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FLORISTIC AND ECOLOGICAL ASSESSMENT OF THE SAMARA FOREST COMPLEX IN THE STEPPE ZONE OF UKRAINE

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Abstract. The article explores the ecological significance of the Samara Forest – a unique forested natural complex in the steppe zone of Northern Prydniprovia, Ukraine. This study assesses the floristic diversity, conservation value, and ecological integrity of the area based on field surveys, historical data, and remote sensing. The flora of the Samara Forest comprises a wide range of native plant species, totaling 1.154 vascular plant species across approximately 451 km², among which a significant number are rare or regionally protected. The high species richness is associated with habitat heterogeneity and the presence of ecotones between forest and steppe elements; floristic density in the region reaches 2.8 species per km², which is substantially higher than the average for the broader Dnipropetrovsk oblast (1.714 species over 31.900 km²; 0.05 species per km²). The results emphasize the urgent need for conservation and provide a scientific basis for assigning protected status to this area. The territory retains considerable ecological potential, supports important ecosystem services, and can play a key role in regional biodiversity preservation strategies. Establishing the Samarskyi Lis National Nature Park would ensure long-term protection of threatened species and ecosystems, under increasing anthropogenic and climatic pressures.

Keywords: biological diversity, steppe areas, forests, rare species, adventive species.

1. Introduction

Forests in Ukraine’s steppe zone serve as essential ecological refugia, preserving a broad range of indigenous plant and animal species (Belova et al., 2010; Horban, 2016). Despite their fragmented distribution and limited area, such ecosystems play crucial roles including safeguarding biodiversity, mitigating erosion and regulating local climatic conditions. (Demianov, 2010;

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Recio Espejo et al., 2020). One of the most notable forested complexes in this zone is the Samara Forest, located within the Samara River basin. Its distinctive hydrological and geomorphological conditions have created a favorable environment for diverse forest bioceonoses. Historical botanical and ecological research from the early 20th century and later synthesized by Tarasov (2012) highlighted the unique structure and biodiversity of the region's vegetation. These works classified key vegetation types and laid the groundwork for further studies on the transformation of the steppe forest environment. However, modern anthropogenic factors, including deforestation, urban expansion, recreational pressure, and invasive species, are increasingly threatening the ecological stability of the Samara Forest. A growing body of satellite-based ecological monitoring data confirms the intensification of landscape fragmentation and canopy disturbance in forested areas (Jiang et al., 2021; Francini & Chirici, 2022). These patterns reinforce the urgent need for a comprehensive ecological assessment of the Samara Forest to support effective conservation and management planning. This study aims to document the current floristic composition, evaluate ecological integrity using indicators of hemeroby and synanthropization, and provide scientific justification for assigning the territory protected status as a National Nature Park.

2. Materials and Methods

Field investigations of the Samara Forest complex were carried out over a long-term period from 1984 to 2024, with intensive sampling conducted in spring (April–May) and summer (June–August). Vegetation was surveyed using 180 relevés, including 20×20 m plots for forest biotopes and 10×10 m plots for herbaceous communities, distributed across different habitat types. Rare species were recorded during systematic route surveys with a total length of over 850 km. Extensive field studies combined with a detailed examination of published and archival data enabled a comprehensive understanding of the Prysamarya natural complex. Various plant communities were characterized using remote sensing methods, ranging from the delineation of vegetation patches (Jiang et al., 2021; Francini & Chirici, 2022; Matsiuk & Masiuk, 2023) to the study of dynamic landscape changes (Austin et al., 2019; Thapa et al., 2021; Faruque et al., 2022). Standard satellite dataprocessing procedures were employed (Austin et al., 2019; Faruque et al., 2022; Francini & Chirici, 2022; Jiang et al., 2021; Li et al., 2021; Thapa et al., 2021). The forest mapping stage included identifying spectral signatures of individual tree species or forest stand conditions, followed by supervised classification of satellite imagery (Francini & Chirici, 2022; Thapa et al., 2021). Forest conditions were assessed using various vegetation indices and their modifications (Austin et al., 2019; Thapa et al., 2021; Masiuk et al., 2023). The applied remote sensing techniques included: ISODATA clustering; the development of surface-type signatures across different seasons; and supervised classification using the Minimum Distance algorithm. Winter satellite imagery and NDVI-based analysis were employed to identify and delineate arenal forest zones, meadow systems, and steppe landscapes within the study area. The primary method for identifying the structure of meadow and steppe landscapes was ISODATA clustering. The most accurate classification results were obtained from June imagery, when deciduous tree species display more distinct spectral characteristics compared to coniferous species and herbaceous vegetation. Post-classification processing produced generalized surface-type layers (biotopes) (Fig. 2) and allowed for the calculation of their area. Vascular plant species were identified according to: *Plant Identifier of Ukraine* (1965), *Flora of the European Part of the USSR* (1974–1989), and *Flora of Eastern Europe* (1996–2004). Taxonomic nomenclature follows the *Plants of the World Online* database maintained by the Royal Botanic Gardens, Kew (POWO, 2025). The bioecological characteristics of the flora (ecomorphological and cenomorphological analysis) were determined using the ecomorph classification system developed by O. L. Belgard in 1950, which was the first ecomorphological system worldwide for vascular plants. Belgard's classification system was applied in this study, incorporating subsequent revisions by Baranovsky and Tarasov (Tarasov, 2012; Baranovski et al., 2023), including the addition of the new ecomorph sylvomargoant (Baranovski et al., 2023). Vegetation was analyzed using established and widely recognized methodologies. The identification of rare phytocoenotic and syntaxonomic diversity was based on syntaxon inventory and the matrix method of synphytozoological assessment of the phytocoenotic pool. Syntaxon names follow the nomenclature rules outlined in the draft *Code of Phytocoenotic Nomenclature* (Ustymenko & Dubyna, 2015).

3. Results and Discussion

Watershed-gully landscapes. The study area is defined by the following geographical boundaries:

eastern – 48.64431° N, 35.773578° E; western – 48.74459° N, 35.292854° E; northern – 48.84247° N, 35.43125° E; and southern – 48.60008° N, 35.66643° E. The Samara River valley is a well-developed right-bank valley approximately 6–7 km wide. Its slopes are dissected by numerous ravines and gullies. Water levels remain generally low throughout the year, with brief increases caused by precipitation-driven flooding events. The river is fed by surface runoff from rainfall and snowmelt, groundwater springs and mine and wastewater discharges. Since 1976, average annual water discharge has gradual increased (Fig. 1). Over recent decades, the peak discharge during spring floods has declined, while the average annual discharge has slightly increase, likely linked to overall climatic warming (Fig. 1). This hydrological shift contributes to decreased moisture levels in the floodplain and a consequent reduction in biodiversity.

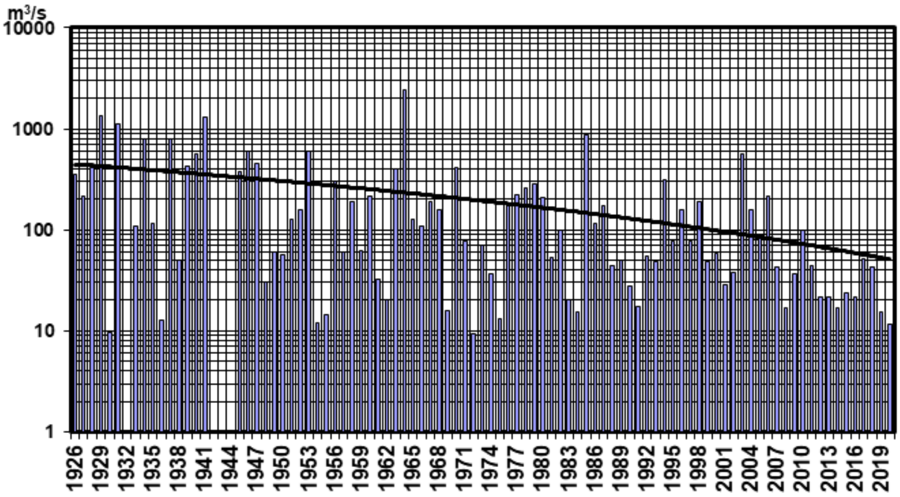

Fig. 1. Long-term dynamics of on maximum flood discharges
of the Samara River at the Kocherezhki gauging station

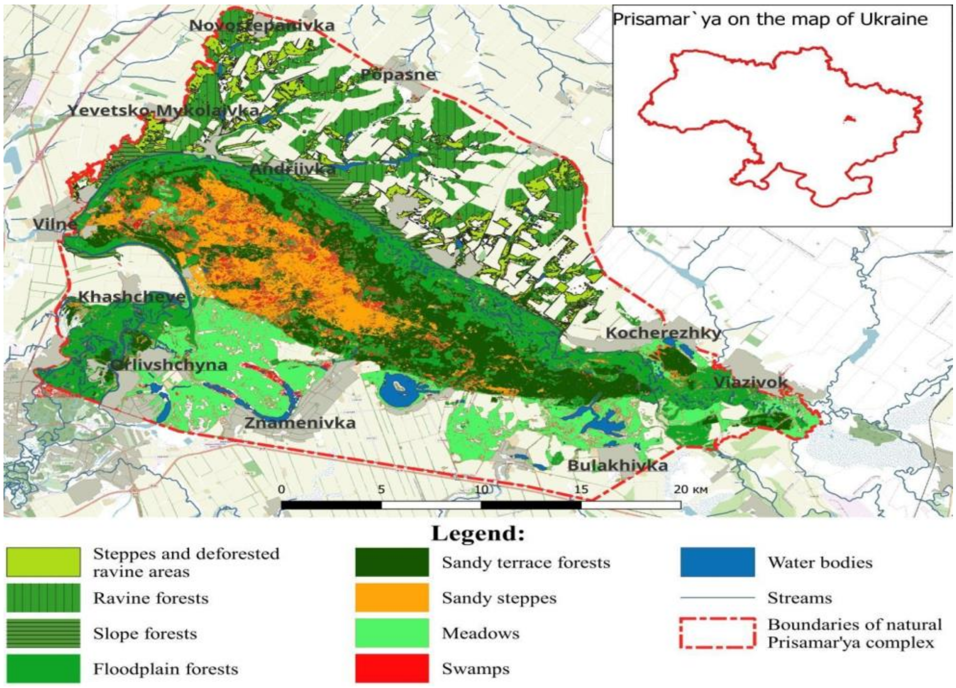

Fig. 2. Map of the Prisamarya natural complex

The watershed–gully landscapes are predominantly characterized by mixed fescue–feather grass steppes developed on typical chernozem soils. This terrain includes steppe areas (including former ravine forests that have been cleared), as well as ravine and slope forests located on the right-bank slopes of the Samara River (Fig. 2).

Within the watershed–gully landscape, zonal soils are represented by typical chernozems with a loamy granulometric composition, developed beneath native mixed fescue–feather grass steppe. The humus content in the topsoil averages 4 %, with a neutral to slightly alkaline pH (up to 7.3). The soil's cation exchange capacity is 40 mEq/100 g, with a base saturation of 96 %, dominated by calcium and magnesium ions prevailing in the composition (Belova et al., 2010; Recio Espejo et al., 2020).

Virgin steppe grass cover is dominated by perennial species, including xerophytes, mesoxerophytes, and mesotrophs. Deforested areas, where ravine forests once existed, are now replaced by steppe communities with low floristic diversity and a significant proportion of ruderal species.

In ravine and slope forests, forest chernozems prevail, characterized by a heavy loamy granulometric composition and dominance of the silty fraction. These soils contain 7 % humus in the topsoil, with a neutral pH. The cation exchange capacity reaches 42.8 mEq/100 g, and the base saturation ranges from 98 to 100 %, again with calcium and magnesium as dominant cations. The concentration of total dissolved substances, expressed as dry residue, varies between 0.09 % and 0.13 %. The influence of woody vegetation in native ravine forests is evident in the lighter granulometric structure of the topsoil, increased organic matter content, and leaching of calcium carbonates from the soil profile (Belova et al., 2010).

Ravine forests are primarily composed of oak stands interspersed with aspen along talwegs, and occasionally willow shrubs near streams. Historical floristic surveys also described psammophytic vegetation and arenal plant communities characteristic of the Samara region (Mytsyk, 2016). These forests are shaped by zonal subarid conditions and served as refugia for southern floristic elements during dry geological periods (e.g., *Aegonychon purpurocaeruleum* (L.) Holub, *Symphytum tauricum* Willd., *Laser trilobum* (L.) Borkh., *Scutellaria altissima* L.). Steppe and weed-steppe species often encroach on forest edges.

Despite their limited area (66.8 km²), ravine and slope forests harbor 412 vascular plant species, yielding a floristic density of 6.1 species per km². By comparison, the broader Prysamarya territory (451 km²) hosts 1.154 species, with a floristic density of 2.8 species per km² (see Table).

A well-developed system exists of forest plantations: Engineered woodlands, shelterbelt plantations, and zones adjacent to gully forests. The dominant tree species are Quercus robur L., Robinia pseudoacacia L., Fraxinus excelsior L., and Fraxinus pennsylvanica Marshall. Invasive alien species are also present, including Acer negundo L., Ulmus pumila L., Elaeagnus angustifolia L., and Ailanthus altissima (Mill.) Swingle. Afforestation improves steppe soil quality: it enhances the granulometric composition, increases humus content up to 5 %, pH up to 7.5, and absorption capacity up to 45 mEq/100 g of soil (Belova et al., 2010).

Valley-terrace landscapes. The valley-terraced lands of the Samara River include floodplains, arenic terrains, and the third meadow-salt marsh terrace. In the floodplain, meadow-forest soils have a layered structure and properties favorable for floodplain forests. The granulometric composition is dominated by clay and medium-textured loam. The upper soil horizon contains approximately 7 % humus and maintains a neutral pH level. Its cation exchange capacity reaches 41.68 mEq/100 g, with a base saturation of 97 %, largely attributed to the prevalence of calcium and magnesium ions. In certain segments of the floodplain, secondary salinization has been detected, linked to forest clearance and the subsequent replacement of natural forest communities with meadow vegetation (Belova et al., 2010). Similar processes have been documented across other areas of the steppe zone (Tóth, 2010).

Floodplain forests subject to short-term flooding are represented by oak stands shaped by hydrological factors (average flooding duration of 1–2 weeks). Based on soil mineralization, these forests are classifed into four trophogenic series. Each series contains distinct forest types occupying different hygrotopes, ranging from fresh to wet conditions. On the riverbed zones of the floodplain, linden-oak forests without ash predominate. Closer to the central floodplain, where soil fertility is higher, linden-ash oak forests occur. Smooth-leaved elm and ash forests dominate near the terrace edge, while black alder communities develop in lower-lying depressions.

Among all biotopes in the region, floodplain forests demonstrate the greatest floristic richness (see Table). Spanning an area of 91.1 km², these forests contain 472 vascular plant species, resulting in an average density of 5.2 species per square kilometer. The composition of woody plants closely corresponds to that of oak-dominated forests found in watershed–gully systems. In addition to the dominant *Quercus robur* L., prevalent tree species include *Fraxinus excelsior* L., *Tilia cordata* Mill., *Ulmus minor* Mill., *Ulmus laevis* Pall., *Ulmus suberosa* Moench, *Acer campestre* L., *Acer platanoides* L., *Acer tataricum* L., and *Alnus glutinosa* L.

Floristic Diversity of the Main Biotopes of Prysamarya Based on Remote Sening Data

Macrolandscapes	**Mesolandscapes**	**Biotopes***	**Biotopes**	**Area, km^2**	**Number of species**
1	2	3	4	5	6
Watershed-gully	Steppes, forestless gully territories	T1.4.a E1.2D	Steppes, forestless gully territories	37	505
	Forests	D1.4.2 G1.7A1	Thermophilous deciduous woodlend	66.8	412
	Reservoirs (ponds)	B1.1.2 C1.2	Artificially created reservoirs	2.24	45
Valley-terrace	Floodplain	D1.6.2 G1.22	Mixed riverine forests	88.4	364
		D1.7.1 G1.4	Alnus swamp woods	2.7	108
		T2.2, T3.1.1 E2.1, E3.43	Floodplain meadows	21.3	511
		B2.2.1, B 2.2.2 D5.1, D5.21	Swamps	0.8	157
		B1.1.2 C1.2	Floodplain lakes	8.5	81
		B4 C3	Riparian zones of the riverbed	0.56	42
	Sandy terrace	D 2.2.4 G3.42	Arenic forests	71.7	287
		T1.1.2 E1.9A	Sandy steppes	44.9	146
		D1.5.2, D1.7.1 G1.9, G1.4	Aspen-birch and alder forests	34.9	125
		B2.2.1 D5.1	Arenic swamps	2.8	68
		B1.1.2 C1.2	Arenic lakes	0.04	75
	Third terrace	T6.2, T6.3.1 E6.2, D6.161	Meadows	59.1	154
		B2.2.1 D5.1	Swamps	2.1	22
		B1.2, B4.3 C1.5	Saline lakes	6.9	32

Note: * – Habitat classification follows the systems proposed by the European Commission (European Commission, 2013), Davies et al. (Davies et al., 2004), Kuzemko et al. (Kuzemko et al., 2018), and Didukh & Alyoshkina (Didukh & Alyoshkina, 2012).

Common shrubs in these forests are Euonymus europaeus L., Euonymus verrucosus Scop., Cornus sanguinea L., and Corylus avellana L. In moist environments, one frequently encounters Salix alba L., S. fragilis L., S. triandra L., S. cinerea L., Populus alba L., and P. nigra L. In lower floodplain oak stands, groundwater lies at a depth of about one meter, providing favorable conditions for enhanced soil fertility.

The invertebrate fauna of the Prysamarya region is highly diverse. Litter samples revealed approximately 280 species from over 30 families, classified into three functional groups: phytophages, zoophages, and saprophages, including coprophages and necrophages. Among them, social insects, particularly ants, are the dominant group. Several rare ground beetle species are unique to the Prysamarya region and are listed in the Red Book of Ukraine, including *Cephalota besseri* (Cicindelidae), *Carabus estreicheri* Fischer von Waldheim, 1822, *Carabus stscheglowi Mannerheim*, 1827, and *Calosoma sycophanta* (Linnaeus, 1758).

Within the floodplain landscape, oak forest complexes alternate with mixed-grass meadows, wetlands, and water bodies (the Samara River channel, oxbow lakes, and ponds). In the near-terrace section of the floodplain, weakly mineralized groundwater emerges from beneath the second terrace. Along the edges of lakes and wetlands, alder forests are composed of black alder (*Alnus glutinosa* (L.) P. Gaertn.) are widespread (Dubyna et al., 2023).

Wetland habitats within the Prysamarya region support a wide range of semi-aquatic plant associations, including communities such as *Phragmitetum australis*, *Thyphetum angustifoliae*, and *Glycerietum maximae*. Additionally, numerous rare plant communities characteristic of wetlands have been recorded in these areas. Many of them are listed in the updated edition of the "Green Book of Ukraine" (Didukh, 2009), and include formations such as: *Aldrovandetum vesiculosae* Borhidi et Komlódi (1959), *Nupharo-Nymphaeetum albae* Nowinski (1930), *Lemno gibbae-Wolffietum arrhizae* Slavnić (1956), *Lemno-Salvinietum natantis* Migan et Tüxen (1960), *Potameto-Nupharetum* Müller et Görs (1960), *Nupharo lutei-Nymphaeetum albae* Nowiński (1930), *Myriophyllo-Nupharetum* Koch (1926), and *Ceratophylletum submersi* Soó (1928).

The second, sandy terrace (arena) of the Samara River valley supports sod-forest soils that are low in humus, moderately leached, sandy in texture, and poorly developed on old alluvial deposits. These soils consist of fine-grained, slightly loamy sands and exhibit low humus content (0.4–2.7 %), acidic pH (5.8–6.4), low cation exchange capacity (3.1–4.1 mEq/100 g), and a low base saturation (2.3–3.5 mEq/100 g). Soil moisture is atmospheric, with groundwater found at depths of approximately 3.5 meters. This area is home to a unique pine forest, considered the southernmost pine stand in Ukraine's steppe zone. Most of the area is covered by pine forests interspersed with sandy steppes (Fig. 2). Depressions contain aspen, birch, alder forests, swamps, and lakes. In landscape depressions, vegetation is represented by aspen, birch, and alder stands, interspersed with wetlands and shallow lakes. Depending on site fertility and hydrological conditions, forest formations are grouped into three major categories: conifer-dominated pine-birch forests, mixed compositions featuring oak, aspen, and willow, and oak-rich groves with varying admixtures of pine and birch. Dominant woody and shrubby species include *Pinus sylvestris* L., *Betula pubescens* Ehrh., *Populus tremula* L., *Salix acutifolia* Willd., *Chamaecytisus ruthenicus* (Fisch. ex Woloszcz.) Klaskova, *Salix rosmarinifolia* Laest. ex Andersson, *Genista tinctoria* L., and *Euonymus verrucosa* Scop.

The arena forests exhibit high floristic diversity (see Table). Over an area of 106.6 km^2, they contain 412 species, averaging 3.9 species per km^2. Sod-type soils are formed within the arena landscape. Habitat types vary widely, from dry lichenous pine forests to wet depressions with birch, aspen, and sphagnum swamps containing rare nemoral and boreal species (e.g., *Sphagnum* spp., *Ricciocarpus natans*, etc.). The herbaceous layer includes rare forest species associated with pine and mixed pine forests: *Epilobium angustifolium* L., *Antennaria dioica* (L.) Gaertn., *Platanthera bifolia* (L.) Rich., *Lycopodium clavatum* L. even reported the presence of *Vaccinium myrtillus* L. in this location at the end of the 19th century. Alder forests in these areas support an unusual fern flora for southern regions, including *Matteuccia struthiopteris* (L.) Tod., *Thelypteris palustris* Schott, and others. In clear-cut areas, pine stands dominate. These forests are typically 60–80 years old and have moderate canopy cover and stand density (0.6–0.7). On the third terrace of the Samara River, under conditions of arid climate and shallow groundwater, highly mineralized soils have developed. These include chloride- and sulfate-rich saline marsh soils with poorly defined profiles, often showing eluvial and illuvial horizon differentiation due to sodium leaching.

The flora of the third terrace includes rare European species such as *Allium regelianum* A. K. Becker and *Frankenia hirsuta* L. In the mineralized lakes (e.g., Bulakhovsky Estuary), *Ruppia maritima* L. has been observed, a marine ecosystem species previously recorded only in Slavyansk. *Typha laxmannii* Lepech. is also found in floodplain and third terrace water bodies and has recently been expanding its distribution across Ukraine (Shevera et al., 2024). The highest diversity is observed along forest edges and near lakes and swamps.

In total, the flora of the Prysamarya region includes 1.154 species, representing 5 divisions, 7 classes, 116 families, and 429 genera. Among them, 239 species are rare and endangered, including 5 listed in the IUCN Red List, 12 in the European Red List, and 38 in the Red Book of Ukraine.

The Prysamarya Dniprovske natural complex, located in the lower reaches of the Samara River, is nearly the only polylandscape complex along the middle rivers of Ukraine's steppe zone. It is designated for the establishment of a national park.

The flora and fauna of the Prysamarya region consist of multiple geographical elements and are distinguished by a high number of rare species. A large proportion of these rare species are concentrated in forest ecosystems, which cover nearly two-thirds of the total area (264.5 hectares). However, habitats in deforested floodplain and gully landscapes, as well as sandy steppes, were once forested.

Forest ecosystems, particularly in subarid climates, help buffer climate change impacts and create favorable conditions for species protection and ecorecreation. The Prysamarya landscape may serve as a reference site for natural complexes in arid regions of Eastern Europe. Despite extensive anthropogenic transformation throughout the steppe zone of Ukraine, its flora and fauna retain significant diversity. However, long-term human impact, recent climate change, and competition from alien species have also caused notable alterations.

Several biotopes in the Prysamarya region are under considerable anthropogenic pressure. In the summer fires of 2010, approximately 800 hectares of forest, mostly pine stands, were destroyed. Pyrogenic succession led to the degradation of forest structure, including loss of shrub and herbaceous layers, as well as changes in the animal and microbial communities. Today, litter and ground vegetation are recovering, though some pine stands continue to decline.

Processes associated with global warming also influence species composition. According to numerous authors, the spread of invasive species does not enrich native biodiversity; on the contrary, intensified human activity often leads to the impoverishment, simplification, and homogenization of native biota. Invasive plant introductions have resulted in disruptions within indigenous steppe and gully forest communities, especially in areas with black locust (*Robinia pseudoacacia*) plantations. Agrocenoses are also expanding, encroaching upon natural forests and artificial shelterbelts.

These challenges underscore the urgent need for conservation efforts to protect the Samara Forest. The scientific rationale for establishing the first phase of the national park in this area was developed by Dnipro National University in 2010. Currently, protected areas comprise only about 3 % of the Dnipropetrovsk region, far below modern conservation targets. The proposed Samara Forest National Park is expected to significantly increase this figure.

4. Conclusions

Based on field investigations and comprehensive analysis of published and archival materials, the Prysamarya Dniprovske natural complex represents the most biologically and geographically diverse not only within Ukraine's steppe zone, but also across the broader Central European steppe biome. This territory exhibits pronounced geomorphological and climatic heterogeneity coupled with exceptionally high plant and animal diversity, and a high density of rare species concentrated across its diverse habitats.

Currently, the vascular plant flora of the Prysamarya region comprises 1.154 species across an area of approximately 451 km². In comparison, the entire Dpropetrovsk oblast, which includes this territory, hosts 1.714 vascular species over 31.900 km², yielding a significantly lower species density (0.05 species/km²) compared to Prysamarya (2.8 species/km²). This floristic richness is largely attributed to the landscape mosaic and the dominance of forested ecosystems, particularly floodplain oak forests, where Quercus robur L. serves as a keystone species at the transitional margin of its ecological and phytocoenotic range.

Further ecological complexity is added by the presence of pine groves, arenal steppes, natural meadows, wetland systems, and aquatic habitats, all of which contribute to a high level of habitat diversity and support numerous rare or threatened taxa endemic to the steppe zone. This area functions as a climatic refugium for both boreal species and taxa of Mediterranean semi-arid environments. In this context, the forest biocoenoses of the Prysamarya complex play a pivotal role in preserving sensitive species, buffering agroecosystems, and mitigating desertification processes in a region vulnerable to climate change and human impact.

Large areas of former forest phytocoenoses require reforestation. Such efforts are now underway through a collaborative initiative between Oles Honchar Dnipro National University and the Eastern Office of the State Enterprise "Forests of Ukraine," as part of the President of Ukraine's "Green Country" program.

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References

Austin, K. G., Schwantes, A., Gu, Y., & Kasibhatla, P. S. (2019). What causes deforestation in Indonesia? *Environmental Research Letters*, *14*(2), 024007. doi: https://doi.org/10.1088/1748-9326/aaf6db

Belova, N. A., Travleev, A. P., Bogovin, A. V., & Chernyshenko, V. S. (2010). Evolution and genesis of soils under ravine forest phytocenoses in the steppe. *Soil Science*, *11*(1–2), 16–27.

Demianov, V. V. (2010). Hydrological characteristics of the Samara River basin. *Problems of Steppe Forestry and Soil Reclamation*, *14*, 67–79.

Didukh, Ya. P. (2009). *Green Book of Ukraine*. Kyiv: Alterpress. Retrieved from http://www.irbis-nbuv.gov.ua/E_LIB/PDF/ukr0002042.pdf

Didukh, Ya., & Alyoshkina, U. (2012). *Biotopes of Kyiv*. Kyiv: Agrarna Media-Hrupa.

Dubyna, D. V., Vakarenko, L. P., Ustymenko, P. M., Davydov, D. A., Dziuba, T. P., Baranovski, B. A., Karmyzova, L. A., Kulik, A. F., & Zhykharieva, A. V. (2023). Rare steppe plant communities in Ukraine: Status, threats and their minimization. *Biosystems Diversity*, 31(2), 209–216. doi: https://doi.org/10. 15421/012322

European Commission, DG Environment Nature. (2013). *Interpretation manual of European Union habitats*. EUR 28. Retrieved from https://eunis.eea.europa.eu/habitats-code-browser.jsp

Faruque, M. J., Vekerdy, Z., Hasan, M. Y., Islam, K. Z., Young, B., Ahmed, M. T., Monir, M. U., Shovon, S. M., Kakon, J. F., & Kundu, P. (2022). Monitoring of land use and land cover changes by using remote sensing and GIS techniques at human-induced mangrove forest areas in Bangladesh. *Remote Sensing Applications: Society and Environment*, *25*, 100699. doi: https://doi.org/10.1016/j.rsase.2022.100699

Francini, S., & Chirici, G. (2022). A Sentinel-2 derived dataset of forest disturbances occurred in Italy between 2017 and 2020. *Data in Brief*, *42*, 108297. doi: https://doi.org/10.1016/j.dib.2022.108297

Holoborodko, K. K., Plyusch, I. G., & Pakhomov, O. E. (2010). *Biodiversity of Ukraine. Dnipropetrovsk region. Higher species of Lepidoptera. Part 1. Lepidoptera: Lasiocampoidea, Bombicoidea, Noctuoidea*. Dnipropetrovsk: Dnipropetrovsk University Press. Retrieved from https://www.zoology.dp.ua/wp-content/downloads/pahomov/PA_10_05.pdf

Horban, V. A. (2016). Physical properties of soils and litter in forest biogeocoenoses of the steppe zone of Ukraine. In *Biogeocoenological studies of forests in the steppe zone of Ukraine* (pp. 142–154). Dnipro: Svidler A. L.

Jiang, F., Zhao, F., Ma, K., Li, D., & Sun, H. (2021). Mapping the forest canopy height in Northern China by synergizing ICESat-2 with Sentinel-2 using a stacking algorithm. *Remote Sensing*, *13*(8), 1535. doi: https://doi.org/10.3390/rs13081535

Kuzemko, A., Didukh, Ya., Onyshchenko, V., & Šeffer, J. (2018). *National habitat catalogue of Ukraine*. Kyiv: Klymenko.

Li, C., Zhou, L., & Xu, W. (2021). Estimating above ground biomass using Sentinel-2 MSI data and ensemble algorithms for grassland in the Shengjin Lake Wetland, China. *Remote Sensing*, *13*(8), 1595. doi: https://doi.org/10.3390/rs13081595

Masiuk, O., Novitskyi, R., Hapich, H., & Chubchenko, Ye. (2023). Elements of assessment of the anthropogenic impact of a coal mining mine on the site of the Emerald Network using methods of remote sensing of the Earth. *International Conference of Young Professionals "GeoTerrace-2023"*, Lviv: European Association of Geoscientists & Engineers. doi: https://doi.org/10.3997/2214-4609.2023510007

Matsiuk, V., & Masiuk, O. (2023). Using remote sensing imagery in the study of long-term dynamics of water bodies in the buffer zone of Vyazivotskyi Landscape Reserve. *International Conference of Young Professionals "GeoTerrace-2023"*, Lviv: European Association of Geoscientists & Engineers. doi: https://doi.org/10.3997/2214-4609.2023510079

Mytsyk, L. P. (2016). Summary of grassland cover research conducted by the Complex Expedition of Oles Honchar Dnipro National University. *In Biogeocoenological studies of forests in the steppe zone of Ukraine* (pp. 83–98). Dnipro: Svidler A. L.

POWO. (2025). *Plants of the World Online*. Facilitated by the Royal Botanic Gardens, Kew. Retrieved from https://powo.science.kew.org/

Recio Espejo, J. M., Kotovych, O. V., Díaz del Olmo, F., Gorban, V. A., Cámara Artigas, R., Masyuk, O. M., & Borja Barrera, C. (2020). Palaeoecological aspects of a Ukrainian Upper Holocene chernozem. *Ecology and Noospherology*, *31*(2), 59–64. doi: https://doi.org/10.15421/032009

Schroeder, T. A., Cohen, W. B., Song, C., Canty, M. J., & Yang, Z. (2006). Radiometric correction of multi-temporal Landsat data for characterization of early successional forest patterns in western Oregon. *Remote Sensing of Environment*, *103*, 16–26. doi: https://doi.org/10.1016/j.rse.2006.03.008

Shevera, M. V., Orlov, O. O., Dziuba, T. P., Baranovski, B. O., Karmyzova, L. O., Ivanko, I. A., Nikolayeva, V. V., & Stotska, O. I. (2024). *Typha laxmannii* (Typhaceae) in Ukraine: Current distribution, ecological and coenotic peculiarities, invasiveness. *Biologia*, *79*, 1147–1167. doi: https://doi.org/ 10.21203/rs.3.rs-2947977/v1

Tarasov, V. V. (2012). *Flora of Dnipropetrovsk and Zaporizhia regions*. Dnipro: Lira. Retrieved from https://www.zoology.dp.ua/wp-content/downloads/KEDU/Tarasov.pdf

Thapa, S., Millan, V. E. G., & Eklundh, L. (2021). Assessing forest phenology: A multi-scale comparison of near-surface (UAV, spectral reflectance sensor, phenocam) and satellite (MODIS, Sentinel-2). *Remote Sensing*, *13*(8), 1597. doi: https://doi.org/10.3390/rs13081597

Tóth, T. (2010). Medium-term vegetation dynamics and their association with edaphic conditions in two Hungarian saline grassland communities. *Grassland Science*, *56*, 13–18. doi: https://doi.org/10.1111/j.1744-697X.2009.00167.x

Ustymenko, P. M., & Dubyna, D. V. (2015). The Code of Phytocoenological Nomenclature of Ukraine (Draft). *Ukrainian Botanical Journal*, *72*(2), 103–115. doi: https://doi.org/10.15407/ukrbotj72.02.103