Introduction. The assessment of the importance of individual areas for the conservation of European biodiversity relies on various criteria, one of which is the presence of threatened species of European significance. Recent botanical surveys have confirmed the proliferation of rare plants within the Divychky Emerald Network Area. Our research aims to conduct a phytosociological analysis and assess the ecological conditions of habitats hosting rare species in the Divychky Emerald Network Area (DENA) under protection at both national and international levels.

Materials and Methods. We conducted a survey of the area and compiled lists of species, identifying those that are rare and protected at the European level. We visually assessed the vitality of populations and utilized synphytoindication method to characterize ecological aspects of habitats.

Results. We compiled a list of species found within the Divychky Emerald network area, which includes those listed in both the European Red List and the Red Data Book of Ukraine. Phytoindicative assessment helped determine the range of individual environmental factors affecting these species.

Discussion. The Divychky Emerald Network Area is home to endangered species of significant importance within Europe. In particular, there are habitats of nine species

under protection of the Bern Convention, and two species included in the European Red List. We have compiled a list of species with protected status and assigned them to six vegetation classes in the plant community. The largest number of plants have been assigned to three vegetation classes. Our studies demonstrate how the types of reproduction affect the distribution and number of species – species with vegetative reproduction had the largest populations. The most vulnerable species populations were described, and information on the distribution and habitat of these species was provided.

Conclusion. We have gathered new chorological and phytocoenotic data concerning the growth of protected plant species within the studied area of the Divychky Emerald Network Area. Species protected at the European level, along with their populations facing varying levels of extinction threat, have been identified and thoroughly studied.

Keywords: Middle-Dnipro, Bern Convention, European Red List, Red Data Book of Ukraine.

INTRODUCTION

The significance of individual areas for the conservation of European biodiversity is assessed by numerous criteria, including the presence of threatened species of European importance (United Nations, 1991; Bakker, 2005; Bennett & W. C. U., 2004; Banskota, 2014; Shvaiko & Manyuk, 2017; Tymochko, 2022).

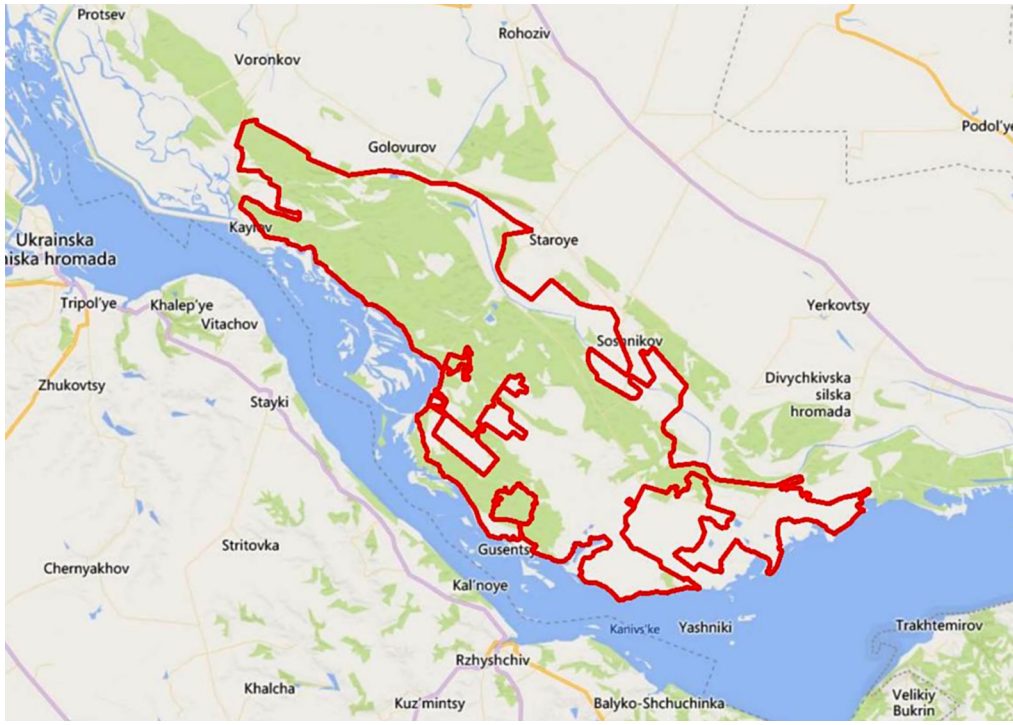
The earliest botanical surveys of the rare species in the studied area were started in 1920–1930 (Kleopov & Dubovyk, 1926; Bachurina, 1939). Botanical surveys of the modern period confirmed the occurrence of rare plants including *Cephalanthera rubra* (L.) Rich., *Dactylorhiza incarnata* (L.) Soó, *Epipactis palustris* (L.) Crantz, *Iris sibirica* L., *Lilium martagon* L., *Neottia ovata* (L.) Hartm., *Pulsatilla patens* (L.) Mill., *Pulsatilla pratensis* (L.) Mill., *Stipa borysthenica* Klok. ex Prok. (Vasyliuk *et al*., 2019). We provided data about the habitat of rare plants in the Divychky Emerald Network Area earlier (Goncharenko *et al.,* 2022; Solomakha *et al*., 2021; Shevchyk & Solomakha, 2021).

MATERIALS AND METHODS

During 2020–2021, a phytosociological survey was performed in Divychky Emerald Network Area UA0000337 (DENA) (total area of 19036.5 hectares). It comprises 168 geobotanical descriptions. The projective cover of species was recorded according to the scale of J. Braun-Blanquet (1964) (Appendices A, B, C, D).

DENA is located in the forest-steppe zone within the central part of Ukraine (see **Figure**). The climate of this territory is subcontinental. The annual rainfall is about 550 mm, the average monthly temperature in January is -6 °C, and the average monthly temperature in July is +19 °C (Comprehensive Atlas of Ukraine, 2005). The surface of the studied territory is composed of ancient and modern alluvial deposits. Redeposited sandbars are located in depressions of Holocene deposits of organogenic origin (silt, sapropel, peat) (Popov *et al*., 1968).

The main elevations are in the range of 88–95 m above sea level (the highest point 126 m above sea level). The ground cover is dominated by hydromorphic soils of different gleying degrees, mainly meadow-swamp and peat-swamp, and on the elevations of the ground cover – by podzolic sandy soils. Plots of open weakly fixed sands are quite common (Veklych, 2005).



The Divychky Emerald Network Area UA0000337 (Central Ukraine)

The nomenclature of species follows the World Flora Online (WFO) (https://wfo-plantlist.org). The GPS coordinates were used to record the locations and areas of all populations.

Additionally, the population size, the area, and the ratio of individuals at pre-reproductive and reproductive ages were determined. For the ecological characteristics of the habitats in which threatened species were found, an assessment was performed using the method of phytoindication. The method is based on a weighted average of ecological scales, taking into account the values of projective coverage of species (Ellenberg *et al*., 1991; Didukh & Pliuta, 1994; Goncharenko, 2017). The ecological scales of Ya. Didukh developed for the Ukrainian flora was taken as a basis (Didukh, 2011). Indicators of soil humidity (Hd), acidity (Rc), nitrogen (Nt), light availability (Lc), as well as thermal regime (Tm) and continentality (Kn) have been calculated.

RESULTS AND DISCUSSION

List of protected species and size of populations. The list of protected species and their characteristics is presented in **Table 1**. The location of populations of identified species is shown on a map available online at www.tinyurl.com/bdfa94am. Relevés with identified protected species are presented in Appendices A, B, C, and D.

The most abundant species include *Aldrovanda vesiculosa*, *Jurinea cyanoides*, *Salvinia natans*, and *Tragopogon ucrainicus*, with recorded findings ranging from 11 to 15 occurrences. The indicators reflecting both the number of individuals and the size of populations show correlation with occurrence indicators. The wide distribution of these

species is explained by the presence of a large number of habitats favorable for these species in the study area, as well as by the satisfactory recovery of populations. The status and abundance of these populations has not changed since previous years of our observations (Solomakha, 2021). Other species *Pulsatilla patens*, *Ostericum palustre*, *Iris aphylla* subsp. *hungarica,* and *Senecio borysthenicus* have lower indices of occurrence and abundance. In the studied populations of the rare species *Thesium ebracteatum* no seed renewal was observed, at the same time vegetative growth processes were maintained. *Liparis loeselii* plants are typically found within herbaceous communities that, amidst frequent fluctuations in water levels, become densely populated with woody vegetation.

Table 1. **List of species included in the European Red List, and the Red Data Book of Ukraine found in DENA**

Species	Protection status	Number of findings	Class of vegetation	Approximate population size
Aldrovanda vesiculosa	A1; R6; RDB	15	*Lemnetea* O. de Bolòs et Masclans 1955	≥500000
Pulsatilla patens	A1; R6; RDB	5	*Quercetea robori-petraeae* Br.-Bl. et Tx. ex Oberd. 1957; *Trifolio-Geranietea sanguinei* T. Müller 1962	≥300
Ostericum palustre	A1; R6	3	*Molinio-Arrhenatheretea* Tx. 1937	≈300
Iris aphylla subsp. *hungarica*	R6	5	*Quercetea robori-petraeae*; *Trifolio-Geranietea sanguinei*	≥300
Jurinea cyanoides	A1; R6	15	*Koelerio-Corynephoretea canescentis* Klika in Klika et Novák 1941; *Pyrolo-Pinetea sylvestris* Korneck 1974; *Trifolio-Geranietea sanguinei*	≥5000
Liparis loeselii	A1; R6; RDB	2	*Phragmito-Magnocaricetea* Klika in Klika et Novák 1941	≥200
Salvinia natans	A1; RDB	15	*Lemnetea*	≥1000000
Senecio borysthenicus	ERL	4	*Koelerio-Corynephoretea canescentis*	≥500
Thesium ebracteatum	A1; R6	2	*Trifolio-Geranietea sanguinei*	≥200
Tragopogon ucrainicus	ERL	11	*Koelerio-Corynephoretea canescentis*	≥5000
Trapa natans	A1; RDB	2	*Potamogetonetea* Klika in Klika et Novák 1941	≥10000

Note: ERL – the European Red List of Globally Threatened Animals and Plants; A1 – Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats; R6 – Resolution No 6 of the Bern Convention; RDB – The Red Data Book of Ukraine

Ecological characteristics. Average values and standard deviations of phytoindicators are provided in **Table 2**. The standard deviation can be considered as an indicator of the range of the ecological amplitude of the species by a definite ecological factor. Meanwhile, the mean value indicates the optimum condition.

Table 2. **Mean value and standard deviation (upper and lower rows) of ecological characteristics of the studied species**

Species	Hd	Rc	Nt	Lc	Tm	Kn
Aldrovanda vesiculosa	93.26 4.28	60.53 1.84	57.74 5.81	62.63 2.19	65.58 4.10	41.05 1.81
Pulsatilla patens	35.33 1.53	59.00 1.00	36.67 2.52	63.33 3.06	55.33 0.58	45.00 1.00
Ostericum palustre	57.67 10.02	59.67 3.06	59.67 3.51	62.33 1.15	54.67 0.58	39.67 2.08
Iris aphylla subsp. *hungarica*	37.50 2.08	57.00 2.00	36.50 2.38	60.75 3.77	56.25 0.50	44.25 2.22
Jurinea cyanoides	27.50 4.25	51.40 5.27	25.10 4.79	69.50 4.06	59.50 2.88	50.00 2.49
Liparis loeselii	72.50 3.70	59.50 3.42	46.00 5.48	63.75 0.96	53.50 0.58	39.50 2.08
Salvinia natans	88.75 5.32	58.00 1.41	59.75 4.92	65.25 2.75	64.50 7.55	43.25 2.50
Senecio borysthenicus	36.00 9.90	45.00 5.66	30.00 1.41	64.50 7.78	54.00 8.49	46.50 3.54
Thesium ebracteatum	31.04 0.25	48.50 2.83	28.04 0.87	66.20 1.41	56.55 0.40	50.11 1.41
Tragopogon ucrainicus	25.43 0.79	48.71 5.02	25.71 3.86	74.29 1.38	61.57 2.23	49.29 3.64

Enviromental variables: Hd – humidity; Rc – soil acidity; Nt – nitrogen; Lc – light regime; Tm – temperature value; Kn – continentality

The species exhibit the widest range of amplitudes in relation to humidity (Hd) and nitrogen (Nt). Considering the edaphic factors of acidity (Rc), and light regime (Lc) the optimum values of most threatened species do not differ much. The vast majority of sozophyte species give preference to neutral soils, there are no notable differences in the climatic indicators of the thermal regime (Tm), and continentality (Kn). Terrestrial species generally exhibit a greater ecological amplitude. Conversely, psammophytic species, such as *Tragopogon ucrainicus* and *Thesium ebracteatum*, are characterized by narrow amplitudes across most factors.

Phytosociological and population characteristics of threatened species. *Aldrovanda vesiculosa* is a Holarctic species, with small areas of distribution in subtropical and tropical latitudes (Didukh, 2009). According to the literature, the species occurred on the outskirts of Stare village (Kleopov & Dubovyk, 1926; Shevchyk & Solomakha, 2021), but is no longer present there. In 2021, we discovered a new locality on the southwestern outskirts of Kovalyn village. The species tends to grow in stagnant and slow-flowing waters. In groups it mainly occurs as a dominant or co-dominant with a projective coverage of 60–100 %. The coexisting species include *Wolffia arrhiza*, *Salvinia natans*, *Lemna minor*, and *Hydrocharis morsus-ranae* (**Appendix A**). The highest density in the identified populations was 270 individuals/m^2.

Salvinia natans is a species native to the Holarctic region and has ancient origins in the Mediterranean. It is notably abundant within the waterways of the Dnipro Reservoir cascade and at the confluence points of tributaries in the middle and lower stretches of

the Dnipro River (Didukh, 2009). The species was discovered within the DENA, inhabiting both permanent and temporary bays of the Kaniv Reservoir, which become disconnected during periods of low water levels. In most localities, this species grows together with *Aldrovanda vesiculosa*, which indicates the similarity of their ecological and coenotic requirements. Other free-floating plants co-dominate in the groups, particularly such as *Hydrocharis morsus-ranae*, *Lemna minor*, *Lemna trisulca*, *Spirodela polyrhiza*. (**Appendix A**).

Trapa natans is a Eurasian plurizonal species that, according to our observations, has actively spread over the water area of the Dnipro Reservoir cascade in recent decades. In particular, two new local populations have emerged in the last decade within the Kaniv Nature Reserve. It is most expansive in areas of low-flowing water area with powerful silty deposits. In the target area, it forms mainly monodominant groups in shallow water along the bank of the Kaniv Reservoir in the vicinity of the village of Kyiliv. The scattered plant groups with an area of several square meters and more.

Senecio borysthenicus and *Tragopogon ucrainicus* are Eastern European species listed in the European Red List. They occur sporadically on sandy elevations of floodplains and pine terraces, primarily in the Middle Dnipro region (Solomakha *et al*., 2021). Within the DENA, these species are restricted to the upper slopes of sand hills of aeolian origin. In areas where these species are present, total coverage ranges from 15 % to 30 %, with psammophytes *Festuca beckeri*, *Koeleria glauca*, and *Corynephorus canescens* dominating the groups. Population sizes are small, with a density of 1 to 5 individuals per square meter. Both generative and pregenerative individuals of seed origin are observed.

Ostericum palustre is a Eurasian species distributed from the southern taiga subzone to the Eurasian steppe zone with isolated habitats in the British Isles, Karelia, the Caucasus, and the Baikal region detached from the main area. Only three habitats of this rare species were identified within the area (**Table 1**). About 100 individuals in large numbers in each habitat were represented. Phytoindication assessment indicates that the species is disposed towards mesophytic conditions because of the humidity in the plots where it grows. The value of 57.67 for HD (refer to **Table 2**) falls close to the midpoint of the scale. The community exhibited a total coverage ranging from 70 % to 90%. It was characterized by typical meadow species, including *Carex hirta*, *Dactylis glomerata*, *Elytrigia repens*, and *Festuca pratensis* (see **Appendix B**). Notably, all identified populations consisted of individuals originating from seeds.

Liparis loeselii is a Holarctic boreal species that is very rare in the Dnipro region (Didukh, 2009). Within the area, it expands on swampy meadows dominated by low-growing sedges with pronounced mossy tier. *Phragmites australis*, *Thelypteris palustris*, *Carex acuta* and other species dominate (**Appendix B**). This species predominantly occurs individually, with groupings less frequent (10–25 individuals), resulting in a density of only 1–2 individuals per square meter. Generative individuals typically reach heights of 15–20 cm, with inflorescences extending up to 10 cm in length.

Thesium ebracteatum is a semi-parasitic species native to the Euro-West Siberian region, found in Polissya and the forest-steppe (Kotov, 1952; Solomakha, 2016). Within the studied area, it is exceedingly rare, observed in only two localities (refer to **Table 1**). It typically inhabits the slopes of sand hills, occurring in clusters with a heliophytic-psammophytic character and covering up to 30 % of the area. The herbaceous vegetation consists of species such as *Stipa borysthenica*, *Carex ericetorum*, *Festuca beckeri*,

Peucedanum orooselinum, among others (see **Appendix C**). Reproduction primarily occurs vegetatively, with a density of 5–7 individuals per square meter.

Pulsatilla patens is a species native to the Euro-West Siberian region, found in Ukraine within the forest and forest-steppe zones (Didukh, 2009). Five localities were found on the DENA (**Table 1**) within areas of fresh soil, amidst trees approximately 100–120 years old. In the tree tier, the closure ranges from 0.3 to 0.6, with *Pinus sylvestris* dominating (10–15 %), alongside co-dominants *Quercus robur* (5–15 %) and *Betula pendula* (up to 5 %). In the bush tier (close to 0.2), *Acer tataricum*, *Frangula alnus*, *Euonymus verrucosus*, *Pyrus communis*, and various other species can be found. The grass stand consists of *Convallaria mayalis*, *Poa angustifolia*, *Polygonatum odoratum*, and *Peucedanum oreoselinum*. The age structure of the identified populations is stable, comprising individuals of seed origin, as well as both pre-generative and generative age groups.

Iris aphylla subsp. *hungarica* is a European-Caucasian species that thrives in meadow steppes and sparsely mixed forests. Typically, this species is found in the upper regions of sandy slopes within pine and oak forests in the area. In sparsely populated stands, its proximity ranges from 0.3 to 0.5, with *Pinus sylvestris* dominating (up to 10 %), along with *Quercus robur* (15–35 %) and *Betula pendula* (up to 10 %). Other species like *Acer tataricum*, *Frangula alnus,* and others can be found in the shrub layer, while *Polygonatum odoratum*, *Pteridium aquilinum*, *Convallaria majalis*, and others thrive in the grass tier. The identified populations of Iris aphylla inhabit areas ranging from 30 to 5000 m^2, with a density of vegetative shoots reaching up to 40 pieces/m^2. The distribution pattern of individuals within populations appears to be contagious, indicating a predominantly clonal (vegetative) method of reproduction. Moreover, young clones containing individuals of seed origin have been observed in all populations.

Jurinea cyanoides is a species native to West Siberia, the Caucasus, and Eastern Europe. It typically occurs on the slopes and summits of sandy hills devoid of forests, occasionally found in sparse pine forests as well (Vinichenko, 2006). This species is primarily found on gentle slopes with an inclination of 5–7° within the DENA, where sands are loosely packed. It occurs within sparse groups in such areas, with a total projective coverage ranging from 5 to 10 %. These groups exhibit a well-developed moss-lichen layer, covering up to 60 % of the surface. Among vascular plants, typical sand-loving species dominate, including *Festuca beckeri*, *Corynephorus canescens*, *Rumex acetosella*, *Otites borysthenica*, and *Koeleria glauca* (**Appendix D**). The population of *Jurinea cyanoides* is notably increasing in sandy areas where the soil is periodically mechanically loosened, particularly along roads and firebreaks within forested areas. In these locations, the population density can reach up to 15 individuals per square meter. Due to anemochory, the species is also dispersed to the edges of forests and into meadows. In addition, *Jurinea cyanoides* tends to avoid dense forested areas.

Between 2020 and 2021, within the DEN area, we identified eleven threatened species, all of which are protected at the European level. Notably, the habitats of nine of these species are subject to conservation measures under the Bern Convention. These species include: *Iris aphylla* subsp. *hungarica*, *Salvinia natans*, *Trapa natans*, *Aldrovanda vesiculosa*, *Pulsatilla patens*, *Ostericum palustre*, *Jurinea cyanoides*, *Liparis loeselii*, and *Thesium ebracteatum* (Convention on the Protection of Wild Flora and Fauna and Natural Habitats in Europe, 2000; Vinichenko, 2006).

Two species listed on the European Red List are *Senecio borysthenicus* and *Tragopogon ucrainicus* (European Red List of Globally Threatened Animals and

Plants, 1992). Five species from this list include *Aldrovanda vesiculosa*, *Pulsatilla patens*, *Liparis loeselii*, *Salvinia natans*, and *Trapa natans*, which are also included in the Red Data Book of Ukraine (Didukh, 2009).

CONCLUSION

Species and natural habitats of European significance, with protected status, were observed within the territory of the DENA UA0000337. Specifically, this area encompasses natural habitats of nine species protected under the Bern Convention and two species included in the European Red List. Among them, five species are also presented in the Red Data Book of Ukraine. Most species with conservation status are confined to groups of the *Lemnetea* class, as well as *Koelerio-Corynephoretea* and *Trifolio-Geranietea sanguinei*, which occupy large areas and have slightly disturbed areas. In the DENA, the most numerous species are populations of free-floating species, in particular *Aldrovanda vesiculosa* and *Salvinia natans*. The clonal reproduction predominates in these species.

Species of the Asteraceae family, including *Tragopogon ucrainicus*, *Senecio borysthenicus*, and *Jurinea cyanoides*, are characterized by a uniform distribution and relatively low population density within the DENA. These species disperse their seeds through anemochory.

All species have an optimum in psammophytic groups of the class *Koelerio-Corynephoretea*. According to the phytoindication assessment, the largest differences are observed in the positions of the optimums of ecological amplitudes in sozophyte species in terms of humidity and nitrogen content.

The amplitudes of the studied species are close in acidity, light regime, climatic indicators of thermal regime and continentality. The prognosis of continued existence for species confined to the classes of aquatic *Lemnetea* and psammophytic *Koelerio-Corynephoretea* vegetation is satisfactory. The most vulnerable populations are *Liparis loeselii* and *Thesium ebracteatum*, which are found in only two localities. In general, DENA is one of the most important territory for the conservation of biodiversity and representative areas within the Middle Dnipro.

COMPLIANCE WITH ETHICAL STANDARDS

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ЕКОЛОГІЧНА ХАРАКТЕРИСТИКА РІДКІСНИХ І ЗНИКАЮЧИХ ВИДІВ ОБ'ЄКТІВ СМАРАГДОВОЇ МЕРЕЖІ ДІВИЧКИ (ЦЕНТРАЛЬНА УКРАЇНА)

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Вступ. Важливість окремих територій для збереження європейського біорізноманіття оцінюють за численними критеріями, включно з представленістю видів, що перебувають під загрозою зникнення, які мають європейське значення. Проведений комплекс ботанічних досліджень підтвердив ріст рідкісних рослин на території Смарагдової мережі Дівички. Метою нашого дослідження є фітосоціологічний аналіз та оцінка з використанням методу фітоіндикації екологічних умов зростання рідкісних видів на території Дівички, котрі перебувають не тільки на національному, а й на міжнародному рівні охорони.

Матеріали та методи. Нами виконано дослідження цієї території та сформовано список видів рослин, включаючи види, які перебувають під охороною на європейському рівні. Проведено візуальну оцінку стану життєвості популяцій та застосовано метод синфітоіндикації для екологічної характеристики оселищ.

Результати. Сформовано список занесених до Європейського Червоного списку та Червоної книги України видів, які виявлено на території Смарагдової мережі Дівички. Визначено показники амплітуди окремих екологічних факторів для цих видів відповідно до фітоіндикаційної оцінки.

Обговорення. На території Смарагдової мережі виявлено зникаючі види європейського значення. Зокрема, природні середовища зростання дев'яти видів, що охороняються відповідно до Бернської конвенції, та два види, занесені до Європейського Червоного списку. Ми склали список видів, які мають охоронний статус, і залучили їх до шести класів рослинності в межах угруповань. Найбільша кількість рослин увійшла до трьох класів рослинності. Виявлено, як типи розмноження впливають на поширення та чисельність видів. З'ясовано, що види рослин із вегетативним розмноженням мають найбільшу популяцію. Також у статті описано найвразливіші популяції видів і наведено інформацію про поширення й ареал цих видів.

Висновки. Отримано нові хорологічні та фітоценотичні дані про виявлені види рослин у межах досліджуваного об'єкта Смарагдової мережі Дівички, що охороняються згідно з Європейським Червоним списком і Червоною книгою України. Види, які охороняються на європейському рівні, а також їхні популяції, які стикаються з різними рівнями загрози зникнення, було ідентифіковано та ретельно вивчено.

Ключові слова: Середня Наддніпрянщина, Бернська конвенція, Європейський Червоний список, Червона книга України

APPENDIX A

Relevés with species *Aldrovanda vesiculosa* and *Salvinia natans* in the DENA

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Herb layer cover	60	80	60	70	90	100	100	95	60	85	60	90	95	100	100	90	85	60	60	100
Moisture, Hd	94	95	96	97	78	89	90	92	94	93	94	95	96	98	95	95	94	93	93	87
Soil reaction, Rc	60	62	61	64	62	61	62	60	60	61	59	61	57	64	58	61	59	59	59	58
Nitrogen, Nt	55	64	61	69	44	56	61	58	59	58	56	57	54	69	54	60	55	56	64	64
Light regime, Lc	64	63	64	58	66	65	64	64	62	64	64	61	64	58	61	63	60	62	67	68
Temperature value, Tm	69	63	61	60	67	62	62	67	68	67	65	68	61	59	68	64	70	73	63	67
Continentality, Kn	41	41	44	37	43	41	41	40	43	41	38	41	42	38	43	41	42	42	47	42
Aldrovanda vesiculosa	4	1	1	1	3	1	1	3	4	4	2	4	1	1	6	2	5	5		
Lemna minor		1	1	1	3	4	2	1	1	1	3	1	1	1	1	2	1	1	2	2
Stratiotes aloides	2	6	3	1		3	5	1	5	4	1	6			3	6	5	2		
Utricularia vulgaris	1	2	4	1		5	4					1	6		4	2	1	1		1
Lemna trisulca	2	2	4	2						1	2	3	1	2	1	2	1			
Spirodela polyrrhiza		1	1	1						1	5		1	1	1		1	1		3
Hydrocharis morsus-ranae	4				3	5	5	6	3	5	2				2		1	3		
Wolffia arrhiza	3				5	3	2	2	1	3	1									
Ceratophyllum platyacanthum			3						1				1	1	2				2	
Phragmites australis							2	1		1										
Potamogeton lucens				6										6						
Salvia nutans					4	2	1													
Potamogeton natans						1														
Salvinia natans																		2	2	5
Hottonia palustris																				5
Bidens cernua																				2
Bidens frondosa																				2

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APPENDIX B

Relevés with species *Ostericum palustre* and *Liparis loeselii* in the DENA

Number	1	2	3	4	5	6	7
Herb layer cover	95	90	65	35	60	70	90
Moisture, Hd	48	57	68	76	71	68	75
Soil reaction, Rc	63	57	59	60	58	56	64
Nitrogen, Nt	63	60	56	50	49	38	47
Light regime, Lc	63	61	63	64	63	65	63
Temperature value, Tm	55	55	54	54	54	53	53
Continentality, Kn	42	38	39	42	39	40	37
Ostericum palustre	2	2	2				
Dactylis glomerata	3	3					
Carex acuta			6	2	4	3	2
Eupatorium cannabinum		2	1		2	1	
Liparis loeselii				1	1	1	1
Phragmites australis				3	3	3	6
Lysimachia vulgaris				1	2	3	1
Carex cespitosa		2					
Carex hirta	2	3					
Carex riparia							1
Centaurea jacea		2					
Cicuta virosa				1			
Cirsium arvense	2	1					
Cirsium oleraceum		2					
Cynoglossum officinale	1						
Dactylorhiza incarnata						1	
Elymus repens	2	1					
Epipactis palustris						2	
Equisetum palustre					1	2	
Equisetum pratense	2						
Festuca pratensis		2					
Frangula alnus					2	2	
Galium boreale	2						
Galium palustre					1		
Galium rivale		3					
Geranium collinum		3	1				
Glechoma hederacea	2	2					
Hieracium umbellatum						1	

Humulus lupulus	1	1					
Hypericum perforatum	1						
Juncus articulatus						2	
Carex acutiformis					2		1
Carex appropinquata			1				
Lathyrus palustris					1	1	
Lycopus europaeus				1	2	1	
Lysimachia thyrsiflora				1			
Lythrum salicaria					1	1	1
Mentha aquatica				1	1	1	
Ophioglossum vulgatum						1	
Origanum vulgare	1						
Picris hieracioides	1						
Poa palustris				1			
Potentilla anserina		2					
Potentilla reptans	2						
Pyrola minor						1	
Rubus caesius	5				2		
Salix cinerea					2	1	
Salix rosmarinifolia						2	
Selinum carvifolia		2					
Silene flos-cuculi				1			
Sium latifolium		2	1	1			
Sonchus asper	1						
Stellaria aquatica		2					
Succisa pratensis		1					
Thelypteris confluens				3		2	4
Tussilago farfara	3						
Typha angustifolia					1		
Urtica dioica	1	1					
Valeriana officinalis		1					
Veratrum lobelianum		1					
Veronica chamaedrys	1	1					
Vicia cracca		2					
Agrimonia eupatoria	1						
Angelica sylvestris			1				
Artemisia vulgaris			1				
Betula pubescens					1		

APPENDIX C

Relevés with species *Pulsatilla patens*, *Iris aphylla* subsp. *hungarica* and *Thesium ebracteatum* in the DENA

Number	1	2	3	4	5	6	7	8
Tree layer cover	0.9	0.6	0.3	0.6	0.3			
Shrub layer cover	0.1	0.1	0.3	0.2	0.1			
Herb layer cover	40	50	50	60	15	40	70	30
Moisture, Hd	35	40	38	37	35	34	31	31
Soil reaction, Rc	56	56	56	60	58	59	46	50
Nitrogen, Nt	33	38	38	37	34	39	28	28
Light regime, Lc	66	57	60	60	66	64	65	67
Temperature value, Tm	57	56	56	56	55	55	56	56
Continentality, Kn	47	43	42	45	46	44	51	49
Iris aphylla	2	1	2	2				
Pulsatilla patens				1	1	1		
Thesium ebracteatum							2	1
Acer tataricum			1	1				
Achillea millefolium	1		1	1		2		1
Anthericum ramosum	2	1	1	1		1		
Calamagrostis epigejos	2					2	1	1
Carex ericetorum	1						5	2
Carex flacca	2	2		1	1	1		
Carex hirta			1					
Carex praecox	2			2	2	2		
Carex rhizina					1	2		
Chamaecytisus ruthenicus	1	1			2	1		
Campanula persicifolia			1	1				
Convallaria majalis		4	5	4	1	2		
Dactylis glomerata	1	1			1			
Daphne cneorum					1	1		1
Dianthus borbasii							1	1
Elymus repens	2		2		1	1		
Epipactis helleborine			1					
Euonymus verrucosus		1		1				
Euphorbia cyparissias	2	1	1	2	1	1	2	1
Festuca beckeri	1						3	3
Festuca ovina					1	2		
Festuca rupicola			1					
Filipendula vulgaris			1					
Frangula alnus		1		1				

Galium aparine		1		1				
Galium boreale		1						
Galium verum	1	1		1	1	2	1	1
Genista tinctoria	2		1				1	
Geranium sanguineum		1	1	1	1			
Helictotrichon pubescens			1					
Hieracium umbellatum		1	1				1	1
Hypericum perforatum						1		1
Hypochaeris maculata		1						1
Jasione montana							1	
Knautia arvensis			1					
Koeleria glauca	1						1	1
Linaria vulgaris				1				1
Luzula multiflora								1
Malus sylvestris		1						
Melampyrum laciniatum		1			1		1	1
Melampyrum nemorosum			1					
Melampyrum pratense	2							
Melica nutans		2		1				
Moehringia trinervia		1		1				
Myosotis stricta					2	1		
Odontites vulgaris							1	
Origanum vulgare			1					
Peucedanum arenarium	1							
Peucedanum oreoselinum	1	1	2	2	2	2	2	3
Phleum phleoides	1		1					
Pilosella officinarum								1
Pinus sylvestris	1	2		3	3			
Poa angustifolia	2	2		2	2	2		
Poa compressa					2			
Poa nemoralis		2						
Poa pratensis			1					
Polygonatum multiflorum		1						
Polygonatum odoratum		1	1	3	1	1		
Populus tremula			2					
Potentilla alba			1			3		
Psephellus sumensis	1				1		1	1
Pteridium aquilinum		4						
Pyrus communis	1	1	1	1				
Quercus robur	5	5	3	3	2			
Ranunculus polyanthemos		1						

Rhamnus cathartica		1						
Rubus saxatilis		1						
Rumex acetosella								1
Salvia nemorosa			1					
Salvia pratensis		1						
Sambucus nigra		1						
Sedum maximum	2			1	1		1	1
Sempervivum ruthenicum	2						1	
Silene nutans	1	1		1	1	1		
Silene viscaria	1							
Solidago virgaurea			1					1
Stachys officinalis	1	1	1					
Stachys recta	1							
Stipa pennata	1						2	1
Taraxacum campylodes		1						
Teucrium chamaedrys	1	1	1	1		1		
Thymus tschernjajevii							1	
Tilia cordata			2					
Trifolium alpestre						2		
Trifolium medium			1					
Turritis glabra							1	
Ulmus laevis				1				
Verbascum lychnitis							1	1
Veronica chamaedrys		1		1	1	2		
Veronica officinalis							1	
Veronica spicata							1	1
Veronica verna							1	1
Vincetoxicum hirundinaria	2			1	1	1		
Arabidopsis thaliana							1	
Arrhenatherum elatius						1		
Ajuga genevensis		1						
Alliaria petiolata		1		1				
Pulsatilla pratensis								1
Anemone sylvestris						1		
Betula pendula			3	2				
Brachypodium pinnatum			1					
Calamagrostis arundinacea			1					
Campanula rotundifolia	1							
Carex caryophyllea	1							
Chondrilla juncea								1
Clinopodium vulgare			1					
Viola tricolor matutina					1			

APPENDIX D

Relevés with species *Jurinea cyanoides* and *Tragopogon ucrainicus* in the DENA

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tree layer cover	0.6				0.7												
Shrub layer cover	0.1				0.1												
Herb layer cover	40	7	50	50	3	30	8	10	7	20	25	10	30	15	10	15	65
Moisture, Hd	34	26	24	29	35	29	23	24	27	24	26	26	26	25	24	26	25
Soil reaction, Rc	58	44	59	49	48	54	54	44	54	50	49	45	56	43	44	50	54
Nitrogen, Nt	32	19	29	29	23	29	19	21	28	22	24	24	27	30	24	20	31
Light regime, Lc	64	77	69	70	63	69	73	69	69	72	74	75	73	73	74	77	74
Temperature value, Tm	55	61	62	60	54	58	61	61	61	62	60	61	60	65	64	59	62
Continentality, Kn	48	52	51	49	54	49	53	46	48	50	52	47	53	45	46	54	48
Jurinea cyanoides	1	2	4	2	1	2	2	2	2	2							
Tragopogon ucrainicus											1	1	1	1	1	1	1
Corynephorus canescens		1		2			2	3		2	3	2	2	3	2	2	
Artemisia campestris		1	1		1		1		1	1				1	1	2	2
Chondrilla juncea			1			1			1	1		1	1	1			3
Koeleria glauca	1			1	1	2	1	1	1	2	2	2	3			2	
Jasione montana		1				1				2	2	1	1	1	1	1	1
Rumex acetosella		1			1	2	1	1	1	2					1	1	1
Veronica verna		1	1	1		2				2				1	2		1
Calamagrostis epigejos	2					1				1	2		2				
Asparagus officinalis			1	1													
Astragalus arenarius											2	2	3			2	
Dianthus pseudosquarrosus			1							1	1	2					
Digitaria ischaemum														2	1		
Erigeron canadensis							1		1	2	1	1	1				2
Erophila verna			2						1								
Euphorbia cyparissias	2					1											
Euphorbia seguieriana			1							1				1	1	1	1
Fallopia convolvulus				2													
Festuca beckeri		2				1	1		1							3	4
Galium verum	1		2			2											
Genista tinctoria	1																
Gypsophila paniculata						2											
Helichrysum arenarium					1		1	1			1		1			1	
Hieracium echinodes				1													

Hieracium umbellatum	1														
Hierochloe odorata						2									
Linaria genistifolia													1	1	
Melampyrum pratense	1														
Myosotis stricta			2	1											
Peucedanum oreoselinum	2				1	3	1	1	1	1					
Phleum phleoides	1														
Pilosella echioides										1					
Pinus sylvestris	4			3	4										
Pleurozium schreberi					2										
Poa angustifolia	3					2									
Poa bulbosa					1										
Polygonatum odoratum	2														
Psephellus sumensis	2				1	1									
Pyrus communis	1														
Quercus robur	2				1										
Rhamnus cathartica	1														
Secale sylvestre												2	2		3
Sedum maximum	1					1									1
Sedum sexangulare															3
Sempervivum ruthenicum	2			1											
Senecio vulgaris				1											
Silene borysthenica							1				2		1		
Silene nutans	2														
Silene sylvestris			3												
Solidago virgaurea			1		1										
Spergula arvensis								1	1						
Spergula pentandra				1											
Stachys recta			1												
Stipa pennata	1		2			1				2					
Teucrium chamaedrys	1														
Thymus pallasianus		1													
Thymus pulegioides pannonicus										1					
Thymus tschernjajevii						1									
Verbascum lychnitis						1									
Verbascum nigrum			1												
Verbascum phlomoides															1

Vincetoxicum hirundinaria	1														
Viola tricolor matutina			2	2											
Agrostis capillaris						2									
Allium podolicum	1														
Anemone pratensis	2			2					1						
Anthemis arvensis												2	1		
Anthericum ramosum	2														
Arabidopsis thaliana			2			1									
Carex ericetorum	1														
Carex flacca	2														
Carex praecox	2					2									
Centaurea borysthenica		1										1			
Chamaecytisus ruthenicus	2			1											
Chenopodium suecicum	1														
Crepis tectorum			1												
Dianthus borbasii							1								2
Aristolochia clematitis															1
Bassia laniflora															1
Berteroa incana															2

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