

Chorology of rare dendroflora of the National Nature Park “Male Polissya” (Ukraine) in zonal comparison

Serhii Popovych¹, Borys Yakubenko¹, Maryna Tsybulia^{2,*}

¹National University of Life and Environmental Sciences of Ukraine,
General Rodimtsev Str., 19, 03041, Kyiv, Ukraine

²National Nature park “Male Polissya”, Mykhelska Str., 32, Iziaslav,
Khmelnyska obl., 30300, Ukraine

*corresponding author e-mail: marinka-bg111@i.ua

Received: 26 January 2022 / Accepted: 4 May 2022

Abstract. Among scientists of various specialities there is still no unambiguous position about the zone belonging of the Male Polissya region (“Little Polissya”, Ukraine). To confirm one of the positions, the authors of the article studied rare protected species of dendroflora of the National Nature Park (NNP) “Male Polissya” (deciduous forest zone) and other national parks that are close to it in the structure of flora and vegetation, and located within this and the northern mixed forest zone (Ukrainian Polissya). Methods of comparative florology have been used with the determination of coefficients of similarity of local floras. The results of chorological analysis, qualitative, quantitative and comparative assessment of rare species of dendromorphic plants of national nature parks in both natural zones have been presented. The analysis of similarity of rare fractions of local dendroflora revealed that the quality of plant species of the National Nature Park “Male Polissya” is more related to the national nature parks of mixed forest zone than to the national nature parks of deciduous forests. Among the national nature parks, deciduous forest zones have the highest levels of representativeness with *Daphne cneorum*, *Hedera helix* and *Daphne mezereum*, and mixed forest zones with *Salix myrtillosum*, *Daphne cneorum*, *Dianthus pseudosquarrosus* and *Hedera helix*. Therefore, for the national nature parks of both natural zones, the most representative is the species of wide chorological but narrow ecological amplitude, that is *Daphne cneorum*, which grows only in pale and dry sod-podzolic forestal ecotopes enriched with carbonates.

Keywords: natural zones, national nature parks, local flora, dendrorarity, correlation analysis, geoelements.

1. Introduction

The need to form a network of protected areas is based on two interrelated fundamental postulates, the conservation and study of biodiversity to ensure the ecological stability and evolutionary processes in natural ecosystems. There is no doubt that the nature protection is inefficient without a scientific basis. Therefore, the primary and urgent task of science is the development of bio-inventory as a trend of research, especially on rare species of flora, fauna, mycobiota, phytocenoses and ecosystems of nature reserves. In the

framework of this area of research in biosphere and nature reserves, national parks and other categories of nature reserves, which are representative of the best-preserved indigenous ecosystems, the first priority was to compile inventories, prodromes, abstracts, checklists, annotated lists of flora, mycobiota and plants.

For these categories of nature reserves, it is also important to determine the degree of rarity of phytodiversity, which is determined by the indicator of their scientific and conservation value. Above all, this indicator is characterized by the level of uniqueness and preservation of the

autochthonous structure of protected natural ecosystems and the degree of diversity of ecological conditions of natural regions. In particular, the priority for the forest zone is the qualitative characteristic of the degree of rarity of its own dendrodiversity. It is obtained by conducting a comparative assessment of plant species, their habitats and geoelements of local protected dendroflora of nature reserves within the defined intra-zonal botanical-geographical space. In Ukraine, the priority is the assessment of the network of national nature parks, as it is the most extensive and occupies the largest areas compared to the network of biosphere and nature reserves.

2. Study area

Over the last half century, and especially over the past two decades, publications on the composition of taxa and syntaxa, structure, representativeness and dynamics of phytodiversity of protected areas have been accumulated in different parts of the world (Zemanek & Winnicki, 1999; Powell et al., 2000; Armenteras et al., 2003; Lieskovský et al., 2010; Popovych et al., 2011, 2014, 2017b, 2020; Claeys et al., 2017; Tran Thi Thanh Huong et al., 2021). Among the wide range of publications, most of the primary papers on nature reserves are devoted to various stages of the inventory of phytodiversity. In this aspect, the first stage of the inventory of phytodiversity research, including rare species, has been completed in the National Nature Park “Male Polissya” (Andriyenko et al., 2007; Andriyenko & Yuglichek, 2016; Yuglichek, 2016).

The natural region of the location of the National Nature Park “Male Polissya” is unique and peculiar. The controversial nature and zonal affiliation of the region of Male Polissya have been the subject of polemics for a long time. Earlier (Marinich et al., 1985) the contour of Male Polissya extended from the west to the east was referred to as the zone of mixed forests, and now in the Ukrainian geographical and geobotanical sciences, it is regarded as belonging to the zone of deciduous forests (Marinich et al., 2003; Shelyag-Sosonko & Didukh, 2003). Accordingly, this region received the status of a separate physical-geographical region within the six regions that are part of the Western Ukrainian province of deciduous forests of Ukraine. However, some sources have not still recognized this opinion and include Male Polissya within the Landscape Zone of Mixed Forests of Ukraine (Hetman, 2021). Instead, according to forestry (Debryniuk, 2003) and agroecological (Konischuk & Egorova, 2018) zonation, the region of Male Polissya is assigned to the subzone of the Western Forest-Steppe of the Ukrainian Forest-Steppe zone. The authors of this article consider the region of Male Polissya within the respective

ranks of physical-geographical (Marinich et al., 2003) and geobotanical (Shelyag-Sosonko & Didukh, 2003) zonation, i.e. within the zone of deciduous forests of Ukraine.

From the perspective of comparative florology, an important argument for the knowledge of the zonal essence of Male Polissya can be contributed by the results of a complete structural analysis of regional floras, which makes it possible to understand their main features and to single out their peculiarities in the comparative aspect. Undoubtedly, a comparative assessment of only rare fractions of regional floras does not provide a complete picture of their structure and genesis. Our narrow chorological and correlation analyzes have been conducted only partially, but they can additionally prove, strengthen or diminish one of the above statements about the place of the Male Polissya region within the zonation system of Ukraine’s territory.

The modern comparative florology counts with many examples of this area of research. One of the most recently synthesized works is a collective monograph on the flora of national nature parks of Ukraine (Onyschenko & Andriyenko, 2012), which lists the species of rare phytogenofund of most national nature parks of Ukraine for comparison. Instead, over the decades, a considerable amount of scientific work has been accumulated that directly address the problems of modern comparative florology (Schmidt, 1980; Malyshev, 1987; Lukash, 2009; Moysiyyenko, 2011; Kostina, 2013), including rare arboretum diversity of the natural reserve fund (Seregin, 2003; Stepanenko & Popovych, 2015; Vlasenko & Popovych, 2016).

3. Material and methods

Inventories of rare species of woody and lignified plants (trees, shrubs, woody vines, subshrubs, prostrate shrubs, dwarf subshrubs) of national nature parks were chosen as the main site of floroanalytical research. For officially recognized rare species of plants of these life forms we use the name of dendrosozophytes, and for their compositions in nature reserves, local dendrosozofloras (Popovych & Pokotylova, 2020), that is, protected ones.

The species composition of the rare fraction of dendroflora of the National Nature Park “Male Polissya” was subject to chorological analysis. The results of this analysis were compared with similar local rare dendrofloras of national nature parks that are located in genetically related areas of deciduous and mixed forests of Ukraine. The chorological analysis was performed on the basis of grouping plant species according to the types of habitats and geoelements of flora (Meuzel et al., 1965, 1978; Kleopov, 1990; Didukh et al., 2000; Pokotylova, 2018). Carrying out chorological analysis and establishing the structure of flora are important

tasks in the study of species diversity of plants in any area. This analysis provides answers to several questions: where certain species of plants come from, what types and nature of their natural habitats are, and so on. In this aspect, two regional protected rare dendrofloras from deciduous and mixed forests of Ukraine were also compared (Popovych et al., 2017a, 2019).

The qualitative and quantitative taxonomic compositions of rare species of local dendroflora of national nature parks of the above two natural zones were compared from the point of view of the degree of their similarity. To obtain the results of comparative evaluation of taxa, there are now several dozen coefficients of similarity/difference (synonyms: degrees of similarity, coefficients of the floral community), and their modifications. However, we applied the most fully tested coefficients suggested by Jaccard (K_j) and Sorensen-Czekanowski (K_{sc}). They are also simpler and easier to calculate (Schmidt, 1980; Yakubenko et al., 2015; Vlasenko & Popovych, 2016; Popovych & Pokotylova, 2020), and also make it possible to compare two different samplings by a variety of plant species.

In the methodological sense, these coefficients are similar: their limits range from 0 to 1: the value $K_j = K_{sc} = 1$ means that the floristic lists completely coincided, $K_j = K_{sc} = 0$ indicates that the compositions of plant species are completely different. If $K_j > 0.50$ and $K_{sc} > 0.67$, then the floras are considered similar. The calculation formulas look as follows:

$$K_j = \frac{c}{a + b - c} \quad K_{sc} = \frac{2c}{a + b}$$

where a is the number of species in one site, b is the number of species in the second site, and c is the number of species common to both sites.

Rare species of dendroflora are those that are included in the official "red lists" (RL) of all levels: international (European Red List, 1992; Walter & Gillett, 1998; Bilz et al., 2011; The IUCN Red List Online, 2021); national (Didukh, 2009) and administrative-regional (Andriyenko & Perehrym, 2012). In the national nature parks of deciduous and mixed forests, no rare dendro-species have been identified as included in the relevant annexe to the Berne Convention (Convention, 1979; Andriyenko & Onyschenko, 2008).

The starting materials for comparative analysis were field diaries with geobotanical descriptions made according to the methodology (Yakubenko et al., 2018) and published abstracts on rare species of woody plants (Popovych et al., 2011, 2014, 2017b, 2020). According to the text, the authors of plant species names are given according to the rule of the first mention of their names. Also, with the first mention of a plant species, its natural rarity status recognized in the literature (relict, endemic, border area species) is indicated.

The names of plant species have been verified according to international taxonomic databases (The World Flora Online, 2021; The IUCN Red List Online, 2021).

4. Results and discussion

There are currently 40 national nature parks in the Ukrainian flatland, including eight in deciduous and mixed forests, 11 in the forest-steppe zone, and 13 in the steppe zone. In particular, there are two national nature parks in the region of Male Polissya – "Male Polissya" and Dermansko-Ostrozkyi. The National Nature Park "Male Polissya" is located in the eastern part of the Male Polissya region, between the Volyn and Podillya Uplands that are separated by a narrower strip, Ostroh Urstromtal Passage (Fig. 1).

We selected 12 out of 16 national nature parks to compare the species composition of rare arboreal diversity. These are the most representative national nature parks from the zone of deciduous and mixed forests. For them, forest, swamp forest and shrub ecosystems are crucial in the process of ecostabilization of vegetation. The results of the chorological analysis and comparison of the National Nature Park "Male Polissya" with other national nature parks of these two zones are presented below.

Deciduous forests zone of Ukraine. Due to its unique location in the landscape mesorelief, the territory of the National Nature Park "Male Polissya" is characterized by forest (90% of the area), meadow and swamp vegetation. The forest vegetation is dominated by phytocenoses of the formation *Pinetea sylvestris*, less often of the subformation *Quercetea (roboris)-Pinetea (sylvestris)*. The flora of the National Nature Park includes 801 species of higher vascular plants. The most numerous is the group of forest plant species, the second is meadow, and the third, swamp and aquatic plants. Most of the flora of the National Nature Park "Male Polissya" is formed by plant species that mainly belong to the leading European, Eurasian, Circumboreal types of habitats. This part of the species composition of plants is characterized by, respectively, European, Holarctic, and Boreal goeolements of flora.

26 species of plants listed in the Red Data Book of Ukraine (Didukh, 2009) and 54 plant species from the list of regionally rare plant species of the Khmelnytskyi region (Andriyenko & Perehrym, 2012) are found on the territory of the National Nature Park "Male Polissya". Among them, there are the following rare species: *Andromeda polifolia* L. (a glacial relict found at the southern boundary of the habitat), *Daphne cneorum* L. (a tertiary relict found at the eastern boundary of the habitat), *Daphne mezereum* L. (a tertiary relict at the eastern boundary of the habitat) *Dianthus pseudosquarrosus* (Novak.) Klok. (an endemic at the southern boundary of

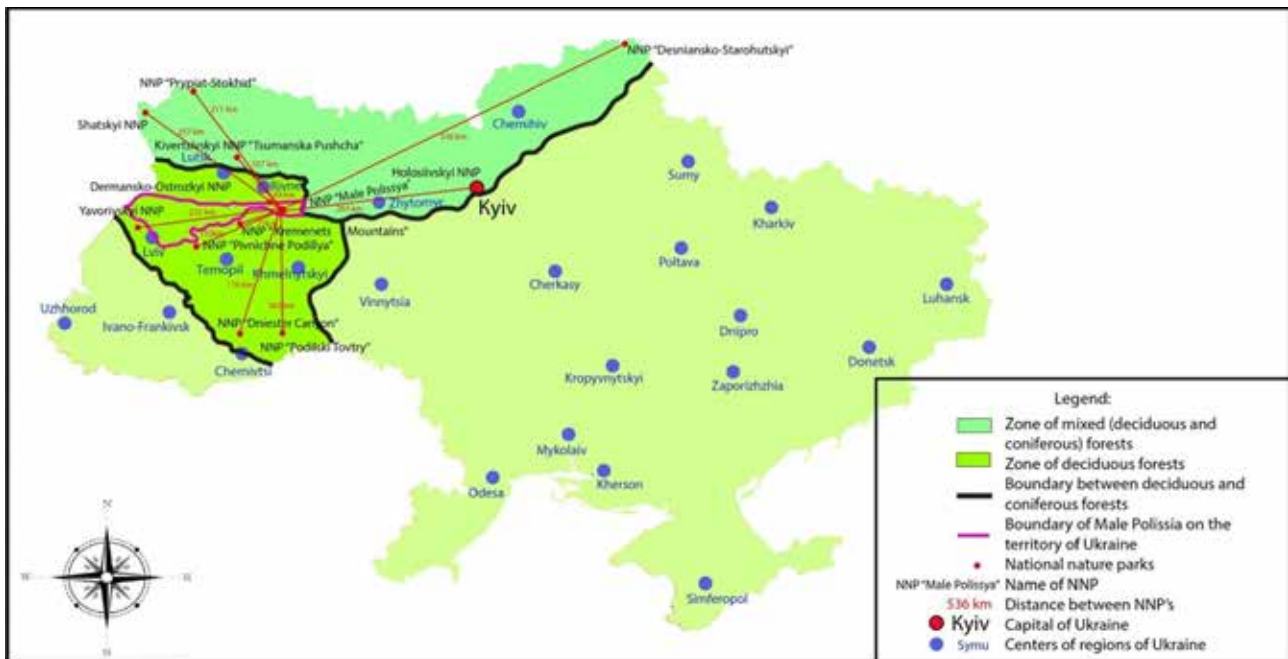


Figure 1. Map of the network of national nature parks in the zones of mixed and deciduous forests of Ukraine (abbreviation on the map and its legend: NNP – National Nature Park)

the habitat), *Genista germanica* L. (a species at the southern boundary of the habitat), *Hedera helix* L. (a tertiary relict at the eastern boundary of the habitat), a moderately distributed species *Ledum palustre* L. (a species at the southern boundary of the habitat), *Oxycoccus palustris* Pers. (a glacial relict at the southern boundary of the habitat), *Salix myrtilloides* L. (a Holocene postglacial relict at the southern boundary of the habitat), *Vaccinium uliginosum* L. (a species at the southern boundary of the habitat). The chorological analysis of the composition of rare arboretums showed that most of them belong to the European, and Circumboreal types of habitats. They are characterized by European, Boreal, and Holarctic geoelements of flora. Among the species composition, *Salix myrtilloides* and *Dianthus pseudosquarrosus* have significant botanical value.

The vegetation cover of the Dermansko-Ostrozkyi National Nature Park is dominated by forest vegetation, which is mainly represented by phytocenoses of the formations *Quercetea roboris* and *Pinetea sylvestris*. Rare species of dendromorphic plants of the National Nature Park include *Betula humilis* Schrank (a glacial relict at the southern boundary of the habitat), *Cerasus fruticosa* (Pall.) Woron. (a species at the northern boundary of the habitat), *Crataegus ukrainica* Pojark. (fragmentary endemic), *Daphne cneorum*, *Hedera helix*, *Lonicera xylosteum* L. (species at the southeastern boundary of the habitat), *Ribes lucidum* Kit. (very rare species), *Salix myrtilloides*, *Salix starkeana* Willd. (relict at the southern boundary of the habitat). Most of

the species of dendrorarities of the Dermansko-Ostrozkyi National Nature Park belong to the Holarctic, Circuboreal, European types of habitats and the following geoelements of flora: European, Boreal, Holarctic. Of these, *Betula humilis*, *Salix myrtilloides* and *Salix starkeana* grow at the southern boundary of the habitat. *Daphne cneorum*, *Hedera helix* and *Salix myrtilloides* are common with the National Nature Park "Male Polissya". Coefficients of similarity and classification of plant species of national nature parks to RL are presented in Table 1.

The territory of the National Nature Park "Dniester Canyon" is dominated by forest vegetation which is mostly represented by phytocenoses of the formations *Carpinetea betuli* and *Quercetea roboris*. The following dendrorarities have been identified in this National Nature Park: *Amygdalus nana* L. (a species at the northern boundary of the range), *Astragalus monspessulanus* L. (a species at the north-eastern boundary of the disjunctive range), *Aurinia saxatilis* (L.) Desv. (an uncommon species within the range), *Cerasus fruticosa*, *Chamaecytisus albus* (Hacq.) Rothm. (a species at the southeastern boundary of the habitat), *Chamaecytisus blockianus* (Pawl.) Klásková (a Tertiary relict, narrow endemic), *Chamaecytisus podolicus* (Blocki) Klásková (a relict, endemic of Eastern Carpathians and Podillya) *Daphne cneorum*, *Daphne mezereum*, *Ephedra distachya* L. (a vulnerable tertiary relict at the western boundary of the habitat), *Hedera helix*, *Rosa czackiana* Besser (an endemic at the eastern boundary of the range), *Scutellaria verna* Besser (a relict, a local Middle

Table 1. Quantitative indicators of comparative assessment of species compositions of dendrorarities of national nature parks of deciduous and mixed forests of Ukraine

Names of national nature parks	Number of plant species						K _j	K _{sc}
	Total	common with the National Nature Park «Male Polissya»	IUCN RL	European RL	Red Data Book Ukraine	Regional RL		
Deciduous forest zone								
Dermansko-Ostrozkyi	9*	3	2	1	4	2	0.2	0.3
«Dniester Canyon»	17*	3	3	2	10	3	0.1	0.2
«Kremenets Mountains»	21*	3	2	2	12	2	0.1	0.2
«Male Polissya»	10*	10	2	-	2	8	-	-
«Pivnichne Podillya»	12*	1	3	1	10	3	0.1	0.1
«Podilski Tovtry»	25*	2	4	3	14	4	0.1	0.1
Yavorivskyi	6*	1	4	-	3	4	0.1	0.1
Mixed Forest Zone								
Holosiivskyi	8*	3	1	-	3	5	0.4	0.5
«Desniansko-Starohutskyi»	14*	6	3	-	3	11	0.3	0.5
Kivertsivskyi, «Tsumanska Pushcha»	6*	3	1	-	4	2	0.2	0.4
«Prypiat-Stokhid»	10*	2	1	-	7	3	0.1	0.2
Shatskyi	12*	2	2	-	6	5	0.1	0.2

Note: * – total plant species are included in two and three RL.

Transnistrian-Northern Black Sea coast endemic), *Sorbus torminalis* (L.) Crantz. (a relict at the extreme northeastern boundary of the range), *Spiraea polonica* Blocki (a relict, a narrowly local endemic of Podillya), *Staphylea pinnata* L. (a tertiary relict at the northeastern boundary of the disjunct range), *Cerasus fruticosa* and *Vaccinium vitis-idaea* L. (a species at the southern boundary of the habitat). Most of these species belong to the European, Holarctic, and Eurasian types of habitats. They are characterized by bipolar extratropical, holarctic, European, and Eurasian geoelements of flora. The types of habitats and geoelements of the studied flora species of national parks "Dniester Canyon" and "Male Polissya" are only partially common. In our opinion, this is because rare species of dendroflora of the neighbouring national nature parks "Dniester Canyon" and "Podilsky Tovtry" are evolutionarily older, since their growth places are related to the outcrop of Mesozoic reef rocks of the Tovtry ridge (Sarmatian limestones, chalk, carbonates, etc.). The national parks "Dniester Canyon" and "Male Polissya" have in common *Daphne cneorum*, *Daphne mezereum* and *Hedera helix*.

The territory of the National Nature Park "Kremenetski Hory" ("Kremenets Mountains") is dominated by deciduous forests inhabited mainly by phytocoenoses of the subform *Carpineto (betuli)-Quercetia (roboris)*, less common are meadow steppe and rock steppe plant communities. The rare fraction of dendroflora is quite rich and phytocenotically

diverse, its composition is represented by *Aurinia saxatilis*, *Betula klokovii* Zaverucha (narrowly local endemic), *Betula obscura* A. Kotula incl. (*B. kotulae* Zaverucha, a species at the north-eastern boundary of the habitat), *Cerasus fruticosa*, *Chamaecytisus albus*, *Ch. blockianus*, *Ch. paczoskii* (V. Krecz.) Klásková (a relict, a narrow endemic) *Chimaphila umbellata* (L.) W. Barton (a species at the southern boundary of the habitat, probably disappearing), *Cotoneaster melanocarpus* Fisch. ex Blytt (an uncommon species within the habitat), *Crataegus ukrainica*, *Daphne cneorum*, *D. mezereum*, *Euonymus nana* Bieb. Incl. (*E. taurica* Kot., a relict), *Helianthemum canum* (L.) Hornem. s.l. (*H. cretaceum* (Rupr.) Juz., a relict at the southwestern boundary of the Mediterranean-Central European disjunct habitat), *Juniperus communis* L. (a species at the southern boundary of the habitat), Wald. and Kit. (a Balkan species at the northern boundary of the habitat), *Rosa czackiana*, *Sorbus torminalis*, *Spiraea picoviensis* Besser (an endemic to the Central Forest-Steppe), *Staphylea pinnata*, *Hedera helix*. Most of the dendrorarity species of the national nature parks "Kremenetski Hory" and "Male Polissya" belong to the European, Holarctic, Eurasian, and Circumboreal types of habitats. They are characterized by bipolar extratropical, holarctic, European, and Eurasian geoelements of flora. A significant proportion of dendrorarities is constituted by habitat boundary species, endemics and relicts. These two national parks have in common *Daphne cneorum*, *D. mezereum* and *Hedera helix*.

The vegetation cover of the National Nature Park “Pivnichne Podillya” (Northern Podillya) is dominated by forest vegetation, which is mainly characterized by phytocenoses formations *Fagetea (sylvaticae)*, *Carpinetea (betuli)* and *Quercetea (roboris)*. A peculiar feature of the territory of this National Nature Park is a successful combination of the steppe, forest, and wet meadow vegetation, which represents the following dendrorarities: *Betula humilis*, *B. obscura*, *Chamaecytisus albus*, *Ch. blockianus*, *Cornus mas* L. (species at the eastern boundary of the habitat), *Daphne cneorum*, *Juniperus communis*, *Rhamnus tinctoria*, *Rosa czackiana*, *Salix starkeana*, *Sorbus torminalis*, *Staphylea pinnata*. Most of the studied plant species of the national nature parks “Pivnichne Podillya” and “Male Polissya” belong to the European, Holarctic, and Eurasian types of habitats and Holarctic, Boreal, European, and Eurasian geoelements of flora. At the same time, a significant number of such species belong to the habitat boundary. These two national nature parks have in common only *Daphne cneorum*.

The vegetation of the National Nature Park “Podilsky Tovtry” is formed mainly by forest phytocenoses of the following subformations: *Querceta roboris pura*, *Carpineto (betuli)-Quercetea (roboris)*, *Carpineto (betuli)-Querceto (roboris)-Fraxineta (excelsioris)*, *Querceto (roboris)-Fagetea (sylvaticae)*. Wetland, steppe, meadow and rock plant groups are less common. This National Nature Park is included in the list of sites subject to the Ramsar Convention, its aqua-territorial complexes constitute the main biotope value as an environment for the conservation of wetland birds of international importance. Among all studied, it is characterized by the highest species richness. Its rare fraction of dendroflora is represented by 25 species: *Amygdalus nana*, *Astragalus monspessulanus*, *Caragana scythica* (Kom.) Pojark. (endemic of the northern coast of the Black Sea), *Cerasus fruticosa*, *Chamaecytisus albus*, *Ch. blockianus*, *Ch. paczoskii*, *Ch. podolicus*, *Crataegus lypskyi* Klok. (endemic at the boundary of the habitat), *Daphne mezereum*, *Ephedra distachya*, *Euonymus nana*, *Hedera helix*, *Helianthemum canum*, *Juniperus communis*, *Linum besarabicum* (Sävul et Rayss) Klokov ex Juz. (an endemic of South-Eastern Europe, narrow subendemic of Bessarabia-Southern Podillya), *Loranthus europaeus* Jacq. (a species at the eastern boundary of the habitat), *Rhamnus tinctoria*, *Rosa czackiana*, *R. glauca* Pour. (*R. rubrifolia* Vill., a species at the eastern boundary of the habitat), *R. nitidula* Bess. (a species at the north-eastern boundary of the habitat), *Scutellaria verna*, *Sorbus torminalis*, *Spiraea media* Franz Schmidt (a species at the eastern boundary of the habitat), *Staphylea pinnata*. Most of the dendrorarities of the National Nature Park “Podilsky Tovtry” belong to the European, Holarctic, Eurasian, and Nomandian types of habitats. They belong to the bipolar Extratropical, Boreal, Holarctic, European, Eurasian, and Balkan geoelements of flora. The types of habitats and geoelements of the flora of the National Nature

Park “Podilsky Tovtry” and the National Park “Male Polissya” are only partially similar, as the rare dendroflora fraction of the National Nature Park “Podilsky Tovtry” differs due to the unique species composition, historical antiquity of its origin and ecotopic features of the growth of the plants. These two national parks have in common only *Daphne mezereum* and *Hedera helix*.

The Yavorivskyi National Nature park is characterized by complex phytocoenotic, ecotopic and botanical-geographical structure of the forests, which is represented by phytocenoses of subformations *Carpineto (betuli)-Quercetea (roboris)*, *Pineto (sylvestris)-Quercetea (roboris)* of the formations *Pinetea sylvestris*, less often *Quercetea petraeae*, sometimes *Abieta albae*, and in depressions, *Alneta glutinosae*. Among all the rare plant species of these syntaxons, the following were subject to analysis: *Betula humilis*, *B. obscura*, *Chamaecytisus albus*, *Ch. blockianus*, *Cornus mas*, *Daphne cneorum*, *Juniperus communis*, *Rhamnus tinctoria*, *Rosa czackiana*, *Salix starkeana*, *Sorbus torminalis*, *Staphylea pinnata*. Dendrorarities of Yavorivskyi National Nature Park and the National Nature Park “Male Polissya” have the following common types of habitats: European, Holarctic, and Eurasian, as well as geoelements of flora: Holarctic, Boreal, European, Eurasian. A significant number of such species grow at the boundary of the habitat. These two national nature parks have in common only one species, *Daphne cneorum*.

From the above, it follows that among the national nature parks of deciduous forests the highest levels of representativeness have *Daphne cneorum* (five sites out of seven), *Hedera helix* (five sites) and *Daphne mezereum* (four sites). These species of dendroflora have a predominantly European type of habitat and belong to the European and Holarctic geoelements of flora.

Zone of mixed forests of Ukraine. The vegetation of the Holoivskyi National Nature Park is characterized by forests of the formation *Pineta sylvestris* and the subformation *Querceto (roboris)-Pinetea (sylvestris)*, meadow, swamp and coastal plant communities. *Arctostaphylos uva-ursi* (L.) Spreng (species at the southern boundary of the habitat), *Betula humilis*, *Betula obscura*, *Cerasus fruticosa*, *Daphne cneorum*, *D. mezereum*, *Dianthus pseudosquarrosus*, *Viscum austriacum* Wiesb. (a species at the northeastern boundary of the habitat) were found within the territory of the national nature park. Most of the dendrorarities of the national nature parks Holoivskyi and “Male Polissya” have the following common types of habitats: Holarctic, Circumboreal, Eurasian, and European, as well as Boreal, Plurregional, Holarctic, European, and Eurasian geoelements of flora. These two national parks have in common *Daphne cneorum*, *D. mezereum* and *Dianthus pseudosquarrosus*.

The vegetation of the National Nature Park “Desniansko-Starohutskyi” is represented by forests of the formation

Pineta sylvestris and complex of floodplain vegetation (meadow, water, mesotrophic and oligotrophic swamps). This National Nature Park is included in the list of sites subject to the Ramsar Convention, its aqua-territorial complexes constitute the main biotope value as an environment for the conservation of wetland birds of international importance. The places of growth of the following arboretums are confined to the above types of vegetation: *Andromeda polifolia*, *Carpinus betulus* L. (a species at the eastern boundary of the habitat), *Cerasus fruticosa*, *Dianthus pseudosquarrosus*, *Genista germanica*, *Juniperus communis*, *Oxycoccus palustris*, *Salix lapponum* L. (a glacial relict at the southern boundary of the habitat), *Salix myrsinifolia* Salisb. (a relict at the southern boundary of the habitat), *Salix myrtilloides*, *Salix rosmarinifolia* L. (a species at the southern boundary of the habitat), *Salix starkeana*, *Spiraea hyperecifolia* L. (an uncommon relict at the northern boundary of the habitat), and *Vaccinium uliginosum*. According to the results of the chorological analysis, most of the studied plant species at the national nature parks "Desniansko-Starohutskiy" and "Male Polissya" have the following common types of habitats: Circumboreal, Holarctic, Eurasian, and European. These plant species are characterized by pluriregional, Boreal, Holarctic, European, and Eurasian geoelements of flora. Quite a significant number of them are habitat boundary species. Both national nature parks have six common dendrorarities (*Andromeda polifolia*, *Dianthus pseudosquarrosus*, *Genista germanica*, *Oxycoccus palustris*, *Salix myrtilloides*, *Vaccinium uliginosum*).

The Kivertsivskiy National Nature Park "Tsumanska Pushcha" is dominated by forests of subformation *Carpineto (betuli)-Quercetea (roboris)*, formations-*Quercetea roboris* and *Pinetea sylvestris*, meadow and swamp vegetation. A number of the following dendrorarities have been identified in the vegetation cover of the National Nature Park: *Betula humilis*, *Chamaecytisus ratisbonensis* (Schaeff.) Rothm. (a species at the southern boundary of the habitat), *Daphne cneorum*, *Genistella sagittalis* (L.) Gams (a species at the north-eastern boundary of the habitat), *Hedera helix*, *Salix myrtilloides*. Most of the rare plant species of the Kivertsivskiy National Nature Park "Tsumanska Pushcha" and the National Nature Park "Male Polissya" have the following common types of habitats: Holarctic, Eurasian, European and geoelements of flora: pluriregional, Holarctic, European, Eurasian, Boreal. Quite a significant number of them are habitat boundary species. Both national nature parks have three common types: *Daphne cneorum*, *Hedera helix* and *Salix myrtilloides*.

The main biotopes in the National Nature Park "Prypiat-Stokhid" are forests of the *Pineta sylvestris* formation (30% of the area), aquatic, meadow, shrub vegetation, and grassy swamps. This National Nature Park is included in the list of sites subject to the Ramsar Convention, its aqua-territorial complexes constitute the main biotope value as

an environment for the conservation of wetland birds of international importance. The following dendrorarities are of great scientific importance in the dendroflora of the National Nature Park: *Arctostaphylos uva-ursi*, *Betula humilis*, *B. obscura*, *Chamaecytisus ratisbonensis*, *Chimaphila umbellata*, *Daphne cneorum*, *Linnaea borealis* L. (a glacial relict at the southern boundary of the habitat), *Salix lapponum*, *Salix myrtilloides*, *S. starkeana*. A significant share of the studied plant species of the national nature parks "Prypiat-Stokhid" and "Male Polissya" have the following common types of habitats: Holarctic, Eurasian, and European. They belong to the pluriregional, Holarctic, European geoelements of flora. Quite a significant number of them is habitat boundary species. These national nature parks have only two common types: *Daphne cneorum* and *Salix myrtilloides*.

The vegetation of the Shatskyi National Nature Park is dominated by forests of the *Pineta sylvestris* formation and wetlands. Swamp forests of *Alnetea glutinosae* and forest swamps are a characteristic element of landscapes. This National Nature Park is included in the list of sites subject to the Ramsar Convention, its aqua-territorial complexes constitute the main biotope value as an environment for the conservation of wetland birds of international importance. The rare components of the arboretum are *Arctostaphylos uva-ursi*, *Betula humilis*, *B. obscura*, *Chamaecytisus ratisbonensis*, *Chimaphila umbellata*, *Hedera helix*, *Juniperus communis*, *Oxycoccus microcarpus* Thunberg ex Rupr. (a pleistocene relict of a disjunct habitat at the southern boundary), *Salix lapponum*, *S. myrtilloides*, *S. starkeana*, *Viscum austriacum*. Most of the dendrorarities of the Shatskyi National Nature Park and the National Nature Park "Male Polissya" have the following common types of habitats: Holarctic, Euroasian, and European, as well as geoelements of flora: pluriregional, Boreal, Holarctic, and European. Quite a significant number of them is habitat boundary species. These national nature parks have only two common types: *Hedera helix*, *Salix myrtilloides*.

In general, among the national parks of mixed forests, *Salix myrtilloides* (found in four sites), *Betula humilis* (in three sites) and *Salix lapponum* (in three sites); *Daphne cneorum* (in two sites) and *Hedera helix* (in two sites), *Dianthus pseudosquarrosus* (in one site) have the highest levels of representation. All these dendrorarities have a predominantly European type of habitat and belong to the European and Boreal geoelements of flora.

In general, for national parks of both of the above-mentioned natural areas, the most representative is *Daphne cneorum* (occurs in eight sites out of 12).

Within the zone of deciduous forests, the National Nature Park "Male Polissya" does not have common species only with the Hotynskiy National Nature Park; in the zone of mixed forests, the National Nature Park "Male Polissya" does

not have common species with three national nature parks (Zalissia, Mezynskyi, Nobelskyi). In addition, the National Nature Park “Male Polissya” does not have common rare species of dendromorphic plants with nine, most similar as for vegetation cover, national nature parks of the forest-steppe zone of Ukraine. Also obvious is the lack of common species of dendrorarities of the National Nature Park “Male Polissya” with similar, as for the structure of vegetation cover, national nature parks “Kreminski Lisy” and “Sviati Hory” (Holy Mountains) in the steppe zone of Ukraine. For example, out of 30 rare species of woody plants of the predominantly forestal National Park “Sviati Hory” 95% of them are associated with the steppe, not forestal ecosystems.

The results of the general interzonal (between zones of deciduous and mixed forests) comparative assessment of types of habitats and geoelements of species of autochthonous rare dendroflora of nature reserves are important as an additional argument and factual addition to the above chorological analysis. The majority of such plant species are found in national nature parks (Popovych et al., 2019). The results of this comparative assessment showed that the protected autochthonous dendrorarities of both natural zones are mainly represented by the following types of habitats: European (25 species or 43.1% in deciduous forests; 41 species or 47.1% in mixed forests); Eurasian (respectively 10 species or 17.2%; 16 species or 18.4%). In both zones, the share (6.9% in each) of species of plants belonging to the holarctic type of habitat is quite significant. In addition, in the area of mixed forests, 8.6% are boreal-type dendrorarities.

A comparative assessment of the composition of geoelements of rare species of dendromorphic plants in the nature reserve fund of both natural zones showed that in the area of mixed forests they represent 24, and in the area of deciduous forests, 39 geoelements. In the area of mixed forests, most arboretums are of northern origin, in particular, six plant species (10.3%) belong to the boreal and five plant species (8.6%), to the panboreal geoelements of flora. A somewhat similar distribution is observed for the zone of deciduous forests, in which the largest share (11 species, 12.6%) are plant species that belong to the boreal geoelement of flora. Further, the rare fraction of dendroflora of the studied plant species of this natural zone is distributed as follows: nine species (10.3%) are classified as European nemoral, eight species (9.2%) as Central European nemoral, seven species (8.1%) as panboreal and five species (5.8%) as steppe geoelements. The remaining geoelements of both natural zones are represented by 1 to 3 species, the share of which does not exceed 5%. In general, in the nature reserve fund of the zone of deciduous forests, including Male Polissya, there is a significant number (18 of 39 species) of dendrorarities of northern boreal origin.

5. Conclusions

According to the degree of dendrofloral rarity, the National Nature Park “Male Polissya” is quite well related to the national nature parks of the deciduous forest zone. They have common dendrorarities, *Daphne cneorum*, *Hedera helix*, *Daphne mezereum*, which belong mainly to the European type of habitat, European and Holarctic geoelements of flora. Within the zone of deciduous forests in the region of Male Polissya, the significant similarity of the composition of rare species of woody plants between the national nature parks “Male Polissya” and Dermansko-Ostrozkyi can be explained by some similarity of phytocenotic vegetation structures and relatively close boundaries of their territories. The local protected dendroflora of these two national nature parks are also orographically connected by the Ostroh Urstromtal Passage.

In addition to the phytocenotic affinity of the vegetation cover, a rather high degree of similarity of the compositions of the species of rarity dendrodiversity can be observed between the national nature parks of the mixed forest zone and the National Nature Park “Male Polissya”. This is evidenced by the following plant species, common with mixed nature parks: *Salix myrtilloides*, *Daphne cneorum*, *Hedera helix*, *Dianthus pseudosquarrosus*. In terms of qualitative composition of dendrorarities, the National Nature Park “Male Polissya” is more related to the following national nature parks of the mixed forest zone: Hosiivskyi, “Desniansko-Starohutskyi” and Kivertsivskyi “Tsumanska Pushcha”. This level of phytocenotic and dendrofloral similarity is also provided by areas with a significant share of wetlands and close psammophytic edaphic conditions. This fact is additional proof for the similarity of the environments of formation of autochthonous local rare dendroflora of the National Nature Park “Male Polissya” and national nature parks of the mixed forests of Ukraine.

Thus, the results of chorological analysis and comparative assessment showed that the rare dendroflora of the National Nature Park “Male Polissya” is formed mainly by species of plants of northern origin, which belong mostly to the European type of habitat. In general, the most representative of the national nature parks of both natural zones is *Daphne cneorum*, which occurs in eight of the 12 studied national nature parks. Among the national nature parks of deciduous and mixed forest zones, the National Nature Park “Male Polissya” occupies an intermediate position in terms of the number (10) of rare species of dendromorphic plants. In general, its dendrorarity essence is ambiguous and characteristic of both natural areas. From the zone of mixed forests, its territory is penetrated by mainly boreal, and from the zone of deciduous forests, by nemoral geoelements of flora.

References

- Andriyenko T.L. & Onyschenko V.A. (ed.), 2008, Methodological aspects of the implementation of the international program "important botanical territories" in Ukraine. Aristey, Kyiv.
- Andriyenko T.L. & Perehrym M.M. (ed.), 2012, Official lists of regionally rare plants of administrative territories of Ukraine (reference edition). Alterpres, Kyiv.
- Andriyenko T.L. & Yuglichek L.S., 2016, Vegetation of the National Nature Park "Male Polissya". Scientific notes of Ternopil National Pedagogical University named after Volodymyr Hnatyuk, Series: Biology 2(66): 6–13.
- Andriyenko T.L., Pryadko O.I. & Yuglichek L.S., 2007, Flora and vegetation, [in:] T.L. Andriyenko (ed.) "Male Polissya" is a designed national nature park of Ukraine (Khmelnitsky region), p. 12–22. PP Moshinsky, Kamenets-Podilsky.
- Armenteras D., Gast F. & Villareal H., 2003, Andean forest fragmentation and the representativeness of protected natural areas in the eastern Andes, Colombia. *Biological Conservation* 113: 245–256. DOI: 10.1016 / S0006-3207 (02) 00359-2
- Bilz M., Kell S.P., Maxted N. & Lansdown R.V., 2011, European Red List of Vascular Plants. Publications Office of the European Union, Luxembourg.
- Claeys C., Herat A., Barthelemy C. & Deldreuve V., 2017, The Calanques National Park, between environmental effort and urban effort. *Journal of Urban Research* 16. <https://doi.org/10.4000/articulo.3252>. URL: <http://journals.openedition.org/articulo/3252>. <https://doi.org/10.4000/articulo.3252>
- Convention on the Conservation of European Wildlife and Natural Habitats, 1979. Bern.
- Debrynyuk Yu.M., 2003, Forest zoning of the Western Forest-Steppe of Ukraine. Kamula, Lviv.
- Didukh Ya.P. (ed.), 2009, Red Data Book of Ukraine. Plant Kingdom. Globalconsulting, Kyiv.
- Didukh Ya.P., Plyuta P.H., Protopopova V.V., Yermolenko V.M., Korotchenko I.A., Karkutsiev G.M. & Burda R.I., 2000. *Ecoflora Ukraine, Volume 1*. Ya.P. Didukh (ed.). Phytosociocentre, Kyiv.
- European Red List of Globally Threatened Animals and Plants, 1992, United Nations: European Economic Commission, New York.
- Hetman V.I., 2021, Landscape diversity and representativeness of the nature reserve fund of Ukraine, monograph. Talkom, Kyiv.
- Kleopov Yu.D., 1990, Analysis of the flora of deciduous forests of the European part of the USSR. Naukova Dumka, Kyiv.
- Konischuk V.V. & Egorova T.M., 2018, Agroecological zoning of Ukraine. *Agroecological Journal* 4: 6–22.
- Kostina N.V., 2013, Application of similarity and difference indices for regionalization of territories based on local floras. *Bulletin of the Samarko Scientific Center of the Russian Academy of Sciences* 15.3 (7): 2160–2168.
- Lieskovský Ju., Bezák P. & Izakovičová Z., 2010, Protection of representative landscape ecosystem of Slovakia – new landscape ecological approach. *Ecology and Environmental. International Multidisciplinary Scientific GeoConference SGEM 2010*: 1–7. DOI: 10.5593/sgem2010.14.20.S1.856
- Lukash O.O., 2009, Flora of vascular plants of Eastern Polissya: structure and dynamics. Phytosociocentre, Kyiv.
- Malyshev L.I., 1987, Modern approaches to quantitative analysis and comparison of floras, [in:] Theoretical and practical problems of comparative floristry: materials of the II Workshop on comparative floristry (Neringa, 1983). Science, Leningrad.
- Marinich A.M., Paschenko V.M. & Shischenko P.G., 1985, The Nature of the Ukrainian SSR. Landscapes and physical and geographical zoning. Naukova Dumka, Kiev.
- Marynych O.M., Parhomenko H.O., Petrenko O.M. & Shyschenko P.H., 2003, Improved scheme of physical and geographical zoning of Ukraine. *Ukrainian Geographical Journal* 41: 16–20.
- Meusel H., Jäger E. & Rauschert S., 1978, Vergleichende Chorologie der Zentraleuropäischen Flora. Fischer Verl.: Bd. 2, Jena.
- Meusel H., Jäger E. & Weinert E., 1965, Vergleichende Chorologie der Zentraleuropäischen Flora. Fischer Verl.: Bd. 1, Jena.
- Moysiyenko I.I., 2011, The Flora of the Pivnichne Prychornomia (Structural Analysis, Synantropization, Conservation): Dr. Sci. Diss. Abstract. Kyiv.
- Onyschenko V.A. & Andriyenko T.L. (ed.), 2012, Phytodiversity of reserves and national nature parks of Ukraine, [in:] National nature parks. Part 2. Phytosociocentre, Kyiv.
- Pokotylova K.G., 2018, Ecological and geographical analysis of dendroflora of artificial protected parks of Rivne region. *Ecological Sciences: scientific and practical journal* 4(23): 134–139.
- Popovych S. & Pokotylova K., 2020, Comparative analysis of regional parks dendrofloras of Ukraine in the zonal aspects. *AgroLife Scientific Journal* 9(1): 273–280.
- Popovych S.Yu., Savoskina A.M., Sherstyuk M.Yu., Mykhaylovych N.V. & Dzyba A.A., 2017a, The protected dendrososoflora of the Ukrainian Polissya: monography. S.Yu. Popovych (ed.), Kompyrnt, Kyiv.
- Popovych S.Yu., Savoskina A.M., Ustyenko P.M., Sherstyuk M.Yu. & Dzyba A.A., 2017b, The dendrosozological the

- catalogue of natural-reserved fund of the Ukrainian Polissya: monography. S.Yu. Popovych (ed.), Komprynt, Kyiv.
- Popovych S.Yu., Sherstyuk M.Yu., Pokotylova K.G., Mykhaylovych N.V. & Miskevych L.V., 2019., The protected dendrososoflora of the areas of deciduous forests of Ukraine: monography. S.Yu. Popovych (ed.), FOP Yamchinsky O.V., Kyiv.
- Popovych S.Yu., Stepanenko N.P., Ustymenko P.M., Diachenko Ya.M. & Korinko O.M., 2011, The dendrosozological catalogue of natural-reserved fund of the Forest-steppe of Ukraine: monography. S.Yu. Popovych (ed.), TOV Agrar Media Grup, Kyiv.
- Popovych S.Yu., Ustymenko P.M., Pokotylova K.G. & Miskevych L.V., 2020, The dendrosozological catalogue of natural-reserved fund of the broad-leaved forest zone of Ukraine: monography. S.Yu. Popovych (ed.), CP Komprint, Kyiv.
- Popovych S.Yu., Vlasenko A.S., Berehuta E.I., Diachenko Ya.M., Ustymenko P.M. & Stepanenko N.P., 2014. The dendrosozological catalogue of natural-reserved fund of the Steppe of Ukraine: monography. S.Yu. Popovych (ed.), CP Komprint, Kyiv.
- Powell G.V.N., Barborak J. & Rodriguez M., 2000, Assessing representativeness of protected natural areas in Costa Rica for conserving biodiversity: a preliminary gap analysis. *Biological Conservation* 93: 35–41. DOI: 10.1016 / S0006-3207 (99) 00115-9
- Schmidt V.M., 1980, Statistical methods in comparative floristics: monograph. Leningrad University Publishing House, Leningrad.
- Seregin A.P., 2003, Coefficients of similarity of local floras (on the example of grid mapping of the flora of the Meschera National Park, Vladimir region), [in:] Materials of the Moscow Center of the Russian Geographical Society. *Biogeography* 11: 39–48.
- Shelyag-Sosonko Yu.R. & Didukh Ya.P., 2003, Geobotanical zoning of Ukraine and adjacent territories. *Ukrainian Botanical Journal* 60(1): 6–11.
- Stepanenko N.P. & Popovych S.Yu., 2015, Reserved dendrosozoic exotics of the Forest-Steppe of Ukraine, monograph. CP Komprint, Kyiv.
- The IUCN Red List of Threatened Species Online, 2021, online version at: <http://www.iucnredlist.org/> [Accessed: 7 November 2021].
- The World Flora Online. An Online Flora of All Known Plants, 2021, online version at: <http://www.worldfloraonline.org/> [Accessed: 7 November 2021].
- Tran Thi Thanh Huong, Nguyen Dang Hoi, Trieu Van Hung & Dang Hung Cuong, 2021, Floristic Composition of Tree Diversity in Mixed Broad – Needle Leaf Forest Communities in Bidoup-Nuiba National Park, Lamdong Province, Vietnam. *Indian Journal of Ecology* 48(3): 702–708.
- Vlasenko A.S. & Popovych S.Yu., 2016, Reserved dendrosozoic exotics of the Steppe of Ukraine, monograph. CP Komprint, Kyiv.
- Walter K.S. & Gillett H.J. (ed.), 1998, IUCN Red List of Threatened Plants. Compiled by the World Conservation Monitoring Centre, 1997. IUCN – The World Conservation Union, Switzerland and Cambridge (UK).
- Yakubenko B.Ye., Popovych S.Yu., Hryhoryuk I.P. & Ustymenko P.M., 2015, Geobotany: an explanatory dictionary. Tutorial. Phytosociocentre, Kyiv.
- Yakubenko B.Ye., Popovych S.Yu., Ustymenko P.M., Dubyna D.V. & Churilov A.M., 2018, Geobotany: methodological aspects of research. Tutorial. Lira K, Kyiv.
- Yuglichek L.S., 2016, Phyto-priorities of the National Nature Park “Male Polissya”, [in:] Dynamics of biological and landscape diversity of protected areas, p. 104–107. Ruta, Kamianets-Podilskyi.
- Zemanek B. & Winnicki T., 1999, Rośliny naczyniowe Bieszczadzkiego Parku Narodowego [Vascular plants of the Bieszczady National Park]. *Monografie Bieszczadzkie, Tom III. Wydawnictwo Bieszczadzkiego Parku Narodowego, Ustrzyki Dolne.*