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ANALYSIS OF THE SPONTANEOUS FLORA OF THE TROSTIANETS DENDROLOGICAL PARK (CHERNIHIV OBLAST, UKRAINE)

Maryna Tarabun [1], ***Oleksandr Shynder*** [2], ***Vitaliy Kolomiychuk*** [3], ***Ihor Goncharenko*** [4]

[1] *Trostianets Dendrological Park of the NAS of Ukraine*
1 I. M. Skoropadskyi Avenue, 16742 Trostianets, Chernihiv Oblast, Ukraine

[2] *M. M. Gryshko National Botanical Garden of the NAS of Ukraine*
1 Sadovo-Botanichna St., 01014 Kyiv, Ukraine

[3] *O. V. Fomin Botanical Garden of the Taras Shevchenko National University of Kyiv*
1 Symon Petlura St., 01032 Kyiv, Ukraine

[4] *Institute of Evolutionary Ecology of the NAS of Ukraine*
37 Academic Lebediev St., 03143 Kyiv, Ukraine

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Background. Trostianets Dendrological Park of the National Academy of Sciences of Ukraine, founded in the nineteenth century in Chernihiv Oblast and now within Ichnianskyi National Nature Park, combines historic plantations with distinct forest-meadow sites. It provides a workable model for assessing how long-term introductions, climate change, and recreation pressure reshape spontaneous floras of the Left-Bank Forest-Steppe.

Materials and Methods. In 2022–2024, we inventoried all wild vascular plants. For each taxon, we noted native or alien status, geographical element (Kleopov, 1990), life form (Clements, 1920; Raunkiaer, 1934), vegetation class (EuroVegChecklist), and CSR strategy.

Results and Discussion. The inventory lists 423 species in 73 families, among which native plants (70.92 %) dominate. The geographical spectrum is dominated by widespread species (58.66 %), which are generally more anthropotolerant, while among zonal geoelements, species with “northern” (21.0 %) and “southern” (20.34 %) distribution types are nearly equally represented. Alien plants hail mainly from America (30.1 %) – almost all of them from North America – as well as from Asia and the

Mediterranean (24.4 % each). In the biomorphological structure, perennial herbs prevail among native plants (66.3%), while short-lived herbs dominate among alien plants (38.2 %). Native plants richness peaks in *Molinio-Arrhenatheretea*, *Carpino-Fagetea,* and *Trifolio-Geranietea*, while alien plants cluster in *Robinietea, Rhamno-Prunetea,* and *Sisymbrietea*. Violents dominate both fractions (47.8 % natives, 43.4 % aliens); ISR reveals only a slight excess of stress-tolerators among natives and ruderals among aliens, confirming strong anthropogenic pressure.

Conclusion. Trostianets Dendrological Park hosts a rich, anthropotolerant spontaneous flora that preserves a forest-steppe core while harbouring many naturalised introduced plants, mainly woody ergasiophygophytes (69.74 % among alien plants). Its balanced yet distorted geographical profile and near-equal stress-tolerant/ruderal ratios form a baseline for tracking vegetation change in historical parks and justify measures to curb further alien spread and maintain meadow–forest mosaics.

Keywords: alien plants, biodiversity, historical parks, inventory, naturalization

INTRODUCTION

Studying the current state of biodiversity in important nature conservation areas, as well as old parks (Kuzemko *et al*., 2011; Khodosovtsev *et al*., 2019; Doiko *et al*., 2021), is extremely important in view of the ongoing climate change, which causes irreversible changes in plant cover (Rakhmetov & Zaymenko, 2022; Didukh, 2023). Such studies not only reveal the scale and direction of floristic transformations but also make it possible to distinguish between natural successional processes and those driven by anthropogenic factors. In historical parks, where cultivated and spontaneous elements have long coexisted, the analysis of spontaneous flora provides valuable insights into how alien and native species interact, naturalize, and form stable plant communities under human influence.

One of the largest and most distinctive parks in Ukraine is Trostianets Dendrological Park of the National Academy of Sciences of Ukraine, founded in the 19th century by a landowner and a descendant of the Hetman lineage, I. M. Skoropadsky (Iljenko & Medvedev, 2009). Today, it is part of Ichnianskyi National Nature Park (Zhyhalenko & Andriyenko, 2012). This territory is therefore a unique object for studying the dynamics of spontaneous flora formation with the participation of a large number of naturalized alien plants. The importance of studying the spontaneous flora of Trostianets Dendrological Park is emphasized by the fact that two neophytes new to the flora of Ukraine were discovered here for the first time in a wild form, namely: *Ampelopsis aconitifolia* Bunge and *Clematis serratifolia* Rehder (von Raab-Straube, & Raus, 2024). The study of the structure of the spontaneous flora of this dendrological park will ensure establishing model indicators that characterize the plantations of the ancient park in the conditions of Left-Bank Ukraine.

MATERIALS AND METHODS

Trostianets (another spelling option – “Trostyanets”) Dendrological Park of the NAS of Ukraine is located in the village of Trostianets, Pryluky Raion, Chernihiv Oblast. The coordinates of its central entrance are 50.786272°N, 32.812757°E. The current area of the park is 204.7 ha. According to physical-geographical zoning (Marynych *et al*., 2003), this is the Left-Bank Forest-Steppe (forest-steppe zone of Eurasia). The aim of

this study was to conduct the first analysis of the geographical, biomorphological, and ecological structure of the spontaneous flora of Trostianets Dendrological Park. Field studies of the vegetation cover were conducted in 2022–2024 using route-expedition and semi-stationary methods.

Only wild-growing plants were considered, including ergasiophygophytes that have spread spontaneously beyond their initial cultivation sites (Naegeli & Thellung, 1905). Ergasiophytes that reproduce within cultivation areas, i.e., those that have not spread spontaneously to new habitats, are not considered here in detail. The native and alien fractions of vascular plants were analyzed separately. For geographical analysis, Yu. D. Kleopov's geoelement system (Kleopov, 1990) was used with slight modifications. For clarity, we grouped the geoelements of the local flora into three main categories: widely distributed (Eurasian, Holarctic, Multiregional and Palearctic), zonal geoelements of the "northern" group (species whose ranges are developed in the temperate and northern zones of the Palaearctic), and zonal geoelements of the "southern" group (species whose ranges are developed in the temperate and southern zones of the Palaearctic). Biomorphological analysis was based on the classification of biomorphs by F. E. Clements (1920) with modern updates (Kokhno, 2002) and the classical eco-biomorph system of C. Raunkiaer (1934). The structure of the adventitious fraction was analyzed considering the specificity of alien plants (Mosyakin & Yavorska, 2002; Protopopova & Shevera, 2012). The proportion of plant-based strategies was analyzed using Grime's system (1977). The ratio of stress-tolerant species to ruderal strategies was estimated as an indicator of successional stages using the formula: ISR = (S – R) / (S + R), where S is the number of stress-tolerators, and R is the number of ruderals (Goncharenko, 2017). The EuroVegChecklist was used as a basis for classifying species into vegetation classes (Mucina *et al*., 2016). Species of Trostianets Dendrological Park flora were assigned to phytosociological classes according to their diagnostic affiliation within the Braun-Blanquet approach. Diagnostic species lists for each Braun-Blanquet class were compiled using floristic data and reference syntaxonomic sources.

Statistical analysis was performed using the PAST v.5.2 software application (https://www.nhm.uio.no). To compare the frequencies of occurrence of species (ergasiophygophytes and xenophytes – **Tables 1** and **2**, alien and native – **Table 3**, local and alien – **Fig. 1**), the Pearson chi-squared consistency criterion was used.

RESULTS AND DISCUSSION

During the inventory, 423 species and subspecies of wild plants from 73 families were recorded in the dendrological park, including 300 native plants (70.92 %) and 123 alien plants (29.18 %). A checklist of wild plant species, as well as their systematic structure, problems of naturalization of ergasiophytes, and the spread of invasive plants will be discussed in separate articles. We have already reported on several important and interesting floristic finds in the park (von Raab-Straube & Raus, 2024).

The geographical structure of the native plants (**Fig. 1**) reflects the regional characteristics of spontaneous flora formation in the northern part of the Left-Bank Forest-Steppe. The spectrum of geoelements is somewhat distorted due to the absence of preserved natural vegetation in this territory. As a result, widely distributed species (58.66 %) dominate, including species of Eurasian (84 species), Holarctic (25), Multiregional (13) and Palearctic (54) geographical elements. The proportion of zonal

geoelements among native plants is lower. They can be divided into two nearly equal groups: zonal geoelements of the “northern” group (European (48), Boreal (11), and European-Siberian (4)) comprising 21.0 %, and zonal geoelements of the “southern” group (European-Mediterranean (50), Eurasian steppe (6), and Mediterranean (5)) accounting for 20.34 %. This indicates a balance in the formation of the natural core of the flora by different geoelements within the forest-steppe zone. However, it also highlights the fragmented nature of the flora, as zonal geoelements constitute less than half of the total spectrum. No endemic species were recorded among wild plants in the park territory. Such a geographical spectrum is characteristic of the forest-steppe zone, though with a reduced representation of geoelements in the overall structure.

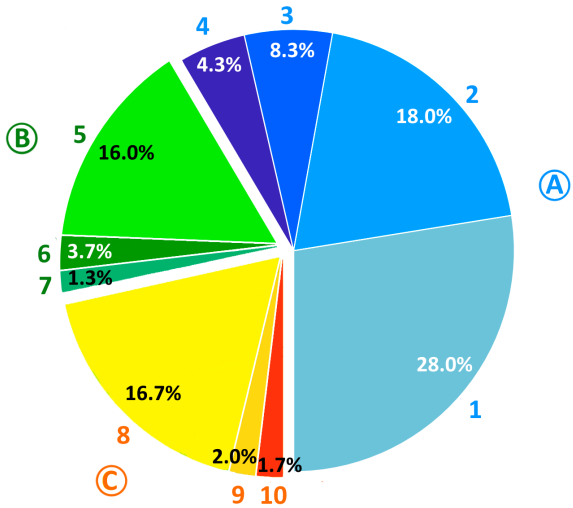

Fig. 1. Geographical structure of the native flora of Trostianets Dendrological Park: **A** – widely distributed geographical elements (1 – Eurasian, 2 – Palearctic, 3 – Holarctic, 4 – Multiregional); **B** – geographical elements of the “northern” group (5 – European, 6 – Boreal, 7 – European-Siberian); **C** – geographical elements of the “southern” group (8 – European-Mediterranean, 9 – Eurasian steppe, 10 – Mediterranean)

The distribution of alien taxa in the spontaneous flora of Trostianets Dendrological Park (**Table 1**) is similar to the studied floras of other parks and botanical gardens (Bomanowska *et al*., 2012; Doiko *et al*., 2021; Koniakin & Gubar, 2022; Shynder *et al*., 2022). This spectrum is polyregional and reflects the consequences of plant introductions from various parts of the world. Among the ergasiophygophytes, the largest number of species originate from American (mostly from North America), Asian, and Mediterranean regions, together comprising 78.96 %. Most of the woody plants that were planted in the dendrological park›s stands originate from these regions.

Among xenophytes, species from the southern regions of Eurasia (Asian and Mediterranean origins) are most represented, making up 76.60 %. This supports the existing theory that the primary group of alien plants prone to spontaneous expansion consists mostly of annual and short-lived species from the southern regions of Eurasia (Mediterranean, Irano-Turanian, and Eurasian Steppe), which actively spread northward (Protopopova, 1991). The Pearson consistency criterion when comparing the frequencies of ergasiophygophytes and xenophytes is Chi2: 25.89, $p = 0.00023 < 0.05$, which indicates statistical differences in the values of the frequencies of these species.

The biomorphological structure of the natural flora includes all life forms characteristic of the regional flora (**Table 2**). Woody biomorphs together constitute 15.33 %,

which is a relatively high figure and emphasizes the dominance of shrub-tree plantations in the park. Notably, in the neighboring regional flora of Eastern Polissia, which is characterized by high forest coverage, the share of woody biomorphs is only 12.02 % (Lukash, 2009).

Table 1. **Geographical structure of alien plants in the spontaneous flora of "Trostianets" Dendrological Park**

Origin	Total		Ergasiophygophytes		Xenophytes	
	Number of species	%	Number of species	%	Number of species	%
American	37	30.08	27	35.53	10	21.28
Mediterranean	30	24.39	12	15.79	18	38.30
Asian	30	24.39	20	26.32	10	21.28
Mediterranean-Asian	9	7.32	1	1.32	8	17.02
European	8	6.50	7	9.21	1	2.12
Anthropogenic	6	4.88	6	7.89	0	0
Eurasian	3	2.44	3	3.95	0	0
Total	123	100	76	100	47	100

Table 2. **Proportions of plant life forms in Trostianets Dendrological Park flora**

Life Forms	Native plants		Alien plants					
			Total		Ergasiophygophytes		Xenophytes	
	Number of species	%	Number of species	%	Number of species	%	Number of species	%
Trees	25	8.33	26	21.14	26	34.21	0	0
Shrubs	15	5.0	16	13.01	16	21.05	0	0
Subshrubs	5	1.68	1	0.81	1	1.32	0	0
Lianas	1	0.33	10	8.13	10	13.16	0	0
Perennials	199	66.33	23	18.70	17	22.37	6	12.77
Short-lived herbs	49	16.33	47	38.21	6	7.89	41	87.23
Aquatic	6	2.0	0	0	0	0	0	0
Total	300	100	123	100	76	100	47	100

Among alien plants, the distribution of life forms differs significantly, particularly in both immigration fractions. Among ergasiophygophytes, the proportion of woody plants is very high, reaching 69.74 %, which is characteristic of spontaneous floras of botanical gardens and dendrological parks (Havrylenko *et al*., 2008; Kuzemko *et al.*, 2011;

Shynder *et al*., 2022). Perennial naturalized escaped plants (especially woody) often become invasive in such areas and spread beyond their boundaries (Galera & Sudnik-Wojcikowska, 2010; Bomanowska *et al*., 2012; Nagodă *et al*., 2014; Burda & Koniakin, 2019). In Trostianets Dendrological Park, the primary objective was the cultivation of woody plants, which is why their proportion exceeds the known figures for spontaneous floras of other plant introduction centers. Meanwhile, among xenophytes, woody plants are entirely absent, with short-lived herbs predominating. This life form is represented by a significant part of synanthropic and adventive species in the flora of Ukraine (Protopopova, 1991). The Pearson consistency criterion when comparing the frequencies of ergasiophygophytes and xenophytes is Chi2: 82.048, p = 0.000001, which indicates statistical differences in the values of the frequencies of these species.

The spectrum of life forms based on Raunkiaer's classification (1934) follows similar trends (**Fig. 2**). The ratio of different life forms among local and alien plants was visualized using a bar chart. The chart was designed in the R environment (R Core Team, 2024) using the graphical package ggplot2 (Wickham, 2016). In the diagram, red columns indicate the proportions of local species, while blue columns represent alien species. This graphical representation clearly illustrates differences in the ecological structure of the flora between native and adventive components of Trostianets Dendrological Park. Hemicryptophytes constitute a significant portion of both flora fractions, with their share among native plants being dominant (52.1 %). The proportion of phanerophytes corresponds approximately to the share of trees and shrubs in the classical life-form structure (**Table 2**), with their share among alien plants exceeding one-third, which is typical of the flora of the park. Therophytes, as an expansive form, dominate among alien plants (26.3 %). Meanwhile, hydrophytes and parasitic plants are poorly represented and only present among native plants, which is related to the low diversity of biotopes.

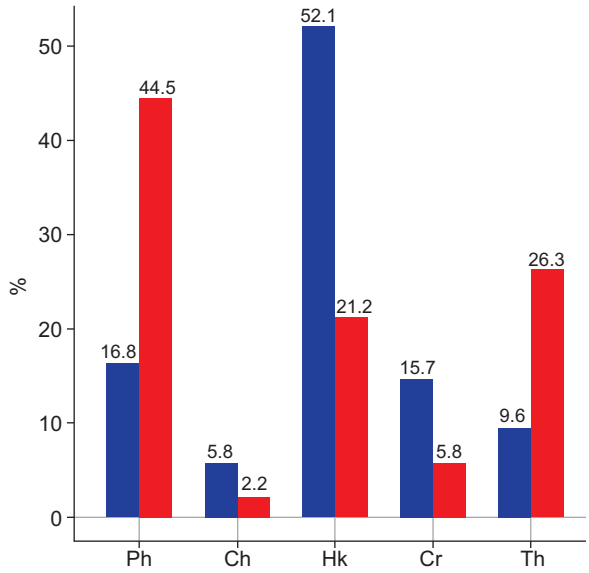

Fig. 2. The ratio of different life forms among local (red columns) and alien (blue columns) plants of the flora of Trostianets Dendrological Park. Designations: Ph – phanerophytes; Ch – chamaephytes; Hk – hemicryptophytes; Cr – cryptophytes; Th – therophytes

Table 3 shows the shares of diagnostic species of different classes of vegetation in the flora of Trostianets Dendrological Park. The vegetation classes are arranged in

decreasing order of the share of diagnostic species of different classes in the natural fraction of the flora. The diagnostic species of the first 15 classes of vegetation make up over 90 % of the flora, i.e. the above list well reflects the ecological and coenotic structure of the studied flora. The statistical estimate of the frequency distributions of alien and native species values between vegetation classes according to the Pearson criterion is Chi2: 160.02, p <0.000001. Thus, the frequencies of species occurrence between vegetation classes are significantly different for native and alien species.

Table 3. **Distribution of species of the spontaneous flora of Trostianets Dendrological Park among different vegetation classes**

Classes of vegetation	Number of species in class communities			%	
	Alien	Native	Total	Alien	Native
Molinio-Arrhenatheretea (Mol)	3	77	80	2.4	25.7
Carpino-Fagetea (Fag)	9	57	66	7.3	19.0
Trifolio-Geranietea (Ger)	1	44	45	0.8	14.7
Festuco-Brometea (Fes)	1	42	43	0.8	14.0
Artemisietea vulgaris (Art)	12	33	45	9.8	11.0
Epilobietea angustifolii (Epi)	11	32	43	8.9	10.7
Quercetea pubescentis (Pub)	2	25	27	1.6	8.3
Phragmito-Magnocaricetea (Phr)	3	20	23	2.4	6.7
Rhamno-Prunetea (Rha)	16	19	35	13.0	6.3
Alnetea glutinosae (Aln)	2	16	18	1.6	5.3
Robinietea (Rob)	24	10	34	19.5	3.3
Sedo-Scleranthetea (Sed)	3	8	11	2.4	2.7
Sisymbrietea (Sis)	15	7	22	12.2	2.3
Papaveretea rhoeadis (Par)	14	6	20	11.4	2.0
Digitario sanguinalis-Eragrostietea minoris (Dig)	4	1	5	3.3	0.3
Other	6	11	17	4.9	3.7
Total	123	300	423	100	100

The ecological-coenotic structure of the native and alien fractions of the dendrological park flora differs, indicating that these species occupy different ecological niches. Among the native plants, the highest species richness is observed in communities of the *Molinio-Arrhenatheretea, Carpino-Fagetea,* and *Trifolio-Geranietea* classes, which together account for nearly half (43.6 %) of the native species. This triad of vegetation classes is typical for these zonal-climatic conditions and reflects the predominant vegetation cover in this natural region.

At the same time, the ecological and coenotic structure of the adventive fraction of the studied spontaneous flora is different. Thus, the highest species richness of alien plants is noted in the groups of the first triad of classes – *Robinietea, Rhamno-Prunetea,* and *Sisymbrietea*, with species shares of 19.5, 13.0, and 12.2 %, respectively. In general, 43.7 % of alien plants are represented in this triad. At the same time, the first place of the classes *Robinietea, Rhamno-Prunetea* is quite logically explained by the significant degree of forestation of the dendrological park territory. At the same time, the class *Sisymbrietea* is formed mainly by synanthropic small-year plants on disturbed ruderal areas, mainly along roads and paths and in clearings.

In general, the main floristic diversity of Trostianets Dendrological Park is represented by species of natural vegetation classes (70.9 %), which is also consistent with the predominance of groups of these classes by the occupied areas in the park.

According to the results of the fractional analysis of the life strategy of spontaneous flora species, it was noted that violents are the basis of both flora fractions, and among alien species, there are even more of them (43.4 % native plants and 47.8 % alien plants). Stress-tolerants slightly predominate among native plants (32.0 % native plants and 24.2 % alien plants), and ruderals – among aliens (24.6 % native plants and 28.1 % alien plants), which is reflected in the ISR index (Goncharenko, 2017).

Stress-tolerant species are adapted to stable, quasi-stable, and climax communities, while ruderal species are adapted to serial, pioneer, and anthropogenically transformed communities (Goncharenko, 2017). Overall, the proportions of native and alien plants among stress-tolerators and ruderals in the flora of Trostianets Dendrological Park differ slightly. Native species form the core of quasi-natural meadow and forest communities, while ruderal strategy species occupy available ecological niches. However, the detected difference in trends is minor, as the anthropogenic pressure on the quasi-natural ecosystems of the park is relatively high. As a result, conditions are formed for the expansion of a significant number of anthropophytes, equalizing the proportions of natural and anthropogenic species despite the predominance of meadow and forest communities of natural origin.

CONCLUSION

The studied flora comprises 423 species and subspecies of wild plants, among which native plants (70.92 %) dominate. The main characteristics of the studied flora correspond to the parameters of the regional flora of the Left-Bank Forest-Steppe, though somewhat distorted. The geographical spectrum is dominated by widespread species (58.66 %), which are generally more anthropotolerant, while among zonal geoelements, species with “northern” (21.0 %) and “southern” (20.34 %) distribution types are nearly equally represented. Among alien plants, the majority are of American (30.08 %, mostly from North America), Asian, and Mediterranean (both 24.39 %) origin.

The biomorphological structure of the park›s natural flora is characterized by the predominance of perennials (66.33 %) and a relatively high proportion of woody plants (15.33 %). Among alien plants, the ergasiophygophyte group has a very high proportion of woody plants (69.74 %), while the xenophyte group is dominated by short-lived herbs (87.23 %). In the ecological-cenotic structure of the spontaneous flora, the highest saturation with local plants is observed in vegetation communities of the classes *Molinio-Arrhenatheretea*, *Carpino-Fagetea*, and *Trifolio-Geranietea*, reflecting the main typical

zonal nature of the park's vegetation cover – an alternation of forest and meadow communities. According to the life strategy analysis, violents dominate among both native and alien plants (47.8 % and 43.4 %, respectively), indicating strong anthropogenic pressure on the park›s vegetation cover and relatively equal conditions for the growth of both native anthropotolerant plants and alien species.

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COMPLIANCE WITH ETHICAL STANDARDS

The article was prepared in compliance with editorial ethical standards. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization, [O.S.; V.K.]; methodology, [O.S.; I.G.]; formal analysis, [O.S.; I.G.]; investigation and writing, [M.T.; O.S.; V.K.; I.G.].

All authors have read and agreed to the published version of the manuscript.

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АНАЛІЗ СПОНТАННОЇ ФЛОРИ ДЕРЖАВНОГО ДЕНДРОЛОГІЧНОГО ПАРКУ “ТРОСТЯНЕЦЬ” (ЧЕРНІГІВСЬКА ОБЛАСТЬ, УКРАЇНА)

***Марина Тарабун*[1], *Олександр Шиндер*[2], *Віталій Коломійчук*[3], *Ігор Гончаренко*[4]**

[1] *Державний дендрологічний парк “Тростянець” НАН України*
просп. І. М. Скоропадського, 1, сел. Тростянець, Чернігівська обл. 16742, Україна

[2] *Національний ботанічний сад імені М. М. Гришка НАН України*
вул. Садово-Ботанічна, 1, Київ 01014, Україна

[3] *Ботанічний сад імені О. В. Фоміна Київського національного університету імені Тараса Шевченка, вул. Симона Петлюри, 1, Київ 01032, Україна*

[4] *Інститут еволюційної екології НАН України*
вул. Академіка Лебедєва, 37, Київ 03143, Україна

Обґрунтування. Державний дендрологічний парк “Тростянець” НАН України заснований у XIX ст. в Чернігівській області та є частиною Ічнянського НПП. Нині історичні насадження в поєднанні із лучно-лісовими біотопами стали вдалою моделлю для оцінювання довготривалого впливу інтродукції рослин на формування спонтанної флори.

Матеріали та методи. Інвентаризацію таксономічного складу спонтанної флори проведено упродовж 2022–2024 рр. Для таксонів зазначено імміграційний статус, географічний елемент (за Клеоповим, 1990), життєву форму (Clements, 1920; Raunkiaer, 1934), клас рослинності (EuroVegChecklist) і CSR-стратегію.

Результати. Загалом виявлено 423 видів і підвидів дикорослих рослин із 73 родин, серед них переважають аборигенні (70,92 %). У географічному спектрі домінують широко розповсюджені види (58,66 %), які є більш антропотолерантними, тоді як серед видів із зональними типами ареалів "північні" (21,0 %) і "південні" (20,34 %) геоелементи представлені майже порівну. Серед адвентивних переважають види американського (30,1 %), азійського та середземноморського (по 24,4 %) походження. У біоморфологічній структурі серед місцевих рослин переважають багаторічні трави (66,3 %), а серед чужорідних рослин – малорічні трави (38,2 %). Найвище видове багатство аборигенних рослин спостерігається у класах *Molinio-Arrhenatheretea, Carpino-Fagetea* та *Trifolio-Geranietea*. У обох фракціях флори домінують віоленти (47,8 % серед аборигенних рослин, 43,4 % – серед адвентивних); оцінка за CSR виявляє лише незначну перевагу стрес-толерантів серед аборигенних видів і рудералів серед адвентивних, що підтверджує сильний антропогенний тиск.

Висновки. Дендропарк "Тростянець" вирізняється багатою, антропотолерантною спонтанною флорою, яка зберігає лісостепове ядро та водночас включає багато натуралізованих інтродуцентів, переважно деревних ергазіофігофітів. Її трохи викривлена природна географічна структура та майже рівні частки стрес-толерантів і рудералів є основою для відстеження змін рослинного покриву в історичних парках і обґрунтування заходів зі стримування адвентивних рослин у лучно-лісових екосистемах.

Ключові слова: адвентивні рослини, біорізноманіття, історичні парки, інвентаризація, натуралізація

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