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## Rare phyto-diversity of the Ivotka river basin within the territory of Sumy region

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**Abstract.** The search and study of the distribution conditions of rare plants are important for their protection from extinction and the conservation of biodiversity. This activity becomes even more relevant due to the acceleration of climate change due to anthropogenic impact on biocenoses, in the formation of which plants play a substantial role, creating grass cover of meadows, floodplains, and undergrowth. The purpose of this study was to collect and analyse information on protected plant species and communities in the Ivotka river basin in the Sumy region and study the conditions of their distribution. In the course of the study, field examinations were conducted to search for rare plants and describe the places of their localisation using the route diagnostic method and desk studies to identify the found material. The result of the study was the finding of 28 rare species of vascular plants in the Ivotka river basin within the Sumy region, among which 2 are listed in Resolution No. 6 of the Berne Convention and the Red Book of Ukraine, 10 – in the Red Book of Ukraine, 16 – in the list of plant species that are not listed in the Red Book of Ukraine, but are rare or endangered in the territory of the Sumy region. These plants can be classified as especially valuable for conservation that require protection and balanced use of both these species and the biocenosis complex in their distribution territory. It is not enough to change the protected status of the plant species itself or the territory of their localisation to preserve and protect rare plants. Systematic implementation of responsible forest and land use

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practices is essential to preserve existing biodiversity. The results obtained help to establish the protected status for rare plants, develop measures for their protection and use, and determine the need to implement a system of responsible forest and land use for Biodiversity Conservation

**Keywords:** Left-Bank Polissia; rare species of higher plants; flora protection; Red Book of Ukraine; responsible forest and land use

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## Introduction

One of the main tasks facing humanity is the preservation of biological diversity, as one of the key factors that ensures the stability and stability of not only the biosphere but also the global climate (Kovalenko, 2021). The depletion of biological diversity occurs both under the anthropogenic impact of global climate change and as a result of human activities to destroy species or the natural environment of their distribution directly, or to worsen their condition due to fragmentation, degradation, overexploitation, exposure to invasive species and pollution. Under the influence of these factors, the following processes occur: a decrease in the vitality of individual plants, a decrease in the population size, and fragmentation of the population into individual loci until its complete disappearance (Kovalenko *et al.*, 2022). The most vulnerable species are the first to respond to this. The same impact was experienced by the territory of the Ivotka river basin within the Sumy region, where this study was conducted to search for rare vascular plant species over a fairly large area (1310 m<sup>2</sup>) of Left-Bank Polissia of Ukraine.

Special search for rare plant species in the river Ivotka basin within the Sumy region began only at the beginning of the 21<sup>st</sup> century as part of national programmes for environmental protection. This activity, aimed at ensuring the protection of rare and endangered species, is relevant in view of their losses over the past decades as a result of the anthropogenic destruction of their dwellings. Reclamation works that were conducted in the 60s of the

20<sup>th</sup> century along the entire floodplain of the Ivotka river basin, ploughing of floodplains led to the disappearance of some species of rare plants, especially those that are biosubjectally tied to floodplain meadows and swamps of the river valley.

Firstly, it is necessary to streamline knowledge about living organisms, their species, and coenoses in specific regions to prevent the impoverishment and destruction of biodiversity (Vakal *et al.*, 2003; Kovalenko, 2021). Examinations in the river basins of the Left-Bank Forest-Steppe of Ukraine were almost never conducted (Bondar *et al.*, 2017). In addition, even the third edition of the “Red Book of Ukraine” in 2009, according to researchers V.V. Budzak & Ya.P. Didukh (2020), contains fragmentary information about the growth sites of rare vascular plants.

For a long time, the study of plants and vegetation cover concerned plant anatomy and morphology, taxonomy, phytocenology, and phytogeography. Such trends dominated the world of science. Only at the end of the 20<sup>th</sup> century did populations begin to be considered as real forms of existence of plant species and cenotic relationships were examined – typical and local, which ensure the stability of the species in general and individual individuals. According to I.P. Lohvynenko *et al.* (2019), monitoring populations, especially rare plants, allows tracking processes that occur at the level of plant species, in plant communities, and in the biosphere in general.

The in-depth study of forest and meadow ecosystems is currently a highly researched subject related to global warming and climate aridification. These processes are chain-based and begin in forest ecosystems with changes in the formation of the grass and shrub tier and meadow ecosystems adjacent to forests and reservoirs, which is also typical for Polissia. This is highlighted by researchers such as O.O. Chusova *et al.* (2022) and I. Kovalenko *et al.* (2022).

Understanding of the importance of biodiversity conservation, especially in forest systems, is increasingly reflected in international instruments and national strategic programmes. Most countries that have submitted materials to the State of Europe's Forests (2021) report, the Ministerial Conference on forest conservation in Europe, provide support, conservation, and improvement of forest biodiversity. Back in 1992, the European Union adopted Council Directive 92/43/EEC (1992), which provides for the protection of not only representatives of fauna and flora but also their places of residence.

Furthermore, the Forest Stewardship Council (FSC) (n.d.) back in 1999 proposed the concept of "High Conservation Value" (HCV) to identify special value for the conservation of species, biocenoses, ecosystems that need protection and balanced use. HCV conservation is becoming increasingly a requirement for timber companies when obtaining a certificate. Such work on identifying plant and animal species from the positions of their dwellings is conducted in many countries.

Y.O. Kremenetska *et al.* (2022) noted that at the national level in Ukraine, obstacles to the implementation of the HCV system as the basis for responsible forest and land use are the lack of localised information on the availability of values for conservation in forests; imperfect legal regulation in the field of forestry, in particular, the lack of approved national criteria

for identifying forests with special values and conflict with existing land use planning. The most difficult obstacle was the identification of HCV ecosystems and habitats, which is the basis of all further actions to protect and preserve biodiversity, and finally, to form forest and land use policies and implement them.

The purpose of this study was to collect and analyse information about plant species and their groups that need protection in the Ivotka river basin in the Sumy region and investigate the conditions of their distribution.

### Materials and Methods

In this study on rare plant species in the Ivotka river basin within the Sumy region, one of the most important approaches was population-based. The main research methods are empirical, namely observation, analytical, cartographic, and statistical. Empirical, statistical, and cartographic methods were mainly used in the course of field expeditions to identify rare plant species and their localisations in the river basin.

Analytical methods were used mainly in desk studies to identify identified plant communities, and their belonging to protected rare plant species of various statuses – from international, national, to regional. The study was conducted through field and desk research.

Field examinations in the course of field studies were conducted during 2001 and 2020–2021 using the route diagnostic method. Routes were laid across the entire territory of the river Ivotka basin within the Sumy region from west to east and from north to south, along and across its valleys and valleys of its tributaries to examine all biotopes characteristic of this area.

The studies were conducted according to the following parameters: the total number of protected species in areas of a certain type of distribution environment, determining the area of protected species distribution sites and their

location, the number of sites where each of the protected species is present, and, if possible, the parameters of the average number of plants of the protected species per site within the habitat or projective cover. The study followed the international principles set out in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973).

In desk studies of the cenotic affiliation of the identified plant species and communities, the method of geobotanic descriptions was applied (Yakubenko *et al.*, 2020), for which the ecological and phytocenotic classification of the vegetation of Ukraine was used (Prokudin, 1987; Shelyag-Sosonko, 1991). The following methods were used to identify protected plant species: Resolution No. 6 of Convention on the Conservation of European Wildlife and Natural Habitats Standing Committee (1998), Red Book of Ukraine (Didukh, 2009a), Green Book of Ukraine (Didukh, 2009b).

Scientific sources containing information about the flora were also used to identify the plant communities of the Ivotka river basin and adjacent territories of Novhorod-Siversky Polissia (Vakal *et al.*, 2003; Chornous, 2006; Boychenko *et al.*, 2019). This allowed identifying a number of located plant communities as those that are not included in the Red Book of Ukraine, but are rare or endangered in the Sumy region.

When investigating the cenotic affiliation of the found plant species and groups, and their identification with protected plant species of different rarity status, or with those species that are threatened with extinction but are not included in the lists of protected species, an analytical comparison method was used. The applied approaches contribute to creating the basis for further research and conservation of biocenoses and ecosystems of Eastern Polissia, and for forming a policy of responsible forest and land use.

## Results

The Ivotka River begins within the Central Russian Upland, at an altitude of about 220 m, near the village of Podliesnyie Novosiolki in the South-East of the Bryansk region, flows into the river Desna between the villages of Korotchenkove and Obrazhiivka. The total length of the river is 93 km. Area of the Ivotka river basin within the Sumy region is 1310 km<sup>2</sup> (Yatsyk, 1991).

In the system of physical and geographical zoning of Ukraine, the territory of the river belongs to the Shostka (Prydesniansky) and Yampolsky physical-geographical regions of the Novhorod-Siversky Polissia region of the mixed forest zone of Ukraine (Popov *et al.*, 1968). This zone is characterised by Polissia landscapes, which are determined by the valley types of terrain of the rivers Desna and Ivotka and morainic-outwash plains created by glacial accumulation.

In the geobotanical zoning system, the territory of the river Ivotka is located within the Chernihiv-Novhorod-Siversky geobotanic district, Shostkinsky district, for which the typical and dominant groups of natural vegetation are pine, oak-pine and lime-oak-pine forests, floodplain meadows, eutrophic swamps (Andrienko *et al.*, 1977).

The wide floodplain of the river Ivotka is characterised by meadow and swamp vegetation, which is now degraded from excessive anthropogenic impact (draining land reclamation, overgrazing, ploughing, large recreational load, etc.). Substantial areas are represented by agrophytocenoses on the site of erected forests.

Forest vegetation of the Ivotka river basin is mainly represented by groupings of the *Pinus sylvestris* formation. Pine forests are mostly represented by associations of *Pinetum calamagrostidosum (epigeioris)*, *Pinetum polytrichosum*, *Pinetum festucosum (rubrae)*, *Pinetum pteridiosum (aquilini)*, *Pinetum (pterldioso-hylocomiosum)*. Oak-pine forests are dominated by

formations of *Querceto-Pinetum coryloso (avel-lanae)-stellariosum (holosteeae)*, *Querceto-Pinetum pteridiosum-calamagrostidosum (epigei)*, *Querceto-Pinetum (pteridiosum (aquilini))*, and in lime-oak-pine trees – *Tilieto-Querceto-Pinetum vaccinosum (myrtilli)*.

Spruce forests are mostly of artificial origin and consist mainly of associations of *Piceetum oxalidoso (acetosellae)* and *Piceetum athyriosum (fili-feminae)*. There are *Betuleto-Pinetum sphanosum* associations in small areas, and in floodplains of rivers – *Saliceta albae*, *Alneta glutinosae*, *Populeta tremulae*. Shrubby vegetation of the floodplain of the river Ivotka mainly consists of *Saliceta cinerea*, *Saliceta triandrae*.

According to the classification, floodplain meadows of the river Ivotka belong to the formations of true, settled, swampy, and soddy meadows (Afanasyev *et al.*, 1956; Sipailova, 1976). Among their vegetation, the following formations predominate – *Agrostideta stoloniferae*, *Alopecureta pratensis*, *Anthoxantheta odorati*, *Calamagrostideta epigeioris*, *Cynosureta cristati*, *Festuceta pratensis*, *festuceta rubrae*, *Phleeta pratensis*, and *Poeta pratensis*.

To a large extent, the meadow lands of the reserve are used as pastures. In some areas with excessive pasture load (Ivot, Antonivka villages), there is a high level of degradation of meadows. Eutrophic swamps in the Ivotka river basin on the territory of the Sumy region is represented mainly by groups of formations of *Alneta glutinosae*, *Betuleta pendulae*, *Phragmiteta australis*, *Equiseteto (palustris)-hypneta*, *Glycerieta maximae*, *Cariceta fcutiformis*.

The type of aquatic vegetation in this area is represented by air-water and aquatic classes of plant formations. The most common formations of air-water vegetation are *Phragmiteta australis*, *Glycerieta maximae*, *Typheta latifoliae*, *Shoeplecteta lacustris*, *Sagitarieta sagitofoliae*, *Sparganieta erecti*. Among the aquatic vegetation, the most widespread groupings are the

formations of *Nuphareta luteae*, *Nymphaeeta albae*, *Nymphoideta peltatae*, *Rotamogetoneta pectinati*, *Myriophylleta spicati*, *Elodeeta canadensis*, *Ceratophylleta demersi*, *Utricularieta vulgaris*, *Lemneta minoris*, *Spirodeleta polyrhizae*.

The main result of this study was original information about rare, sparsely distributed, and endangered plant species collected during field research in the Ivotka river basin within the Sumy region. Notably, the plant world of this part of Polissia is insufficiently examined, and the relatively small number of special scientific papers, which are quite fragmentary in nature. Therefore, a comprehensive collection and initial analysis of empirical information about the flora of each part of Polissia is an important basis for further research and conservation of both individual vegetation species, coenoses, and ecosystems in general.

The result of the analysis of field research materials and their identification using databases of international and national conservation documents for the conservation of wildlife and biodiversity was information about the finds in the Ivotka river basin within the territory of the Sumy region of populations of 28 rare vascular plant species, among which 2 are listed in Resolution No. 6 of the Berne Convention and the Red Book of Ukraine, 10 – in the Red Book of Ukraine, 16 – in the list of plant species that are not listed in the Red Book of Ukraine but are rare or endangered in the territory of the Sumy region.

Among the plants included in Resolution No. 6 two species were identified at the Berne Convention – *Nymphoides peltata* (S. G. Gmel.) and *Pulsatilla patens* (Mill.). Among the plants included in the Red Book of Ukraine, 10 species were identified – *Lycopodium annotinum* (A. Haines), *Iris sibirica* (L.), *Lilium martagon* (L.), *Dactylorhiza fuschsii* (Druce, Soó), *Dactylorhiza incarnata* (L.), *Epipactis helleborine* (L.), *Goodyera repens* (L.), *Neottia nidus-avis* (L.),

*Platanthera bifolia* (L.), *Platanthera chlorantha* (Custer and Rchb.). Among the plants that are not listed in the Red Book of Ukraine but are rare or endangered in the Sumy Region, 16 species were identified – *Lycopodium clavatum* (L.), *Matteussia struthiopteris* (L.), *Juniperus communis* (L.), *Nymphaea alba* (L.), *N. candida* (J. Presl), *Aquilegia vulgaris* (L.), *Drosera rotundifolia* (L.), *Gentiana pneumonanthe* (L.), *Antennaria dioica* (L.), *Parnassia palustris* (L.), *Dianthus pseudosquarrosus* (Novak) Kleopow, *Arctostaphylos uva-ursi* (L.), *Psephellus sumensis* (Kalen.), *Pyrethrum corymbosum* (L.), *Digitalis grandiflora* (Mill.), *Calla palustris* (L.). In the Ivotka river basin, plant groups listed in the Green Book of Ukraine were also found, namely – *Nuphareta luteae*, *Nymphaeeta albae*, *Nymphaeeta candidae*, *Nymphoideta peltatae*.

Their conservation status characteristics: the species are listed in Resolution No. 6 of the Berne Convention (Boychenko *et al.*, 2019), the Red Book of Ukraine (Didukh, 2009a), and species that are rare or endangered in the Sumy re-

gion (Andrienko & Peregrym, 2012). Plant species included in Resolution No. 6 of the Berne Convention, – *Nymphoides peltata* (S. G. Gmel.) and *Pulsatilla patens* (Mill.).

*Nymphoides peltata* (S.G. Gmel.) in Ukraine, occur in the estuaries and floodplains of the lower reaches of the Danube, Dniro, Southern Bug, Dniester rivers, in Transcarpathia, Zhytomyr, and Chernihiv Polissia, in the Forest-Steppe (Boychenko *et al.*, 2019). The total population area is about 0.5 ha with a density of up to 200 generative plant specimens per 100 m<sup>2</sup>.

*Pulsatilla patens* (Mill.) in Ukraine is distributed in Polissia, Forest-Steppe, and Northern Steppe (Boychenko *et al.*, 2019). In the area of the field studies, it is scattered throughout the territory on sod-podzolic, in middle-aged and old pine, pine-oak soils. In the course of field studies of the Ivotka river basin on the territory of the Sumy Region, 10 plant species included in the Red Book of Ukraine were identified. The results are presented in Table 1.

**Table 1.** Plant species included in the Red Book of Ukraine found in the Ivotka river basin

No.	Species name	Localisation in Ukraine	Characteristics of the environment of loci of the species	Area of loci found	Places where the species was found in the Ivotka river basin
1.	<i>Lycopodium annotinum</i> (L.)	Carpathians, Roztochia, Volyn Upland, Polissia, Forest-Steppe (occasionally)	1. Wet pine forest on the hog terrace of the Ivotka river. 2) Old spruce forest. 3) Associations of <i>Pinetum-Querceto coryloso (avellanae)-caricosum (pilosae)</i> on a plot with low terrain. 4) Old pine forest. 5) Old pine-oak forest.	1. 0.01 ha with a projective coating of 30%. 2. 0.1 ha with a projective coating of 50-60%. 3. 0.05 ha. 4. 0.01 ha with a projective coverage of about 20%. 5. 0.1 ha with a projective coating of up to 100%.	1. Tract "Radkiv Bir" Myronivsky Forestry, sq. 15. 2. Prudyshchanske Forestry, sq. 106. 3. Kremlianske Forestry, sq. 62. 4. Tract "Forest Plot" of the Kremliansky Forestry, sq. 96. 5. Protected area "Pidivotsko-Chuikivska dacha" Chuikivsky Forestry, sq. 32.
2.	<i>Iris sibirica</i> (L.)	Transcarpathia, Prykarpattia, Roztochia, Polissia, less often – Forest-Steppe, occasionally – the northern part of the Steppe Zone, and the Crimea	Meadow vegetation of the floodplain of the river Ivotka	Up to 0.2 ha in the floodplain of the river Ivotka	1 km south of the village Chuikivka

Table 1, Continued

No.	Species name	Localisation in Ukraine	Characteristics of the environment of loci of the species	Area of loci found	Places where the species was found in the Ivotka river basin.
3.	<i>Lilium martagon</i> (L.)	Carpathians, Transcarpathia, pre-Carpathia, Roztochia, Opillia, Polissia, in the Forest-Steppe	Old su-boron of the <i>Querceto-Pinetum pteridoso-calamagrostidosum (epigei) association</i>	0.05 ha, 4 generative age specimens	Protected area "Prudyshchanska dacha" Prudyshchansky Forestry, sq. 62
4.	<i>Dactylorhiza fuschii</i> (Druce and Soó)	Carpathians, pre-Carpathia, Roztochia, Opillia, Polissia, northern part of the Forest-Steppe, Steppe	Soddy meadow with a predominance of <i>Deschfmpsia caespitosa (L.) Beauv.</i> , <i>Carex nigra (L.) Reichard.</i>	0.01 ha, up to 20 specimens	East of the village Derazhnia
5.	<i>Dactylorhiza incarnata</i> (L.)	Carpathians, Forest Zone, Forest-Steppe, mountains of Crimea, occasionally Steppe	1. Wet meadows among shrubs of <i>Caricetum (nigrae) agrostidosum (caninae)</i> association. 2. Wet and swampy meadows.	1. 0.1 ha, 30 specimens of generative age. 2. 0.2 ha, location density up to 20 generative age specimens per 100 m <sup>2</sup> .	1. floodplain of the river Kosychykha near the village Derazhnia. 2. Hydrological reserve of local importance "Doroshivsky".
6.	<i>Epipactis helleborine</i> (L.)	Carpathians, Forest, Forest-Steppe, Steppe zones (in the forests of large river valleys)	1. Old pine-oak forest. 2. medium-age wet su-boron.	1. 6 plants of generative age. 2. 28 instances in multiple locations.	1. Protected area "Prudyshchanska dacha" Prudyshchansky Forestry, sq. 62. 2. Sveske Forestry, sq. 58.
7.	<i>Goodyera repens</i> (L.)	Carpathians, Roztochia, Polissia, Podillia, mountains of Crimea	Old spruce forest in the association of <i>Piceetum oxalidoso (acetosellae)</i>	0.05 ha, 200 specimens	Prudyshchanske Forestry, sq. 106
8.	<i>Neottia nidus-avis</i> (L.)	Carpathians, Transcarpathia, Polissia, Forest-Steppe, northern Steppe, mountains of Crimea	1. Pine-oak Forest. 2. Association <i>Querceto-Pinetum coryloso (avellanae)-caricosum (pilosae)</i> .	1.0.01 ha, 28 plants of generative age. 2. 5 specimens.	1. Protected area "Prudyshchanska dacha" of the Prudyshchansky Forestry district, sq. 62. 2. Sveske Forestry, sq. 58.
9.	<i>Platanthera bifolia</i> (L.)	Carpathians, Roztochia, Opillia, Polissia, northern Forest-Steppe, occasionally Steppe	Old pine-oak forest	0.1 ha, 12 specimens of generative age	Protected area "Prudyshchanska dacha" of Prudyshchansky Forestry, sq. 62
10.	<i>Platanthera chlorantha</i> (Custer and Rchb.)	Carpathians, Roztochia, Opillia, Polissia, Forest-Steppe, occasionally – Steppe	Oak-pine forest	18 specimens	Landscape reserve of local importance "Prudyshchansky" of the Prudyshchansky Forestry, sq. 65

Source: compiled by the authors

In the course of field study in the Ivotka river basin 16 plant species that are not listed in the Red Book of Ukraine were also identified

but are rare or endangered in the Sumy region (Andrienko & Peregrym, 2012). The results are presented in Table 2.

**Table 2.** Rare plants or those that are threatened with extinction on the territory of the Sumy region, not included in the Red Book of Ukraine, found in the Ivotka river basin

No.	Species name	Localisation in Ukraine	Characteristics of the environment of loci of the species	Area of loci found	Places where the species was found in the Ivotka river basin
1.	<i>Lycopodium clavatum</i> (L.)	Carpathians, Polissia, northern Forest-Steppe	1. Sparse grass stand <i>Molinia caerulea</i> (L.) Moench. and <i>Lysimachia vulgaris</i> L. among cultures <i>Pinus sylvestris</i> L. and <i>Betula pendula</i> Roth. 2. Pine forest. 3. <i>Pinetum polytrichosum</i> association. 4. Pine-Oak forest in hollow depressions. 5. Pine forest. 6. Old Pine forest on low terrain areas.	1. 0.05 ha with a projective coating of up to 30%. 2. 0.02 ha with a projective coating of 5-10%. 3. 0.01 ha with a projective coating of up to 70%. 4. 0.01 ha, small curtains. 5. 0.1 ha, scattered, small spots with an average projective coverage of 40%. 6. 0.05 ha.	1. Tract "Radkiv Bir" Myronivsky Forestry, sq. 15. 2. Myronivske Forestry, sq. 81. 3. protected area "forest plot" of the Kremlianske Forestry district, sq. 96. 4. Protected area "Pidivotsko-Chuikivska dacha" Chuikovsky Forestry, sq. 32. 5. Forest tract "Sveska dacha" of the Svesky Forestry district, sq. 14. 6. protected area "Kremlianska dacha" of the Kremlianske Forestry, sq. 40-42.
2.	<i>Matteussia struthiopteris</i> (L.)	Carpathians, Polissia, Forest-Steppe	Grassy snyt vegetation in a wet oak forest	0.05 ha, 30 specimens	Ostriv Tract
3.	<i>Juniperus communis</i> (L.)	Carpathians, Polissia, Crimea, occasionally Steppe	Pine forest	0.1 ha	Kremlianske Forestry, sq. 116
4.	<i>Nymphaea alba</i> (L.)	Occasionally throughout Ukraine	Starystsia, sometimes the riverbed of Ivotka river and its tributaries	Multiple plots up to 0.05 ha	
5.	<i>Nymphaea candida</i> (J. Presl)	In lakes and floodplain reservoirs in broad-leaved forest and Forest-Steppe zones	Staritsa, riverbeds	Sporadically throughout the territory	The entire pool river Ivotka
6.	<i>Aquilegia vulgaris</i> (L.)	Forest-Steppe, Polissia	Medieval meadows, the edge of the forest	0.05 ha, 8 specimens	Protected area "Prudyschchanska dacha" of Prudyschchansky Forestry, sq. 62
7.	<i>Drosera rotundifolia</i> (L.)	Carpathians, Polissia, northern part of the Forest-Steppe	1. Sphagnum swamp surrounded by pine forest. 2. Mesotrophic forest swamp.	1. 0.01 ha. 2. 27 specimens.	1. Chuikivske Forestry, sq. 38. 2. Kremlianske Forestry, sq. 42.
8.	<i>Gentiana pneumonanthe</i> (L.)	Most of the territory of Ukraine, except Crimea	Wet meadows in the floodplain of tributaries of river Ivotka	2.0 ha, 34 specimens	Near the village of Derazhnia

Table 2, Continued

9.	<i>Antennaria dioica</i> (L.)	Scattered almost all over Ukraine	<i>Pinus sylvestris</i> culture with sparse stands of trees, among grassy vegetation	0.3 ha, single specimens	Tract "Radkiv Bir" Myronivske Forestry, sq. 28
10.	<i>Ragpasia rlustris</i> (L.)	Polissia, Forest-Steppe (occasionally)	Wet meadows around a grassy swamp in a <i>Alopecureta (pratensis) deschampsiosum (cespitosae)</i> formation	0.1 ha, 20 specimens	Doroshivsky hydrological reserve
11.	<i>Diantus pseudosquarros</i> (Novak) Kleopow	Polissia, northern Forest-Steppe	Clearing in a pine forest with sparse grass	0.01 ha, single specimens	Kremlianske Forestry, sq. 42
12.	<i>Arctostahylos uva-ursi</i> (L.)	Polissia	<i>Pinus sylvestris</i> Culture	0.3 ha, small sparse curtains, sometimes single bushes	Landscape reserve of local importance "Prudyshchansky", near the village of Prudyshche
13.	<i>Psephellus sumensis</i> (Kalen.)	Polissia, Forest-Steppe, Steppe (occasionally)	Culture <i>Pinus sylvestris</i> , boron sands	Not localised, occurs throughout the territory	Landscape reserve of local importance "Prudyshchansky" of the Prudyshchansky Forestry of the Svesky State Forestry Enterprise
14.	<i>Pyrethrum corymbosum</i> (L.)	The entire territory of Ukraine	Forests, shrubs, dry meadows	Not localised, occurs throughout the territory	Landscape reserve of local importance "Prudyshchansky" of the Prudyshchansky Forestry of the Svesky State Forestry Enterprise
15.	<i>Digitalis grandiflora</i> (Mill.)	Carpathians, Right Bank of Ukraine, Left Bank (occasionally)	Deciduous and mixed forests, clearings, shrubs	Not localised, occurs throughout the territory, single instances	Landscape reserve of local importance "Prudyshchansky" of the Prudyshchansky Forestry of the Svesky State Forestry Enterprise
16.	<i>Calla palustris</i> (L.)	Polissia	Swamps, swampy riverbanks	Sporadically, in small curtains or groups	Landscape reserve of local importance "Prudyshchansky" of the Prudyshchansky Forestry of the Svesky State Forestry Enterprise

Source: compiled by the authors

In the course of this study, the place of growth in part of the Novhorod-Siversky Polissia in the Sumy region *Psephellus sumensis* (Kalen.), *Pyrethrum corymbosum* (L.), *Digitalis grandiflora* (Mill.), *Calla palustris* (L.) on the territory of the landscape reserve of local

importance "Prudyshchansky" of the Prudyshchansky Forestry of the Svesky State Forestry Enterprise was also confirmed. In the Ivotka river basin, *Nuphar lutea* (Smith), *Nymphaea alba* (L.), *Nymphaea candida* (J. Presl), *Nymphoides peltata* (S.G. Gmel) plant groups, listed

in the Green Book of Ukraine were identified (Didukh, 2009B).

Finds of rare plants and places of their localisation on the territory of the Ivotka river basin within the Sumy region will allow further spatial monitoring of populations, conducting information and explanatory work on their conservation and measures to ensure their protection regimes.

### Discussion

The intensification of research on the phyto-diversity of the Left-Bank Polissia over the past three decades has been in the trend of global scientific research and international and national management decisions on measures to preserve biodiversity. These studies can be divided into three groups – those that relate to strategic issues of biodiversity conservation, the study of phyto-diversity in river basins or other unique territories, the study of individual species of rare plants or species that were the basis of the forests of Polissia and phytosystems with rare herbaceous plants.

All researchers pay attention to the main factor that is a threat to biodiversity, namely the thoughtless and irresponsible practice of human activity, which destroys its habitat. This practice concerns the irresponsible treatment of forest, land, water, plant, and animal resources. Anthropogenic impact on the environment has reached such a level that it has become a key factor in global climate change. Many researchers highlight the connection between these processes.

For example, R.T. Corlett (2020) explicitly states that the anthropocene was marked by crises related to climate change and biodiversity loss, and shows the link between biodiversity and ensuring climate sustainability. Thus, wild plants are used by people as food, medicine, and genetic resources, as wood, feed for pets, etc. However, their functions, such as

regulating water supply and absorbing carbon, already depend on the entire community, and not on individual species. Therefore, for the protection of biodiversity, it is proposed to apply an ecosystem approach, in which the priorities should be to improve the plant cadastre with a focus on geographical areas and groups that are insufficiently examined, expand the reserve system, prevent overexploitation, manage invasive species, and preserve endangered species *ex situ*, ecosystem restoration, climate change control.

One of the main threats to humanity is the deterioration of the health of the global ecosystem, according to K. Kougioumoutzis *et al.* (2020). At risk of extinction are primarily endemic species that suffer from habitat loss and fragmented populations, as they have smaller geographical ranges and ecological niches. The author argues that the conservation of as many species/communities as possible should form the basis of a “climatically reasonable” strategy, which should be based on identifying relatively climatically stable regions with a large number of species of high conservation value with high endemic and genetic diversity. This could be a way to quickly raise global temperatures.

A. Raven & M. Wackernagel (2020) state that biodiversity conservation is achieved by limiting excessive human demand, focusing on areas where the greatest diversity is concentrated, and taking inventory of species diversity. Preservation *in situ*, preserving ecosystems and biodiversity in their natural habitats through biotechnology, is the most appropriate conservation approach for the conservation of species, including endemic species, as it preserves the original genetic and geographical centres of biodiversity. It includes not only the conservation of plant genetic resources but also their management (sustainable use) (Coelho *et al.*, 2020).

Researchers A. Di Sacco *et al.* (2021), pointing to the interconnectedness of biodiversity

and climate change, suggests ten rules for forest ecosystem restoration: protect the existing forest, engage all stakeholders, strive to maximise biodiversity restoration, select areas for restoration, use natural restoration whenever possible, select species to maximise biodiversity, use sustainable plant material, plan infrastructure, capacity and seed supply, learn in practice, and ensure the economic sustainability of the project.

H. Albrecht *et al.* (2016), S. Pironon *et al.* (2020) proposed to combine to preservation of biodiversity with the preservation of agro-diversity. E. Dinerstein *et al.* (2020), describing the Global Safe Network for saving life on Earth, emphasise that the crises of biodiversity loss and climate change have generally been considered separately, the key solution to the two most pressing challenges of our time are the same: to preserve enough nature and in the right places.

Many researchers in Ukraine emphasise the relevance of botanical inventory of plants and determination of their conservation status, inventory of phyto-diversity throughout Ukraine, determination of localisation of plant populations, especially rare ones, creation of protected areas of rare plant locations to prevent further fragmentation of their populations to maximise the restoration of their integrity in the future (Budzak & Didukh, 2020; Kremenetska *et al.*, 2022; Chusova *et al.*, 2022).

In particular, the biosphere role of forests is indicated by I.M. Kovalenko (2021), T.V. Marukha (2022), highlighting their part in regulating the accumulation of greenhouse gases in the atmosphere, the hydrological cycle, and air purification. The researchers draw attention to the fact that forest catchments provide more than 75% of the available fresh water in the world – the most important resource of all life on the planet. In Ukraine, the largest woodlands have been preserved in the Carpathians and Polissia, but they are destroyed by contin-

uous logging, resulting in the fragmentation or even destruction of local ecosystems. It is proposed to take measures to abandon continuous logging, mono-specie artificial afforestation, and afforestation with mixed tree species to preserve the forests of Polissia, which are vital not only for Ukraine, with their rich biodiversity, (Bondar *et al.*, 2017; Kovalenko, 2021) inherent in this area, the transition to the principles and methods of sustainable forestry.

The importance of locating, identifying, and preserving integral (intact) forest landscapes for the restoration of a human-friendly biosphere is emphasised by Y.O. Kremenetska *et al.* (2022). The role of meadows in ecosystem resilience to global climate change is highlighted by O.O. Chusova *et al.* (2022), in particular, on thermoregulation, soil formation, and erosion control. In addition, meadows, especially dry ones, are home to many local endemics.

Other researchers, J. Bengtsson *et al.* (2019) consider grasslands to be one of the world's major ecosystems, covering about one-third of the Earth's surface. Grasslands are not only locally important for maintaining biodiversity and food production, but they also affect environmental processes in the landscape (e.g. pollination), regionally (e.g. water regulation, recreation), and globally (e.g. climate regulation). Grasslands remain undervalued in ecosystem services compared to, for example, forests. They were largely ignored in global political discussions, although more attention was paid to them at the regional level.

A number of researchers conducted search and identification work on rare plants in river basins or in a specially defined search area. Thus, V. Skliar *et al.* (2022) conducted a study of the Phyto-diversity of the Syrovatka river basin in the Sumy region for the purpose of using natural resources for the development of ecotourism. In the course of the study, about 50 plant species belonging to the international

rank of protection were found and identified. This study, as presented in this study, is aimed at the inventory of plant species that are found in the river basins of the Sumy region.

Long-term monitoring can provide important data for managers to prioritise management actions, namely resource status and benchmarks for comparison with other modified or protected environments, early warning of abnormal conditions in selected resources, helping to develop mitigation measures, the dynamic nature of natural systems and trends in selected indicators of these systems (Perles *et al.*, 2022).

Rare plant species on the territory of the Volyn Upland (Right-Bank Polissia of Ukraine) were searched and examined by a group of researchers I.P. Lohvynenko *et al.* (2019). In addition to searching for and identifying rare plants of the Volyn Upland, they made a comparative analysis of the populations they examined with populations from other areas. Population regression was identified to be a general trend for rare species due to the negative impact of anthropogenic factors. Approaches to the inventory and conservation of phyto-diversity on the territory of territorial communities, as a factor of their sustainable development, are considered in a study by A. Kostyshin (2019). The studies of a number of researchers are devoted to the specific features of the state of populations of species that are important for forest formation or individual rare plant species.

In Particular, I.M. Kovalenko *et al.* (2022) investigated the processes of replacing the species composition of Polissia forests from boreal to nemoral, drawing attention to the greater resilience of non-moral species in the context of global warming, which increases their competitiveness in the forest environment and leads to the displacement of boreal species. In addition, changes in temperature conditions lead to the fact that the flowering

of boreal species does not coincide with the life cycles of pollinating insects, which leads to a decrease in the populations of both species. The role of grassy and shrubby forest cover also attracted the attention of researchers. They note that the composition of the soil cover depends not only on the species contribution of trees but the composition of the grass and shrub cover is dominant in the formation of the species diversity of the forest.

Common oak (*Quercus robur*) is one of the main, and often the main forest-forming species in the Ukrainian Polissia. The features of self-healing of oak forests in the Left-Bank Polissia are considered in the study by V. Skliar *et al.* (2019). Self-restoration of oak forests in Polissia is considered by them as a way to restore forest phyto-diversity. It can also become one of the methods of sustainable forestry.

Rare species of forest orchids are examined in the studies of J. Roleček (2021) and O.P. Chornous (2022). The study by J. Roleček (2021) is mainly devoted to the description of the species of *Ophrys insectifera* (L.) (*Orchidaceae*) and found places of its location, while the paper of O.P. Chornous (2022) is based on multi-year observation of *Epipactis helleborine* (L.) (*Orchidaceae*) populations in different parts of the Left-Bank Polissia, including in the Ivotka river basin. The author examined the influence of various factors, in particular, anthropogenic, on the state and resilience of populations *Epipactis helleborine* (*Orchidaceae*) (L.). In addition, he concluded that the optimal types of forest trees for *Epipactis helleborine* (L.) (*Orchidaceae*) populations, there are old ones – *Quercus robur* (L.), *Tilia cordata* (Mill.), *Acer platanoides* (L.).

The study by I. Zubtsova *et al.* (2019) is devoted to the examination of the conditions that are most favourable for the existence and distribution of populations *Hypericum perforatum* (L.) (*Hypericaceae*) and *Saponaria officinalis* (L.) (*Caryophyllaceae*) in Polissia. Expanding

healthy populations of these medicinal plants would allow them to be used more widely in medicine. Notably, all the studies mentioned in the discussion, and studies of earlier periods, are a contribution to unfilled niches of scientific information on the biodiversity of the Ukrainian Polissia and do not contradict, but complement each other.

### Conclusions

The presented study concerned the identification of rare plants and the description of their loci in the Ivotka river basin within the Sumy region. Rare plants are now an integral part of the ecosystems of Polissia, which were formed for thousands of years. In case of violation of the hydrological regime of ecosystems, fragmentation of forests due to deforestation, excessive ploughing of land and destruction of ecosystems themselves under the anthropogenic influence, the most vulnerable were plants whose survival depends to a greater extent not only on the amount of moisture or air temperature but also on the composition of established cenoses. They passed into the category of rarities.

Detected in the process of the study, a rare component of the flora of the vegetation of the Ivotka river basin within the territory of the Sumy region includes 2 species that are included in Resolution No. 6 of the Berne Convention, 12 species listed in the Red Book of Ukraine and 16 plant species that are not listed in the Red Book of Ukraine, but are rare or endangered in the Sumy region. Analysis of the state of protection of rare species showed that out of 28 rare plant species found in the

research area, 12 species grow outside the territory of the objects of the nature reserve fund, which indicates the need to create new objects of the nature reserve fund.

It is established that to preserve the Red Book, regionally rare and endangered species identified in the area of research, and the phytogenofond of Polissia, and implement practical measures to reproduce their resources, it is necessary to expand the territory of the hydrological reserve of local importance "Doroshivsky"; it is advisable to expand the territories of protected forest tracts and transfer them to the category of botanical nature monuments of local importance; create a "Desniansko-Ivotsky" hydrological reserve of local importance, at the confluence of the river Ivotka in river Desna.

The conducted study is a contribution both to the enrichment of an array of scientific information about the vegetation of the Left-Bank Polissia of Ukraine and to the formation of the basis for creating a system of responsible forest and land use in Polissia in the context of climate change. For Polissia, where the rich phyto-diversity is insufficiently examined and localised, search and research work is the basis for further study of the mechanisms of the existence of local cenoses, which should become the basis for creating a system of responsible forest and land use.

### Conflict of Interest

None.

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## Раритетне фіторізноманіття басейну річки Івотка в межах території Сумської області

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**Анотація.** Пошук і вивчення умов поширення раритетних рослин є важливими для їх захисту від зникнення та збереження біорізноманіття. Ця діяльність стає ще більш актуальною з огляду на прискорення процесу змін клімату внаслідок антропогенного впливу на біоценози, у формуванні яких суттєву роль відіграють рослини, які створюють трав'янистий покрив лук, заплавлі річок і підліску. Метою цього дослідження були збір і аналіз інформації про види і угруповання рослин, що підлягають охороні, в басейні річки Івотка на території Сумської області і вивчення умов їх поширення. В процесі роботи були проведені польові дослідження по пошуку раритетних рослин і опису місць їхньої локалізації з застосуванням маршрутно-діагностичного методу та камеральні дослідження з ідентифікації знайденого матеріалу.

Результатом дослідження стали знахідки на території басейну річки Івотка в межах Сумської області 28 раритетних видів судинних рослин, серед яких 2 – занесені до Резолюції No. 6 Бернської конвенції та Червоної книги України, 10 – до Червоної книги України, 16 – до списку видів рослин, які не занесені до Червоної книги України, але є рідкісними або такими, що перебувають під загрозою зникнення на території Сумської області. Ці рослини можна віднести до категорії особливих цінностей для збереження, які потребують захисту і збалансованого використання як самих цих видів, так і комплексу біоценозу на території їх поширення. Для збереження і захисту раритетних рослин недостатньо зміни охоронюваного статусу самого виду рослин чи території його локалізації. Необхідним є системне впровадження практики відповідального лісо- і землекористування, щоб зберегти існуюче біорізноманіття. Отримані результати допомагають встановити охоронний статус для рідкісних рослин, розробити заходи з їхнього захисту та використання, а також визначити необхідність впровадження системи відповідального лісо- і землекористування для збереження біорізноманіття

**Ключові слова:** Лівобережне Полісся; раритетні види вищих рослин; охорона флори; Червона книга України; відповідальне лісо- і землекористування