SCIENTIFIC HORIZONS

Journal homepage: https://sciencehorizon.com.ua
Scientific Horizons, 27(10), 124-135

UDC 574.474
Doi: 10.48077/scihor10.2024.124

Ecological typology of woody vegetation of the Starohut forest massif as a component of the restoration of disturbed ecotopes

Olena Tykhonova*
PhD in Biological Sciences, Associate Professor
Sumy National Agrarian University
40021, 160 Herasym Kondratiev Str., Sumy, Ukraine
https://orcid.org/0000-0003-0961-4896
Tatiana Marukha
Postgraduate Student
Sumy National Agrarian University
40021, 160 Herasym Kondratiev Str., Sumy, Ukraine
https://orcid.org/0000-0001-5913-shshshch
Petro Rybalko
Doctor of Pedagogical Sciences, Professor
Sumy State Pedagogical University named after A.S. Makarenko
40002, 87 Romenska Str., Sumy, Ukraine
https://orcid.org/0000-0002-6460-4255
Serhii Butenko
PhD in Agronomy, Senior Lecturer
Sumy National Agrarian University
40021, 160 Herasym Kondratiev Str., Sumy, Ukraine
https://orcid.org/0000-0002-9925-3029
Serhii Horbas
PhD in Agronomy, Associate Professor
Sumy National Agrarian University
40021, 160 Herasym Kondratiev Str., Sumy, Ukraine
https://orcid.org/0000-0003-3768-8833

Article's History:
Received: 20.04.2024
Revised: 22.08.2024
Accepted: 25.09.2024

Abstract. The study aimed to determine the typological structure of the Starohut forest massif within the Desniansko-Starohutskyi National Nature Park based on the Ukrainian school of forest typology by Alekseev-Pogrebnyak. The massif covers an area of 6,778.8 hectares. The following trophotopes were identified in the study area: bors, subors, and sugruds. Bors, consisting of pine communities with some birch, occupy dry and fresh hygrotopes on flat terrain, covering 1.8 hectares or 0.02% of the total

Suggested Citation:
Tykhonova, O., Marukha, T., Rybalko, P., Butenko, S., & Horbas, S. (2024). Ecological typology of woody vegetation of the Starohut forest massif as a component of the restoration of disturbed ecotopes. *Scientific Horizons*, 27(10), 124-135. doi: 10.48077/scihor10.2024.124.

*Corresponding author

forest area. Subors, comprising pine-oak communities with birch and aspen, are found in fresh, moist, damp, and swamp hygrotopes, covering 4,510.1 hectares or 66.53% of the territory. Sugruds, consisting of oak-pine-linden-maple forests on plains and aspen-birch-linden-maple forests in depressions, cover 2,266.9 hectares or 33.44% of the Starohut forest massif. No gruds were identified. The study found that the primary forest-forming species in the national park is *Pinus sylvestris*, occupying 5,092.7 hectares. *Betula pendula* covers 1,207.1 hectares, *Alnus glutinosa* – 201.4 hectares, *Picea abies* – 111.5 hectares, and *Quercus robur* – 90.0 hectares. Other tree species are sparsely represented. In the protected area of the park, fresh subors and sugruds dominate, including a mixture of birch, black alder, and spruce over a total area of 1,181.1 hectares, along with moist pine-birch-alder-oak subors and sugruds covering 849.4 hectares. The recreational zone is dominated by fresh hygrotopes with subors and sugruds totalling 2,336.4 hectares. In the economic zone, subors and sugruds prevail on fresh sandy soils, totalling 430.7 hectares. The results support the restoration of natural forest types in areas affected by large-scale fires in 2023-2024 and other anthropogenic influences

Keywords: forest types; hygrotopes; trophotopes; biodiversity; rare species of flora

INTRODUCTION

Forests are essential biosphere components, providing numerous ecological functions such as oxygen production and regulating soil water balance. They also support vast areas of biodiversity, which are integrated into the ecological network. M. Pesendorfer *et al.* (2020) state that forest resources have significant economic value. The degradation of forest vegetation due to anthropogenic impact represents a global issue. Over the past 30 years, global forest cover has declined from 29% to 27%. L. Oitsius *et al.* (2020), through an analysis of forest phytocenoses in Ukrainian Polissia, concluded that their sustainability depends, to some extent, on biodiversity levels. S. Chadro *et al.* (2024) observed that significant changes in the vegetation cover of forest phytocenoses in recent years are attributed to climate change and human economic activities. D. Litvinov *et al.* (2020) assert that global climate change contributes to the reduction of species diversity in forest phytocenoses. M. Trifanova *et al.* (2024) emphasise that the EU's Biodiversity Strategy 2030 aims to strictly protect 10% of land to prevent the loss of rare flora and fauna species.

I. Koval and S. Sidorenko (2019) argue that intense anthropogenic impacts, such as deforestation, fires, and military operations, have significantly altered the structure of forest communities in Ukraine, particularly in Polissia, leading to a decline in biodiversity. A long-term consequence of the full-scale war in 2022-2024 is the destruction of forest ecosystems. The forests of the Desniansko-Starohutskyi NNP are suffering from constant shelling, forest fires, and extensive fortifications. Military actions have had a significant impact on the condition of the area's vegetation. Restoring and preserving forests for future generations is a critical task for foresters, ecologists, and environmental organisations, including the Desniansko-Starohutskyi NNP. This challenge can be addressed through the use of the Alekseev-Pogrebnyak forest typology, which is based on ecological and edaphic principles. Forest typology enables the restoration of disturbed forest phytocenoses, preserving the characteristic natural diversity of a given climate zone. According to E. Collado *et al.* (2023), close-to-nature forest management, also known as continuous cover forestry, is a sustainable forest management approach that maximises the conservation of species diversity in forest ecosystems while providing significant economic benefits.

According to R. Seidl *et al.* (2018), when restoring forest phytocenoses damaged by fires, hurricanes, or other negative factors, it is important to adhere to an environmentally appropriate forest crop typology to create a sustainable ecosystem; specifically, moisture-loving species should be planted on moist soils and mesotrophic species on moderately moist soils. As noted by V. Melnyk (2020), this is particularly relevant for spruce plantations, as spruce is highly sensitive to soil moisture levels and requires 30% to 80% soil moisture for optimal growth and development during the initial stages of ontogenesis. This ecological characteristic of the European spruce explains why the island spruce forests of Polissia are listed in the Green Book of Ukraine.

The restoration of disturbed ecotopes, including the forest ecosystem of the Starohut forest, requires a thorough understanding of the typology of the area across edaphic and hydrological gradients. An essential component of the restoration process is the development of an ecological and typological characterisation of this territory, which was the purpose of this article.

MATERIALS AND METHODS

The research was conducted within the Desniansko-Starohutskyi National Nature Park (Ukraine, Sumy region) from 2021 to 2023. According to the physical-geographical classification of Ukraine, the study area is located within the Pridesnyansky district of the Novgorod-Seversky physical-geographical region of Ukrainian Polissia. The coordinates of the Starohut massif as recorded by Landsat-8 are as follows: westernmost point – 52°18'39"N, 33°34'50"E; easternmost point – 52°19'55"N, 33°51'16"E; northernmost point – 52°22'06"N, 33°47'18"E; and southernmost point –

52°18'97"N, 33°39'47"E. The terrain of the natural park is a moraine low plain with a gentle slope westward towards the Desna River. The elevation above sea level in the park's western part, within the Desna floodplain, is 122 metres, while in the eastern part, it reaches 163 metres (Marynych *et al*., 2003). The soil cover of the Starohut forest includes soddy-podzolic gleyed fluvioglacial sandy soils in flat areas and peat, peat-bog soils in low-flow and drainage-deficient depressions. The study area has approximately 7% swampy terrain. The climate is temperate continental, with warm, humid summers and mild winters. The average annual air temperature is 6.5°C. In winter, the average temperature is -3.9°C, while in summer it is 18.7°C. Annual precipitation totals 608.7 mm and is unevenly distributed across the seasons: an average of 136 mm falls in winter, 148.5 mm in spring, 193.8 mm in summer, and 130.4 mm in autumn.

The data analysed included information from the Starohut forestry on forest management. The calculations were based on forest management tax descriptions provided by the SEBR of Ukraine (2022) in the Desniansko-Starohutskyi NNP. Route surveys and geobotanical descriptions by S. Panchenko (2013) were used to identify forest types. A total of 6,778.8 hectares of the Starohut forest was studied, focusing on the distribution of forest area by forest type, soil moisture conditions, and main tree species. The study of the typological structure of the park's forest vegetation was conducted using methods from the Ukrainian school of forest typology (Hensiruk, 2002; Ostapenko & Tkach, 2002; Andriienko, 2006). Pogrebnyak's edaphic table served as a methodological framework for determining forest conditions: horizontal lines represent five hygrotopes based on soil moisture, while vertical columns represent trophotopes based on soil fertility (Table 1).

***Table 1**. Predominant tree species in trophotopes according to Alekseev-Pogrebnyak*

Hygrotopes	Trophotopes			
	A - Bor	**B - Subor**	**C - Sugrud**	**D - Grud**
0 – Xerophilic (Very dry)	Pine	Pine, oak	Oak, pine	Oak, maple
1 – Mesoxerophilic (Dry)	Pine	Pine, oak	Oak, linden, maple, pine,	Oak, linden, maple, ash
2 – Mesophilic (Fresh)	Pine, birch	Pine, oak, birch	Oak, birch, linden, maple, pine	Oak, linden, maple, ash
3 – Mesohygrophilic (Moist)	Pine, birch	Pine, oak, birch	Oak, birch, linden, maple, pine	Oak, linden, maple, ash
4 – Hygrophilic (Damp)	Pine, birch	Pine, oak, birch, alder	Alder, linden, maple, pine, oak	Oak, birch, maple, ash, alder
5 – Ultrahygrophilic (Swamp)	Pine, birch	Pine, alder	Alder, birch	Alder, ash

***Source:** prepared based on research data by P.S. Pogrebnyak (1959)*

In various types of forests, according to Pogrebnyak's typology, different perennials dominate the herbaceous-shrub layer depending on moisture conditions: A_0 – *Stipa pennata*, *Helichrysum arenarium;* A_1 – *Arctostaphylos uva-ursi, Pulsatilla patens;* A_2 – *Vaccinium vitis-idaea;* A_3 – *Vaccinium myrtillus, Polytrichum commune;* A_4 – *Molinia caerulea, Vaccinium uliginosum;* A_5 – *Ledum palustre, Eriophorum angustifolium, Vaccinium oxycoccos;* B_0 – *Stipa pennata*; B_1 – *Pulsatilla patens;* B_2 – *Pulmonaria angustifolia;* B_3 – *Vaccinium myrtillus;* B_4 – *Sphagnum palustre;* B_5 – *Potentilla palustris;* C_0 – *Carex pilosa, Melica nutans;* C_1 – *Stellaria holostea;* C_2 – *Pulmonaria angustifolia, Rubia tinctorum;* C_3 – *Pulmonaria angustifolia;* C_4 – *Athyrium filix-femina, Filipendula ulmaria, Impatiens noli-tangere;* C_5 – *Thelypteris palustris, Caltha palustris;* D_0 – *Melica nutans, Carex hirta;* D_2 – *Rubia tinctorum;* D_3 – *Pulmonaria angustifolia;* D_4 – *Impatiens noli-tangere, Filipendula ulmaria;* D_5 – *Chrysosplenium alternifolium*. The plant community studies were conducted in line with national and international guidelines. The authors adhered to the standards of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979) and the Convention on Biological Diversity (1992).

RESULTS AND DISCUSSION

According to forest management data, forests within the Desniansko-Starohutskyi NNP cover an area of 8,583.9 hectares, with 6,778.8 hectares located in the Starohut forest massif. The vascular plant flora of the Desniansko-Starohutskyi NNP includes 852 species, making it the richest among the national parks and reserves of Polissia. The park is home to 35 plant species listed in the Red Book of Ukraine and 49 regionally rare species. The main natural factors influencing plant community distribution are soil fertility and the proximity of groundwater to the surface. Anthropogenic impact on this area is significant – unauthorised logging and fires have nearly eradicated oak forests from the park.

The forest vegetation in the study area primarily comprises coniferous, moderately humid mixed, and broad-leaved forests of the *Vaccinio-Piceetea, Quercetea robori-petraeae*, and *Querco-Fagetea* classes. In the

eastern and central areas of the park, mesotrophic forest swamps of the *Scheuchzerio-Caricetea nigrae* class are present. In the northern part of the park and the Chern River floodplain, there are oligotrophic and oligo-mesotrophic forest swamps of the Oxycocco-Sphagnetea class. The classification of forest vegetation types in the Starohut massif according to ecological and floristic criteria is shown in Table 2.

***Table 2**. Taxonomy of forest vegetation of the Starohut massif*

Ecological and floristic classification (after Brown-Blanque)			Types of forest vegetation (after P. Pogrebnyak, 1959)		Growing conditions
Order	**Union**	**Association**	**Forest type**	**Code**	
Menyantho trifoliatae-Betuletalia pubescentis Grygora *et al.* 2005	*Oxycocco palustri-Betulion pubescentis* Grygora *et al.* 2005	*Menyantho trifoliati-Betuletum pubescentis* Grygora *et al.* 2005 em.	Damp birch-pine subor; Moist oak-pine subor	B_4BP B_3OP	Mesotrophic bogs on peatlands and their periphery
Vaccinietalia uliginosi R. Tx. 1955	*Ledo palustris-Pinion sylvestris* R. Tx. 1955	*Eriophoro vaginati-Pinetum sylvestris* Hueck 1925	Damp birch-pine subor; Swamp birch-pine subor	B_4BP B_5BP	Peat-bog soils in closed low-flow depressions
Alnetalia glutinosae R.Tx. 1937	*Alnion glutinosae* Malcuit 1929	*Sphagno squarrosi-Alnetum glutinosae* Solińska-Górnicka (1975)	Damp birch-pine subor; Moist oak-pine subor	B_4BP B_3OP	Along the edges of swamps in closed depressions
		Carici elongatae-Alnetum Schwickerath 1933	Swamp black alder sugrud	C_5A	In swamps, along the edges of streams on swampy and peat-marsh soils
Salicetalia auritae Doig 1962	*Salicion cinereae* T. Müller et Gors 1958	*Salicetum pentandro-cinereae*	Damp black alder sugrud	C_4A	Peat bogs, peat-bog soils in depressions
		Betulo-Salicetum repentis	Damp black alder sugrud	C_4A	Peat meadows
Fagetalia sylvaticae Pawlowski 1928	*Querco roboris-Tilion cordatae* Bulokhov et Solomeshch 2003	*Mercurialo perennis-Quercetum roboris* Bulokhov et Solomeshch 2003	Fresh linden-oak-pine sugrud; Moist linden-oak-pine sugrud	C_2-LOP C_3-LOP	Moderately humid flat areas along the edges of swamps on soddy-podzolic gleyed sandy soils
		Corylo avellanae-Pinetum sylvestris Bulokhov et Solomeshch 2003	Fresh linden-oak-pine sugrud; Moist linden-oak-pine sugrud	C_2-LOP C_3-LOP	Plakors on soddy-slightly podzolic gleyed sandy soils
	Alnion incanae Pawlowski 1928	*Ficario-Ulmetum minoris* Knapp 1942 em. J. Matuszkiewicz 1976	Moist linden-oak-pine sugrud	C_3-LOP	Small narrow areas along the edges of eutrophic swamps
		Fraxino-Alnetum W. Matuszkiewicz 1952	Moist linden-oak-pine sugrud; Damp black alder sugrud	C_3-LOP C_4A	Outskirts of eutrophic swamps and alder forests
Quercetalia roboris R. Tx. 1931	*Pino-Quercion* Medw.-Korn. 1959	*Querco-Pinetum* (*sylvestris*) (W. Matuszkiewicz 1981) J. Matuszkiewicz 1988	Fresh oak-pine subor; Fresh linden-oak-pine sugrud; Moist linden-oak-pine sugrud	B_2OP C_2LOP C_3LOP	Flat relief on soddy-podzolic gleyed sandy soils

Table 2. Continued

Ecological and floristic classification (after Brown-Blanque)			Types of forest vegetation (after P. Pogrebnyak, 1959)		Growing conditions
Order	**Union**	**Association**	**Forest type**	**Code**	
Cladonio-Vaccinietalia Kielland-Lund 1967	*Dicrano-Pinion* Libbert 1933	*Cladonio-Pinetum* (sylvestris) Juraszek 1927	Dry pine bor; Fresh pine bor;	A_1P A_2P	River terrace
		Molinio caerulea-Pinetum sylvestris W. Matuszkiewicz et J. Matuszkiewicz 1973	Fresh oak-pine subor; Moist oak-pine subor; Damp oak-pine subor; Fresh linden-oak-pine sugrud	B_2OP B_3OP B_4OP C_2LOP	Levelled, moderately moist areas on soddy-podzolic sandy and sandy-clayey gleyed soils
		Peucedano-Pinetum (sylvestris) W. Matuszkiewicz (1962) 1973	Fresh pine bor; Fresh oak-pine subor; Moist oak-pine subor	A_2P B_2OP B_3OP	Dry flat areas and slopes of ridges on sod-podzolic sandy and sandy-clayey gleyed soils
		Veronico incanae-Pinetum sylvestris Bulokhov et Solomeshch 2003	Fresh oak-pine subor	B_2OP	Flat areas on sod-podzolic sandy and sandy-clayey gleyic soils
		Vaccinio uliginosi-Pinetum sylvestris Kleist 1929	Swamp birch-pine subor; Damp oak-pine subor	B_5BP B_4OP	Closed depressions, edges of swamps on peat-bog and sod-podzolic sandy gley soils
Vaccinio-Piceetalia Br.-Bl. 1939	*Melico nutanstis-Piceion abietis* (Killand-Lund 1981) Onyshchenko 2005 prov	*Querco-Piceetum* (W.Matuszkiewicz 1952) W.Matuszkiewicz et Polak 1955	Fresh linden-oak-pine sugrud; Moist linden-oak-pine sugrud	C_2LOP C_3LOP	Flat areas on soddy-podzolic sandy gleyic soils
Chelidonio-Robinietalia Hada... et Sofron 1980	Chelidonio-Robinion Hada... et Sofron 1980	*Chelidonio-Robinietum* Hada... et Sofron 1963	Fresh linden-oak-pine sugrud	C_2LOP	Sandy soddy-podzolic soils

Source: *prepared by the authors based on the research data of S. Panchenko (2013)*

According to the established classification, the flora of the natural park includes three types of vegetation, seven classes of formations, eleven formation groups, twenty-three formations, thirty-five subformations, 104 association groups, and 242 associations, encompassing forest, meadow, and aquatic vegetation. Research has shown that the forest vegetation of the area comprises five hygrotopes: dry, fresh, moist, damp, and swamp. Monospecific pine forests cover a small area of 1.8 hectares, occupying 0.02% of the total forest area. Subors occupy the largest forest area, spanning 4,510.1 hectares, or 66.5% of the total. Sugruds cover a significantly smaller area of 2,266.9 hectares or 33.4% of the forest area. The oak grove forest type is absent in the Starohut forest massif (Table 3).

Table 3*. Structure of woody vegetation by hygrotopes in the Starohut forest, ha*

Trophotopes	Hygrotopes						Total, ha
	0	**1**	**2**	**3**	**4**	**5**	
	Very dry	**Dry**	**Fresh**	**Moist**	**Damp**	**Swamp**	
Bor (A)	–	0.7	1.1	–	–	–	1.8
Subor (B)	–	–	2,594.5	1,430.5	425.7	59.4	4,510.1
Sugrud (C)	–	–	1,352.6	720.6	179.7	14.0	2,266.9
Grud (D)	–	–	–	–	–	–	-
Total, ha	–	0.7	3,948.2	2,151.1	605.4	73.4	6,778.8

Source: *compiled by the authors*

Fresh soils predominate among hygrotopes, covering 3,948.2 hectares, or 58.24% of the total forest area. A smaller area is occupied by moist soils, which account for 2,151.1 hectares, or 31.73%. Damp soils are located in depressions, covering 605.4 hectares, or 8.93%. Wet, swamp soils and lakes occupy 73.4 hectares, or 1.08%. Conditions of very dry soil are completely absent. *Pinus sylvestris* is the primary forest-forming species, encompassing 75.1% of the area (5,092.7 hectares). Significantly smaller areas are occupied by *Betula pendula* (1,207.1 hectares, or 17.8%), *Alnus glutinosa* (201.4 hectares, or 2.9%), *Quercus robur* (90.0 hectares), *Picea abies* (111.5 hectares), and *Populus tremula* (71.7 hectares). Species such as *Tilia cordata, Pinus strobus, Larix decidua*, and *Robinia pseudoacacia* collectively occupy an area of 4.4 hectares, which represents 0.2% of the forest area. *P. abies* can sustain its populations over extended periods only in sufficiently fresh soils with 30-80% of full moisture content. Spruce phytocenoses are localised in areas adjacent to swamp ecosystems, where the soil remains consistently moist regardless of the weather. Only such environmental conditions facilitate the continuous regeneration of *P. abies* populations. Most of the sugruds in the Starohut forest area are situated in the regulated recreation zone of the National Natural Park, with considerably fewer located in the protected area.

In the Starohut forest massif, ten forest types have been identified. The predominant type is the fresh oak-pine subor, covering 2,594.5 hectares or 38.3% of the total area. Almost half of the area – 1,430.5 hectares – is occupied by the moist oak-pine subor, which constitutes 21.1% of the total forest area, along with the fresh linden-oak-pine sugrud, which spans 1,352.6 hectares or 19.95%. Smaller areas are occupied by the moist birch-oak-pine sugrud (720.6 hectares or 10.6%), the damp oak-pine subor (425.7 hectares or 6.3%), and the damp alder-pine sugrud with black alder (179.7 hectares or 2.6%) (Table 4).

***Table 4**. Forest types in the Starohut forest massif*

Forest type index	Forest types	Area, ha
A_1P	Dry pine bor	0.7
A_2P	Fresh pine bor	1.1
B_2OP	Fresh oak-pine subor	2,594.5
B_3-OP	Moist oak-pine subor	1,430.5
B_4-BP	Damp birch-pine subor	425.7
B_5-BP	Swamp birch-pine subor	59.4
C_2-LOP	Fresh linden-oak-pine sugrud	1,352.6
C_3- LOP	Moist birch-oak-pine sugrud	720.6
C_4-A	Damp alder sugrud	179.7
C_5-A	Swamp alder sugrud	14.0
Total area, ha		6,778.8

***Source:** compiled by the authors*

The park is divided into several functional zones: the protected area, the zone of regulated recreation (which is subdivided into two subzones), and the economic zone (also divided into two subzones) (Fig. 1).

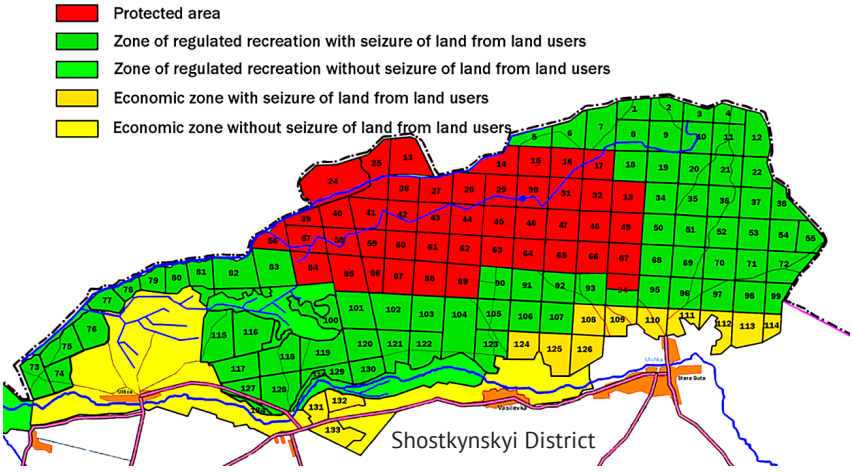

***Figure 1**. Functional zones of the Starohut forest massif of the Desniansko-Starohutskyi NNP*
***Source:** NNP Desniansko-Starohutskyi (2024)*

The protected area is located in the northern part of Starohut forest, covering 2,294.3 hectares. Trophotopes in the protected zone are divided into two categories: subors, which occupy 1,500.5 hectares, and sugruds, which cover 793.8 hectares. An analysis of the hygrotopes within the park's protected area shows that the largest areas are occupied by fresh soil – 1,181.1 hectares – and moist soil – 849.4 hectares. Smaller areas are occupied by damp soils – 238.0 hectares – and swamp areas – 25.8 hectares. There are no dry or very dry conditions within the reserve zone. The recreational zone occupies 57.55% of the study area, amounting to 3,901.3 hectares. This zone is dominated by subors – 2,746.3 hectares – with a significantly smaller area occupied by sugruds – 1,153.2 hectares. There are very few monoculture pine forests – 1.8 hectares – and no oak forests. Forest-covered hygrotopes in the recreational zone are distributed as follows: fresh – 2,336.4 hectares, moist – 1,164.2 hectares, damp – 352.4 hectares, swamp – 47.6 hectares, and dry – 0.7 hectares.

The economic functional zone of the Starohut part of the park occupies 583.2 hectares, constituting 8.6% of the total area. The trophotopes in this zone are primarily represented by sugruds, covering 319.9 hectares, while subors occupy 263.3 hectares. There are no monoculture pine forests or oak forests. Among the hygrotopes, fresh soil conditions predominate – 430.7 hectares, followed by moist soils – 137.5 hectares. Very small areas are occupied by damp soils in depressions – 15.0 hectares. There are no very dry, dry, or swamp conditions in the park's economic zone. The distribution of forest types by edaphic conditions in the Starohut forest can be seen in Table 5. The percentage of hygrotopes in various functional zones of the Starohut forest is presented in Figure 2.

***Table 5**. Typological structure of forest vegetation by functional zones of the Starohut part of the Desniansko-Starohutskyi NNP*

Functional areas of the park	Hygrotopes	Trophotopes				Total area, ha
		Bor	Subor	Sugrud	Grud	
Protected area	Very dry	–	–	–	–	–
	Dry	–	–	–	–	–
	Fresh	–	862.9	318.2	–	1,181.1
	Moist	–	470.3	379.1	–	849.4
	Damp	–	148.0	90.0	–	238.0
	Swamp	–	19.3	6.5	–	25.8
Recreation zone	Very dry	–	–	–	–	–
	Dry	0.7	–	–	–	0.7
	Fresh	1.1	1,543.0	792.3	–	2,336.4
	Moist	–	893.8	270.4	–	1,164.2
	Damp	–	269.4	83.0	–	352.4
	Swamp	–	40.1	7.5	–	47.6
Economic zone	Very dry	–	–	–	–	–
	Dry	–	–	–	–	–
	Fresh	–	188.6	242.1	–	430.7
	Moist	–	66.4	71.1	–	137.5
	Damp	–	8.3	6.7	–	15.0
	Swamp	–	–	–	–	–
Total area, ha		1.8	4,510.1	2,266.9	–	6,778.8

***Source:** compiled by the authors*

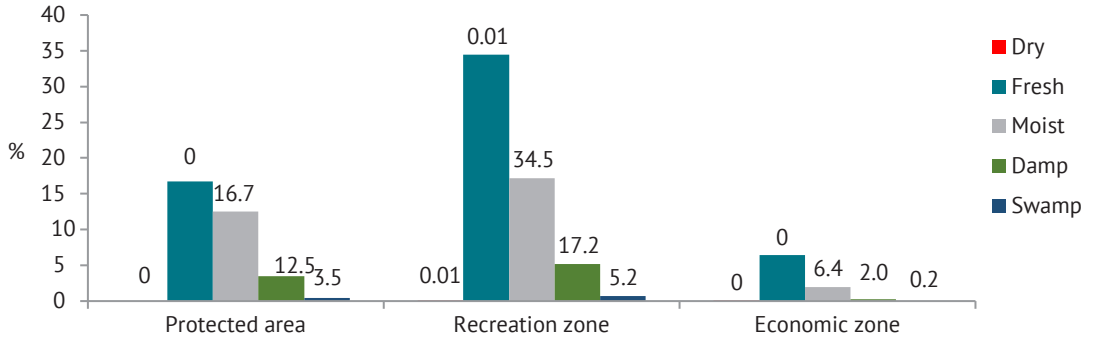

***Figure 2**. The ratio of hygrotopes in various functional zones of the Starohut part of the National Park, %*
***Source:** compiled by the authors*

The study of the typological structure of the Starohut forest massif, based on the main forest-forming species, revealed that the largest areas are occupied by *P. sylvestris* and *B. pendula* (Table 6).

***Table 6**. Typological structure of the Starohut forest massif according to the main forest-forming species*

Trophotopes	Species	Soil moisture conditions, ha						Total, ha
		Very dry	Dry	Fresh	Moist	Damp	Swamp	
Bor	*P. sylvestris*	–	0.7	1.1	–	–	–	1.8
Subor	*P. sylvestris*	–	–	2,486.1	1,076.7	171.4	15.6	3,749.8
	B. pendula	–	–	94.8	326.9	232.8	25.3	679.8
	A. glutinosa	–	–	–	1.3	20.7	18.5	40.5
	P. abies	–	–	10.1	13.2	–	–	23.3
	P. tremula	–	–	1.3	12.4	0.8	–	14.5
	Q. robur	–	–	2.1	–	–	–	2.1
Sugrud	*P. sylvestris*	–	–	1,039.0	299.2	2.9		1,341.1
	B. pendula	–	–	205.2	271.2	47.8		527.3
	A. glutinosa	–	–	–	21.0	129.0		160.9
	P. abies	–	–	54.3	33.9	–		88.2
	Q. robur	–	–	21.1	66.8	–		87.9
	P. tremula	–	–	30.8	26.4	–		57.2
	P. strobus	–	–	0.6	2.1	–		2.7
	R. pseudoacacia	–	–	1.0	–	–		1.0
	T. cordata	–	–	0.6	–	–		0.6
	L. decidua	–	–	0.1	–	–		0.1

***Source:** compiled by the authors*

P. sylvestris is an ecologically adaptable species, adapted to various moisture conditions; it is found in five hygrotopes and dominates in fresh, moist, and damp soil conditions. Of all ten forest-forming species, only *P. sylvestris* is present under dry conditions. The total area of *P. sylvestris* in the Starohut forest massif is 5,092.7 hectares. *B. pendula* is also a species with a wide ecological amplitude, growing in various types of hygrotopes but preferring fresh, moist, and damp conditions. In the Starohut forest, *B. pendula* occurs in subors – 679.8 hectares – and sugruds – 527.3 hectares. *A. glutinosa*, like birch, is found in two trophotopes – subors and sugruds – covering 40.5 and 160.9 hectares, respectively. This species prefers moist, damp, and swamp soil conditions. *P. abies* has a narrow ecological amplitude, growing in two trophotopes – subors and sugruds – and occupying very small areas – 23.3 and 88.2 hectares, respectively. This species prefers fresh and moist soils.

Q. robur is a plant that does not tolerate damp or swamp soil. In the study area, the species primarily grow on elevated terrain in sugruds, occupying 87.9 hectares. In some locations, *Q. robur* is found as an associated species in subors, covering an area of 2.1 hectares. The species thrives in two hygrotopes – fresh and moist. *P. tremula* is also present in two trophotopes and predominates in sugruds. The total area of presence of this species in the forest is 71.7 hectares and it prefers fresh and moist soil conditions. *T. cordata* is found only on fresh soil in drifts, covering an area of 0.6 hectares. Introduced forest-forming species in the Starohut forest massif – *Larix decidua, P.strobus,* and *Robinia pseudoacacia* – occupy a small area in sugruds on fresh hygrotopes.

During the fire of 2023, all types of forests growing on the eastern side of the massif were damaged, except swamp communities: dry pine bor – A_1P, fresh pine bor – A_2P, fresh oak-pine subor – B_2OP, fresh linden-oak-pine sugrud – C_2LOP, and moist birch-oak-pine sugrud – C_3LOP. This fire became the largest since the establishment of the Desniansko-Starohutskyi National Natural Park. According to Sentinel satellite images, the area of forest affected by the fire is approximately 500 hectares. In the northeastern part of the park, the fire raged for more than a week, with no possibility of extinguishing it due to the danger posed by proximity to the state border. As a result of the fire, 33 forest blocks were damaged to varying degrees. This represents a fifth of the land covered with forest vegetation and a third of the recreational zone. The area of forest phytocenoses damaged by the fire consists mainly of forest crops of *P. sylvestris* older than 60 years. According to the Global Fire Information Management System, 15.6% of the forest area in the park was affected by fire in May 2023 (Fig. 3).

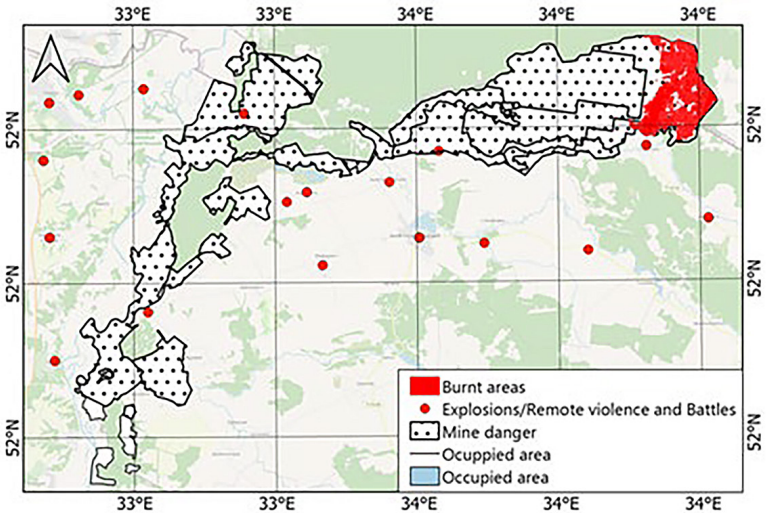

***Figure 3**. Area of fire spread in the NPP Desniansko-Starohutskyi, May 2023*
***Source:** compiled by the authors*

As a result of repeated shelling and fires, populations of many species in the eastern and northern parts of the Starohut forest were on the verge of extinction: *Primula veris* L., *Corydalis solida* (L.) Clairv., *Clinopodium vulgare* L., *Trifolium montanum* L., *Galium boreale* L., *Cardamine bulbifera* (L.) Crantz, *Pimpinella saxifrage* L., *Steris viscaria* (L.) Rafin., *Vaccinium myrtillus* L., *Vaccinium vitis-idaea* L., *Filipendula vulgaris* Moench, *Ulmus glabra* Huds, *Acer campestre* L., *Acer platanoides* L., and *Pinus sylvestris* L.. Plant species listed in the Red Book of Ukraine were affected, including *Lycopodium annotinum* L., *Huperzia selago* (L.) Bernh., *Diphasiastrum zeilleri* (Rouy) Damboldt, *Dactylorhiza incarnata* (L.) Soo, *Dactylorhiza fuchsia* (Druce) Soo, *Epipactis helleborine* (L.) Crantz, *Carex brunnescens* (Pers.) Poiret., *Platanthera bifolia* (L.) Rich., and *Salix starkeana* Willd.. Populations of regionally rare species protected in the Sumy region were also negatively affected by the fire, such as *Gymnocarpium dryopteris* (L.) Newman, *Viola riviniana* Rchb., *Helianthemum chamaecistus* Mill., *Salix rosmarinifolia* L., and *Salix myrsinifolia* Salisb.. Some of these are included in the list of the International Union for Conservation of Nature.

The problem of using forest typology in practice can be traced in the works of modern authors. According to I. Myskovets *et al.* (2024), forest typology is crucial for forest restoration. The authors assert that anthropogenic landscapes should be incorporated into forest typology, but priority attention should be given to natural forest phytocenoses to ensure the rational use of forest resources and the maximum preservation of the natural forest ecosystem. The idea of restoring damaged forest phytocenoses based on an ecological approach is present in the works of authors such as O. Prikhodko *et al.* (2019), H. Berglund and T. Kuuluvainen (2021), and A. Bugno-Pogoda and T. Durak (2021).

The problem of the restoration of damaged forest phytocenoses is also relevant for intrazonal territories. According to M. Dodan and S. Peric (2019), reforestation efforts in the coniferous forests of Croatia should be conducted with consideration for the ecology of spruce forests and their resistance to hurricane winds. A study by E. Collado *et al.* (2023) of mixed forests in the Mediterranean revealed a direct relationship between pine growth processes and soil moisture. The study assesses the impact of local moisture on the quality of forest cover formation. The authors advocate for forest restoration in conditions that closely resemble natural ones, taking into account the landscape diversity of the area to cultivate forests that are more adapted to climate change by increasing the biodiversity of the planted forest species. Ch. Haga *et al.* (2022) employed the LANDIS-II Net Ecosystem Carbon and Nitrogen Succession extension to optimally plan forest species composition for restoring damaged forest cover in the Oshima-Hiyama National Forest in southern Hokkaido, northern Japan. R. Seidl *et al.* (2018) are deeply convinced that, in the conditions of the Austrian Alps, mixed forests are better adapted to the impact of the bark beetle than monoculture coniferous stands. In analysing the spatial patterns of landscape disturbance, the authors identified an uneven distribution of risk for coniferous phytocenoses. Therefore, they propose planting broad-leaved species adapted to the changed climate alongside conifers. W. Mason *et al.* (2021) note that there is a growing interest in Europe in ecological forest management strategies that enhance species and structural diversity through the use of irregular silvicultural systems. The core principle of the European Continuous Forest Cover Strategy is that natural forest stands are established following the forest types of the original stands, using authentic seed sources.

Thus, researchers highlight the importance of using forest typology for the restoration of forest ecosystems, with priority given to natural phytocoenoses and the

consideration of landscape diversity. The significance of an ecological approach in forest restoration is emphasised by numerous authors who note that utilising natural conditions is key to successfully adapting forests to climate change and enhancing their biodiversity. Ecological forest management, particularly based on the establishment of mixed forests and the use of irregular silvicultural systems, contributes to improving the resilience of forest stands to adverse factors such as pests and extreme weather conditions. In many regions of the world, emphasis is placed on restoring forests under conditions that closely resemble natural ones to preserve biodiversity and ensure their resilience to future challenges.

CONCLUSIONS

In the course of the study, it was established that the territory of the Starohut forest massif within the Desniansko-Starohutskyi NNP is represented by the following trophotopes: bors, subors, and sugruds. Bors occupy dry and fresh hygrotopes on flat terrain, covering an area of 1.8 hectares or 0.02% of the total forest area. Subors occupy fresh, moist, damp, and swamp hygrotopes, with a total area of 4,510.1 hectares, or 66.53%. In the same hygrotopes, sugruds grow on an area of 2,266.9 hectares, which is 33.44% of the study area; no gruds were found. *P. sylvestris* is the main forest-forming species, growing on an area of 5,092.7 hectares. *B. pendula* occupies a much smaller area – 1,207.1 hectares, *A. glutinosa* – 201.4 hectares, *P. abies* – 111.5 hectares, and *Q. robur* – 90.0 hectares. Other tree species are poorly represented. The protected area of the Starohut forest massif is dominated by fresh pine subors, with an admixture of birch, black alder, and spruce – 1,181.1 hectares, and moist pine-birch-alder-oak subors – 849.4 hectares. The recreation zone is dominated by fresh subors – 2,336.4 hectares, and moist sugruds – 1,164.2 hectares. The economic zone is dominated by subors – 430.7 hectares, and sugruds – 137.5 hectares. As a result of logging, military aggression, and forest fires in the eastern part of the park, the following forest types were damaged: dry pine forest, fresh pine forest, fresh oak-pine subor, fresh linden-oak-pine subor, and damp birch-oak-pine subor. After the end of military actions, it is necessary to study the condition of trophotopes in more detail to carry out forest restoration works that are close to natural conditions.

ACKNOWLEDGEMENTS

The authors express special gratitude for the support in conducting the study and providing necessary materials to the director of the Research and Production Enterprise "Desniansko-Starohutskyi", Sergei Kubrakov.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Andriienko, T.L. (2006). *Phytodiversity of Ukrainian Polissia and its protection*. Kyiv: Fitosotsiotsentr.
[2] Berglund, H., & Kuuluvainen, T. (2021). Representative boreal forest habitats in Northern Europe, and a revised model for ecosystem management and biodiversity conservation. *Ambio,* 50, 1003-1017. doi: 10.1007/s13280-020-01444-3.
[3] Bugno-Pogoda, A., & Durak, T. (2021). Climate and management factors underlying changes in beech forest herbaceous layer plant communities in the Polish Eastern Carpathians. *Forests,* 12(11), article number 1446. doi: 10.3390/f12111446.
[4] Chadro, S., Uzunovic, M., Omerovic, Z., Vlahovljak, E., Konjic, A., & Markovic, M. (2024). Climate change influence on occurrence of extreme dry-wet periods in Bosnia and Herzegovina. *Agriculture and Forestry*, 70(1), 325-344. doi: 10.17707/AgricultForest.70.1.2.
[5] Collado, E, Piqué, M., Coello, J., García, J., Fuentes, C., & Coll, L. (2023). Close-to-nature management effects on tree growth and soil moisture in Mediterranean mixed forests. *Forest Ecology and Management,* 549, article number 121457. doi: 10.1016/j.foreco.2023.121457.
[6] Convention on Biological Diversity. (1992, June). Retrieved from https://zakon.rada.gov.ua/laws/show/995_030#Text.
[7] Convention on International Trade in Endangered Species of Wild Fauna and Flora. (1979, June). Retrieved from https://zakon.rada.gov.ua/laws/show/995_129#Text.
[8] Dodan, M., & Peric, S. (2019). Windthrow resistance of Norway spruce (Picea abies /L./ Karst.) forest cultures – preliminary results. *South–East European Forestry*, 10(1), 77-88. doi: 10.15177/seefor.19–09.
[9] Haga, Ch., Hotta, W., Inoue, T., Matsui, T., Aiba, M., Owari, T., Suzuki, A.N., Shibata, H., & Morimoto, J. (2022). Modeling tree recovery in wind-disturbed forests with dense understory species under climate change. *Ecological Modelling*, 472, article number 110072. doi: 10.1016/j.ecolmodel.2022.110072.
[10] Hensiruk, S. (2002). *Forests of Ukraine*. Lviv: Scientific Society named after Shevchenko.
[11] Koval, I., & Sydorenko, S. (2019). The influence of surface fire on radial and height growth of Pinus sylvestris L. in Forest-Steppe in Ukraine. *Folia Forestalia Polonica*, *Series A – Forestry*, 61(2), 123-134. doi: 10.2478/ffp–2019–0012.

[12] Litvinov, D., Litvinova, O., Borys, N., Butenko, A., Masyk, I., Onychko, V., Khomenko, L., Terokhina, N., & Kharchenko, S. (2020). The typicality of hydrothermal conditions of the forest steppe and their influence on the productivity of crops. *Environmental Research*, 76(3), 84-95. doi: 10.5755/j01.erem.76.3.25365.
[13] Marynych, O., Parkhomenko, H., Petrenko, O., & Shyshchenko, P. (2003). Improved scheme of physical and geographical zoning of Ukraine. *Ukrainian Geographical Journal*, 1, 16-20.
[14] Mason, W.L., Diaci, J., Carvalho, J., & Valkonen, S. (2021). Continuous cover forestry in Europe: Usage and the knowledge gaps and challenges to wider adoption. *Forestry: An International Journal of Forest Research,* 95(1), 1-12. doi: 10.1093/forestry/cpab038.
[15] Melnyk, V.I. (2020). On the causes of island localization of spruce forests of Polissya. *Reports of the National Academy of Sciences of Ukraine*, 9, 86-97. doi: 10.15407/dopovidi2020.09.086.
[16] Myskovets, I., Shymchuk, Yu., Nurgaziev, R., Shergaziev, U., & Akhmatbekov, M. (2024). The influence of agroforestry on the formation of the structure of forest ecosystems. *Ukrainian Journal of Forest and Wood Science*, 15(1), 72-88. doi: 10.31548/forest/1.2024.72.
[17] NNP Desniansko-Starohutskyi. (2024). Retrieved from http://www.nppds.inf.ua/.
[18] Oitsius, L.V., Volovyk, H.P., Doletskyi, S.P., & Lysytsya, A.V. (2020). Distribution of adventive species Solidago canadensis, Phalacroloma annuum, Ambrosia artemisiifolia, Heracleum sosnowskyi in phytocenoses of Volyn' Polissya (Ukraine). *Biosystems Diversity,* 28(4), 343-349. doi: 10.15421/012043.
[19] Ostapenko, B., & Tkach, V. (2002). *Forest Typology*. Kharkiv: Publishing House of Kharkiv State Agrarian University.
[20] Panchenko, S.M. (2013). *Forest vegetation of the National Natural Park "Desnyansko-Starogutsky"*. Sumy: University Book, 312 p.
[21] Pesendorfer, M.B., Bogdziewicz, M., Szymkowiak, J., Borowski, Z., Kantorowicz, W., Espelta, J.M., & Fernández-Martínez, M. (2020). Investigating the relationship between climate, stand age, and temporal trends in masting behavior of European forest trees. *Global Change Biology,* 26(3), 1654-1667. doi: 10.1111/gcb.14945.
[22] Pogrebnyak, P.S. (1959). *Fundamentals of forest typology*. Kyiv: Academy of Sciences.
[23] Prikhodko, O., Pasternak, V., & Yarotsky, V. (2019). Condition, structure and productivity of pine forests of SE "Lymanske Forestry". *Forestry and Forest Melioration*, 135, 24-29. doi: 10.33220/1026–3365.135.2019.24.
[24] SEBR of Ukraine. (2022). *State Enterprise "Biological Resources of Ukraine"*. Retrieved from https://vkursi.pro/card/dp-bru-20064338.
[25] Seidl, R., Albrich, K., Thom, D., & Rammer, W. (2018). Harnessing landscape heterogeneity for managing future disturbance risks in forest ecosystems. *Journal of Environmental Management*, 209, 46-56. doi: 10.1016/j.jenvman.2017.12.014.
[26] Trifanova, M., Zadorozhna, G., Novitsky, R., Ponomarenko, O., Makhina, V., Khrystov, O., Ruchiy, V., & Zhukov, O. (2023). How much space is needed for biodiversity conservation? *Biosystems Diversity*, 31(4), 521-534. doi: 10.15421/012362.

Екологічна типологія деревної рослинності Старогутського лісового масиву як складова відновлення порушених екотопів

Олена Тихонова
Кандидат біологічних наук, доцент
Сумський національний аграрний університет
40021, вул. Герасима Кондратьєва 160, м. Суми, Україна
https://orcid.org/0000-0003-0961-4896
Тетяна Маруха
Аспірант
Сумський національний аграрний університет
40021, вул. Герасима Кондратьєва, 160, м. Суми, Україна
https://orcid.org/0000-0001-5913-shshshch
Петро Рибалко
Доктор педагогічних наук, професор
Сумський державний педагогічний університет імені А.С. Макаренка
40002, вул. Роменська 87, м. Суми, Україна
https://orcid.org/0000-0002-6460-4255
Сергій Бутенко
Доктор філософії з агрономії, старший викладач
Сумський національний аграрний університет
40021, вул. Герасима Кондратьєва, 160, м. Суми, Україна
https://orcid.org/0000-0002-9925-3029
Сергій Горбась
Кандидат сільськогосподарських наук, доцент
Сумський національний аграрний університет
40021, вул. Герасима Кондратьєва, 160, м. Суми, Україна
https://orcid.org/0000-0003-3768-8833

Анотація. Метою дослідження було визначення типологічної структури Старогутського лісового масиву в межах Деснянсько-Старогутського національного природного парку на основі української школи лісової типології Алексєєва-Погребняка. Площа лісового масиву становить 6778,8 га. На досліджуваній території виділено такі трофотопи: бори, субори та сугруди. Бори, що складаються з соснових угруповань з домішкою берези, займають сухі та свіжі гігротопи на рівнинних місцевостях, займаючи 1,8 га або 0,02 % від загальної площі лісу. Субори, що складаються з сосново-дубових угруповань з участю берези та осики, зустрічаються у свіжих, вологих, мокрих та перезволожених гігротопах, займаючи 4510,1 га або 66,53 % території. Сугруди, що складаються з дубово-соснових липово-кленових лісів на рівнинах та осиково-березово-липово-кленових лісів у зниженнях, займають 2266,9 га або 33,44 % території Старогутського лісового масиву. Порушень не виявлено. Дослідженнями встановлено, що основною лісоутворюючою породою в національному парку є сосна звичайна (*Pinus sylvestris*), яка займає 5092,7 га. *Betula pendula* займає меншу площу – 1207,1 га, ще меншу – *Alnus glutinosa* (201,4 га), *Pice aabies* (111,5 га) та *Quercus robur* (90,0 га). Інші породи дерев представлені незначною мірою. У заповідній зоні парку переважають свіжі субори та сугрудки з домішкою берези, вільхи чорної та ялини загальною площею 1 181,1 га та вологі сосново-березово-вільхово-дубові субори та сугрудки – 849,4 га. У рекреаційній зоні переважають свіжі гідротопи з суборами та сугрудами – 2336,4 га. У господарській зоні переважають субори та сугруди на свіжих піщаних ґрунтах, загальною площею 430,7 га. Отримані результати дають змогу відновити природні типи лісів на територіях, що постраждали від масштабних пожеж 2023-2024 рр. та інших антропогенних впливів

Ключові слова: типи лісу; гідротопи; трофотопи; біорізноманіття; рідкісні види флори