The Species Composition of the Dendroflora in the Exposition Areas of "Nova Sofiyivka" Park

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The study aimed to determine the species composition of the "Nova Sofiyivka" park and assess the appropriateness of plant selection for creating thematic compositions. The analysis of 9 exhibition zones in the "Nova Sofiyivka" park revealed differences in the species composition across the various areas. The dendroflora of the Entrance Zone plot includes 13 taxa from 5 families. The composition of the Entrance Group plot consists of 9 taxa of woody plants, which belong to 5 families. The species diversity of woody plants in the Fountain Square plot includes 19 taxa from 10 families. The dendroflora of the Regular Garden plot includes 16 taxa from 12 families, the Fairytale Garden plot includes 14 taxa from 8 families, and the Japanese Garden plot includes 68 taxa from 12 families. To create the dendro-compositions in the Ukrainian Homestead plot, 7 taxa from 7 families are used, in the Dragon Garden plot, 7 taxa from 6 families, and in the Lake plot, 11 taxa from 4 families. The plant compositions on the territory of the "Nova Sofiyivka" park include 112 taxa of woody plants: 49 taxa of deciduous tree species, 47 taxa of deciduous shrubs, 8 taxa of coniferous tree species, and 8 taxa of coniferous shrubs. The research results can be used for planning ethno-compositions and creating recreational areas in urbanized environments.

Keywords: Species composition, Taxon; Taxonomic diversity; Urbanized environment; Woody plants.

Nature has a positive impact on many aspects of human health, from mental health to physical well-being (Methorst et al., 2021). The ecosystem services provided by urban trees depend on the size and density of their canopy, which are limited in cases of poor tree growth and vitality (Rahman et al., 2020; Rötzer et al., 2021).

Green spaces also have socio-economic significance; they create a "luxury effect", reflecting the community's status. Wealthier areas tend to have higher biodiversity levels than poorer ones (Lin et al., 2021; Anderson et al., 2023). This trend is more typical for street plantings, while in parks, it is less pronounced, as parks are usually designed with a greater variety of species and varieties (Padullés Cubino & Retana, 2023). Kiraz & Thompson (2023) highlight the positive impact on both physical and mental health and confirm the intensive use of green spaces in urban areas during the COVID-19 pandemic, when there were various restrictions on mass gatherings and movement.

Parks, gardens, and other green spaces directly impact subjective well-being, which is reflected in an individual's attitude towards themselves, their life, and relationships with others. This, in turn, contributes to life satisfaction as a whole or in specific areas and serves as a foundation for self-realization (Mashchak & Kuchvara, 2023). Zhao et al. (2024) assert that individuals who are more satisfied with green spaces generally have a higher level of subjective well-being, regardless of how frequently they use these spaces. Young et al. (2020) found that the biodiversity of green spaces has a positive impact on the recovery outcomes of green space users. In their view, the value of biodiversity fits into the psycho-evolutionary theory of stress recovery, which explains the reactions to contact with nature.

Green spaces satisfy the key conditions required for the restoration of attentional capacity, as stress recovery and attention restoration are supported by shared cognitive mechanisms (Shi et al., 2024). Bele & Chakradeo (2021) argue that the quantitative and

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qualitative assessment of public perception of urban biodiversity is important for evaluating the quality of life in cities. Urban biodiversity plays an important role in achieving the resilience of urban ecosystems (Jalkanen et al., 2020). The authors emphasize that in the process of urban biodiversity conservation, the perceptions, needs, and knowledge of the public are almost completely disregarded.

The understanding of biodiversity perception by non-professionals is limited, which can lead to a significant gap in the perception and value of green spaces. The difference in the perception of biodiversity between non-professionals and biologists, according to Breitschopf & Bråthen (2023), arises due to the lack of knowledge and low interest among non-specialists. They discovered that plant biodiversity is most favorably perceived when there are variations in species richness, meaning the vegetation cover is not uniform. The respondents' answers indicated that high plant biodiversity is valued more than low biodiversity. The authors note that botanical literacy is key to raising people's awareness of the issues surrounding the conservation of plant biodiversity. To increase botanical awareness, dendrological parks and botanical gardens are created, educational events are held, and the value of plants is highlighted in the media. Modern parks feature high biodiversity, with green plantings consisting of valuable decorative species and varieties, which helps to engage visitors in prolonged recreation.

The study aimed to determine the species composition of the "Nova Sofiyivka" park and assess the appropriateness of plant selection for creating thematic compositions.

Materials and Methods

The "Nova Sofiyivka" park is a separate part of the National Dendrological Park "Sofiyivka" of the National Academy of Sciences of Ukraine. It was opened to visitors in 2019 and covers an area of 10.7 hectares in the lower reaches of the Kam'yanka River (Figure 1).

The park is built in an eclectic style and consists of ten separate compositions, arranged along the riverbed and united into one complex through an alley and pathway network (Figure 2).

Figure 1: Location of the "Nova Sofiyivka" park

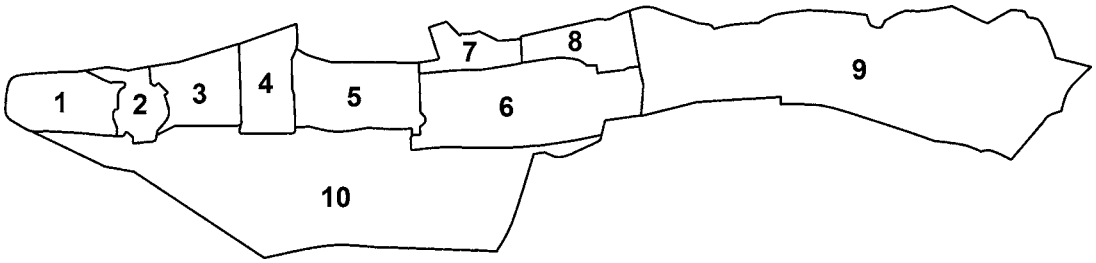

Figure 2: Layout of the exhibition areas of the "Nova Sofiyivka" park

(**Note**: 1-Entrance Zone; 2-Entrance Group; 3-Fountain Square; 4-Regular Garden; 5-Fairytale Garden; 6-Japanese Garden; 7-Ukrainian Homestead; 8-Dragon Garden; 9-Lake; 10-Buffer Zone)

The study of the species composition of the park was conducted during 2020-2021, and the scientific process consisted of the following stages: site selection, comprehensive survey of plantings, species identification, data recording, and final analysis. On the lake site, only woody plants and lawn grasses were used in the landscaping of the area.

The inventory control of the park's dendroflora was conducted in accordance with the guidelines outlined in the Inventory of Green Spaces in Settlements of Ukraine (Order of the State Committee for Construction, Architecture and Housing Policy of Ukraine No. 226 "On the Approval of the Instructions for the Inventory of Green Spaces for the Inventory of Green Spaces in Settlements of Ukraine", 2001).

Species identification was performed using a combination of biodiversity databases and taxonomic reference books. Preliminary identification was supported by iNaturalist (https://www.inaturalist.org) and GBIF (https://www.gbif.org). Taxonomic verification of woody species was performed using Hillier's Handbook of Trees and Shrubs (Hillier, 2002) and Dirr's Encyclopedia of Trees and Shrubs (Dirr, 2011). The plant names were determined using the acceptance documents for planting material and the POWO resource (2024), with the relevance of the names verified according to Word Flora Online (2024).

The study applied a descriptive method, which involved determining the taxonomic affiliation of the plants used in the creation of the park, a comparative method to identify the structure of the dendroflora, and analysis and synthesis methods to interpret the results and draw conclusions.

Results

The taxonomic diversity of the plant species used in the creation of garden and park landscapes is a means of expressing the artistic vision of the landscape architect and acts as a tool for enhancing the spatial and color composition of the landscape.

The Entrance Zone of the "Nova Sofiyivka" park channels the flow of visitors to the new landscape object. The planting consists of allochthonous species, predominantly ornamental-leaved and brightly flowering shrubs - 99.1% (Figure 3).

In quantitative terms, the highest percentage of plants used for landscaping the Entrance Zone is *Cotoneaster dammeri* C.K.Schneid. - 35.6%. In second place are spireas (*Spiraea* × *vanhouttei* (Briot) Zabel, *S.* × *cinerea* Zabel, *S. japonica* 'Anthony Waterer' and 'Goldflame') - 30.4%. The smallest number of plants was observed in the varieties of *Syringa vulgaris* L. - 0.3%. The trees *Quercus palustris* Münchh. and *Prunus serrulata* 'Kanzan', which grow in linear plantings along the walking path and parking lot, make up only 0.9% of the total number of woody plants.

The dendroflora of the Entrance Zone consists of 13 taxa, belonging to 5 families: *Rosaceae* Juss. (9), Caprifoliaceae Juss. (1), Cornaceae Bercht. ex J.Presl (1), Oleaceae Hoffmanns. & Link (1), Fagaceae Dumort. (1).

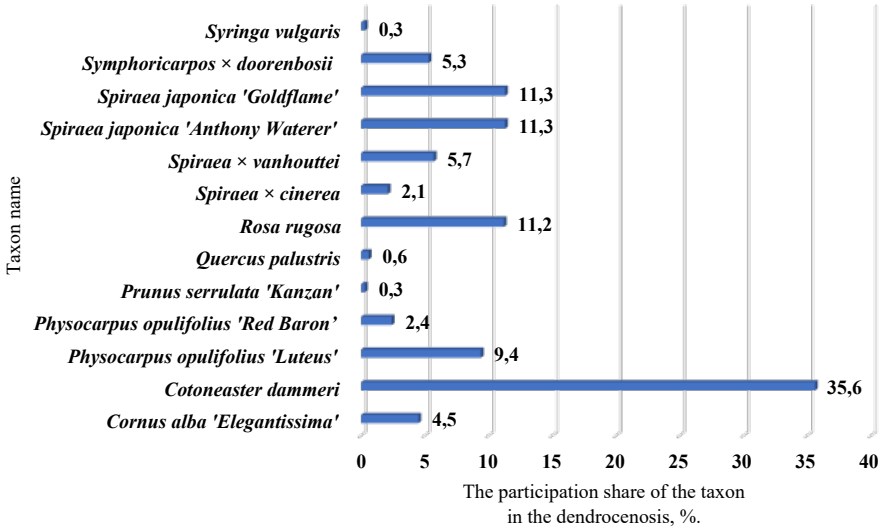

Figure 3: Species composition of the dendrocenosis in the Entrance Zone of the "Nova Sofiyivka" park

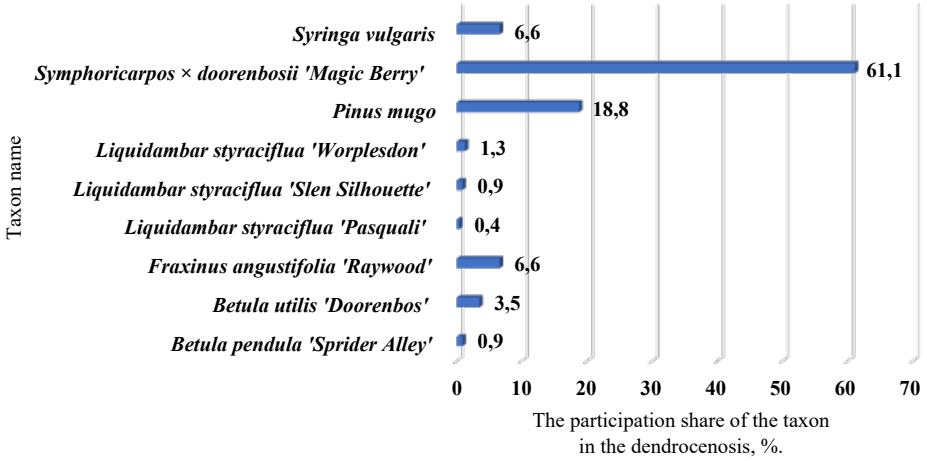

Figure 4: Species composition of the dendrocenosis in the Entrance Group of the "Nova Sofiyivka" park

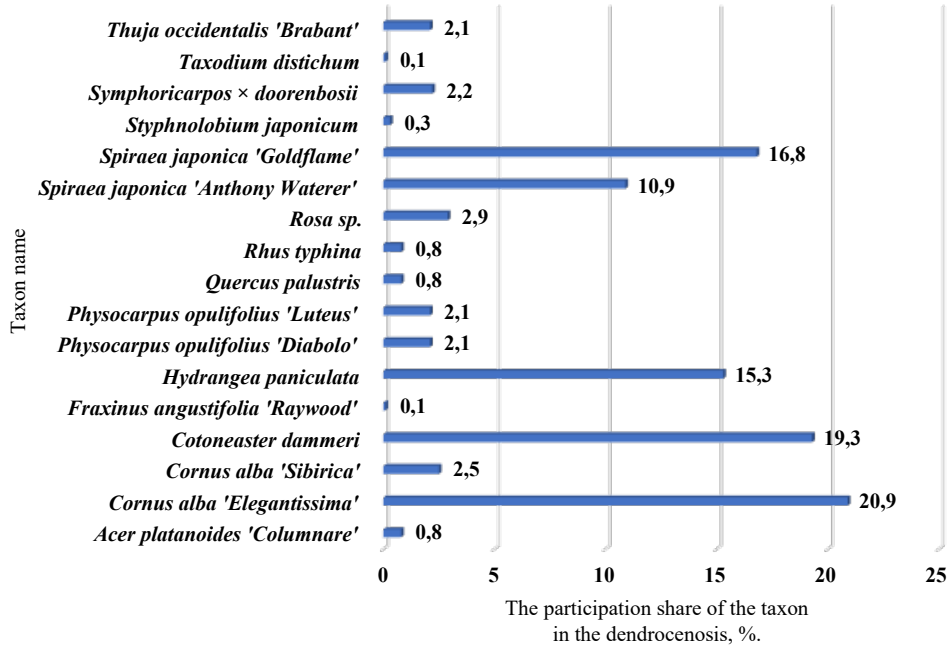

Figure 5: Species composition of the dendrocenosis in the Fountain Square of the "Nova Sofiyivka" park

The species structure of the dendrological component of the cultural phytocenosis of the Entrance Group (Figure 4) is represented by 9 tree species, with shrubs consisting of 3 taxa (86.5% of the total number of plants), and trees - 6 taxa (13.5%), belonging to 5 families: Caprifoliaceae (1), Oleaceae (2), Altingiaceae Horan. (3), Betulaceae Gray (2), Pinaceae Spreng. ex Rudolphi (1).

Among the shrubs, the largest number of plants was found in *Symphoricarpos × doorenbosii* 'Magic Berry' - 61.1%, while the smallest number was in *Syringa vulgaris* L. - 6.6%. The highest values among the trees are found in *Fraxinus angustifolia* 'Raywood' - 6.6%, while the lowest are in *Liquidambar styraciflua* 'Pasquali' - 0.4%.

The species diversity of the woody plants in the Fountain Square is represented by 19 taxa from 10 families: Cornaceae (2), Caprifoliaceae (1), Rosaceae (8), Hydrangeaceae Dumort. (1), Oleaceae (1), Sapindaceae Juss. (1), Fabaceae Juss. (1), Anacardiaceae R.Br. (1), Fagaceae (1), Cupressaceae Gray (2). The largest share of shrubs is held by *C. alba* 'Elegantissima' - 20.9%, while among the trees, three taxa - *A. platanoides* 'Columnare', *R. typhina*, and *Q. palustris* - each represent 0.8% (Figure 5).

For the landscaping of the Regular Garden area, 5 species of coniferous and 11 species of deciduous woody plants (Figure 6) from 12 families were used: Rosaceae (3), Hydrangeaceae (1), Cornaceae (1), Anacardiaceae (1), Fabaceae (1), Sapindaceae (1),

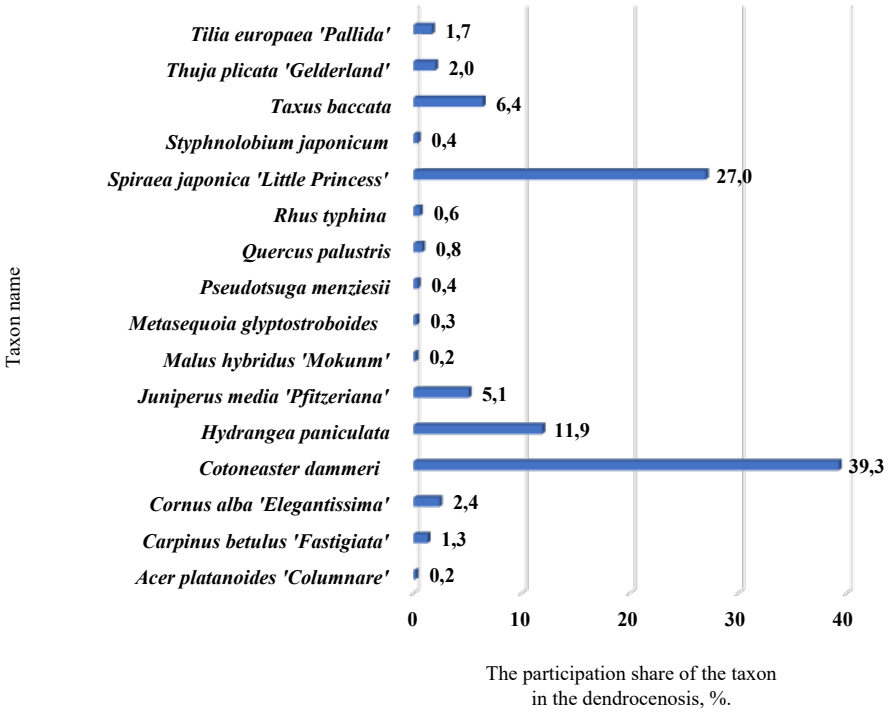

Figure 6: Species composition of the dendrocenosis in the Regular Garden of the "Nova Sofiyivka" park

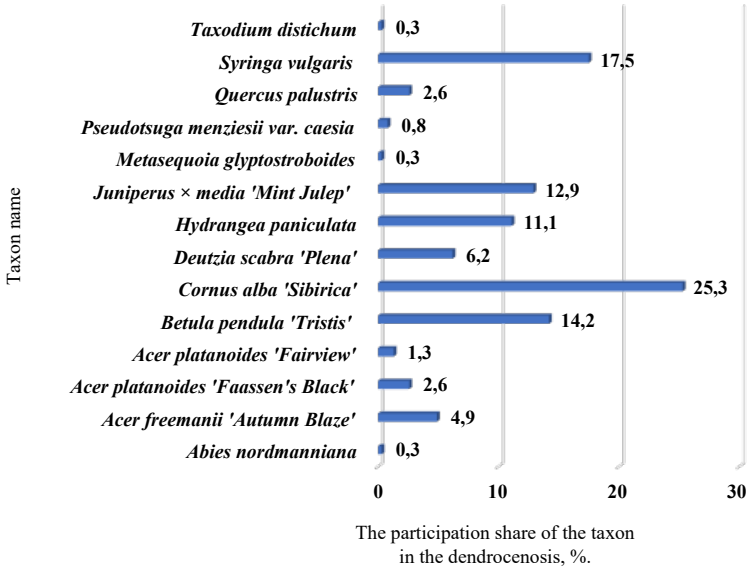

Figure 7: Species composition of the dendrocenosis in the Fairytale Garden of the "Nova Sofiyivka" park

Fagaceae (1), Betulaceae (1), Malvaceae Juss. (1), Cupressaceae (3), Taxaceae Gray (1), Pinaceae (1).

Coniferous plants make up 14.2% in terms of quantity, with the largest share of 6.4% belonging to *Taxus baccata* L. Deciduous plants dominate the area of the site, accounting for 85.8%, with the highest share of 39.3% belonging to *C. dammeri*. However, the highest aesthetic effect is achieved by the mass planting of *H. paniculata* varieties 'Bobo', 'Magical Candle', 'Confetti', and 'Candlelight', which make up 11.9% of the plantings.

The Fairytale Garden area is landscaped using group and solitary plantings. Coniferous plants are planted individually and in small groups, making up 14.6% of the planting, with 12.9% of them being *Juniperus* × *media* 'Mint Julep'.

Among the deciduous plants, trees make up 25.6%, with the largest share belonging to *Betula pendula* 'Tristis' at 14.2%. The share of shrubs constitutes 60.1%, with *C. alba* 'Sibirica' making up 25.3% (Figure 7).

To create the cultural phytocoenosis in the exhibition area of the Fairytale Garden, 5 taxa of coniferous plants and 9 taxa of deciduous woody plants were used, belonging to 8 families: Hydrangeaceae (2), Cornaceae (1), Oleaceae (1), Sapindaceae (3), Fagaceae (1), Betulaceae (1), Cupressaceae (3), Pinaceae (2).

The Japanese Garden area is characterized by the greatest taxonomic diversity. Conifers make up 40.1% of the total number of trees, with *Pinus sylvestris* L. being the dominant species at 18.8%. Among the deciduous trees, the largest proportion is held by *A. platanoides* 'Fairview' at 6.9%, while others range from 0.6% to 5.0%, depending on the species and cultivar (Figure 8).

The proportion of coniferous shrubs used in the Japanese Garden is 16.1%, with the highest percentage in *Pinus mugo* Turra at 5.6%, and the lowest in *Juniperus chinensis* 'Blue Alps' at 0.3% (Figure 9). Among the deciduous species, plants of

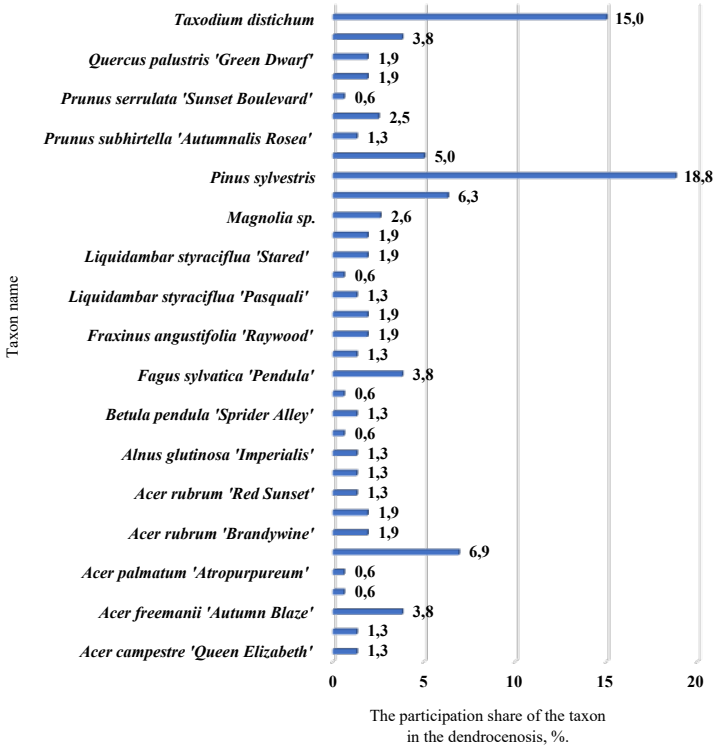

Figure 8: The species composition of the trees in the Japanese Garden of the "Nova Sofiyivka" park

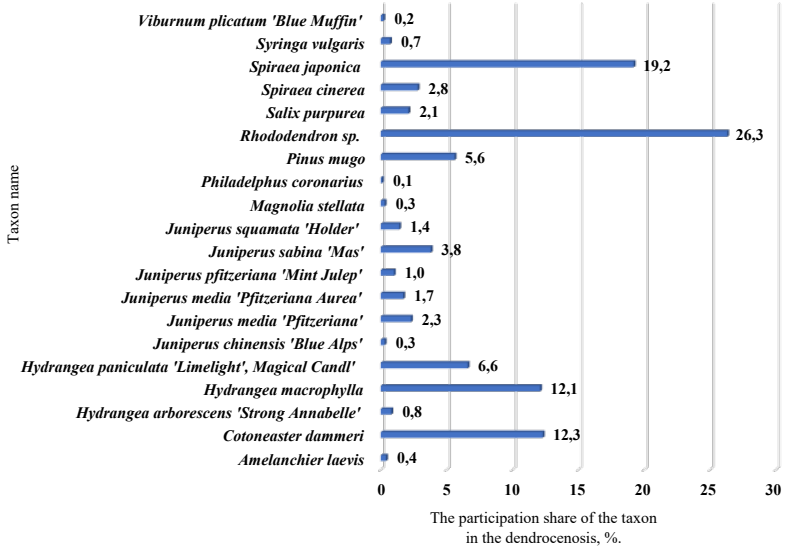

Figure 9: The species composition of the shrubs in the Japanese Garden of the "Nova Sofiyivka" park

the genus *Rhododendron* L. (*R. atlanticum* (Ashe) Rehd.; *R. viscosum* 'Lollipop'; *R. luteum* 'Jolie Madame'; *R. obtusum* 'Ìålina', 'Königstein', 'Hino Crimson', 'Pure White', 'Anuke'.) are quantitatively dominant, making up 26.3%, followed by cultivars of *S. japonica* L.f. at 19.2%. The lowest percentages are observed in *Viburnum plicatum* 'Blue Muffin' at 0.2% and *Philadelphus coronarius* L. at 0.1%.

The dendroflora composition of the Japanese Garden includes 68 taxa, belonging to 12 families: Altingiaceae Horan. (5 taxa), Betulaceae (4), Cupressaceae (7), Ericaceae Juss. (8), Fagaceae (3), Hydrangeaceae (5), Magnoliaceae Juss. (3), Oleaceae (7), Pinaceae (3), Rosaceae (11), Salicaceae Mirb. (2), Sapindaceae (10).

The dendrological composition of the Ukrainian Homestead site (Figure 10) comprises 3 species and 4 cultivars of woody plants belonging to 7 families: Cornaceae - 1, Celastraceae R.Br. - 1, Hydrangeaceae - 1, Viburnaceae Raf. - 1, Cupressaceae - 1, Salicaceae - 1, Rosaceae - 1. The share of trees is 2.8%, and shrubs make up 97.2%. The highest percentage is in *C. alba* 'Elegantissima' - 70.4%, and the lowest in *V. opulus* 'Roseum' - 0.9%.

The plant composition of the Dragon Garden consists of deciduous and coniferous plants belonging to 7 taxa from 6 families: Ericaceae - 1, Anacardiaceae - 1, Rosaceae - 2, Salicaceae -1, Cupressaceae - 1, Pinaceae - 1.

Coniferous trees, *P. nigra* J.F.Arnold, make up 2.4% of the total number of woody plants, coniferous shrubs, *J.* × *media* 'Mint Julep', account for 4.4%, among deciduous trees, *R. typhina* 'Dissecta' predominates with 2.0%, and among deciduous shrubs, *C. horizontalis* makes up 38.6% (Figure 11).

Among the vegetation on the Lake site (Figure 12), the dominant species are *B. utilis* and *B. pendula*, making up 43.1%.

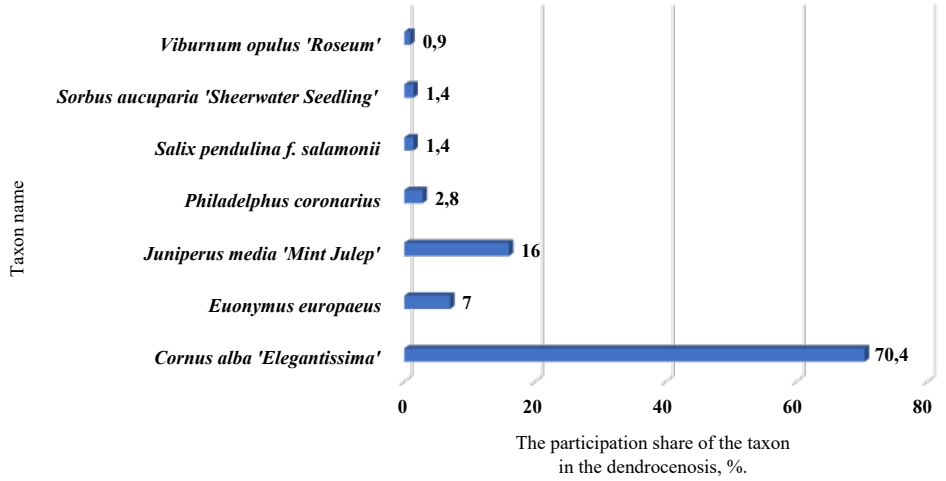

Figure 10: Species composition of the dendrocenosis in the Ukrainian Homestead of the "Nova Sofiyivka" park

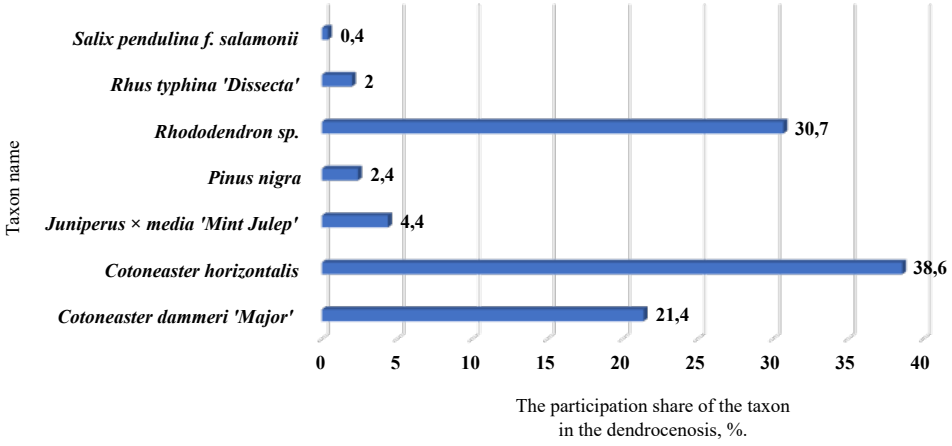

Figure 11: Species composition of the dendrocenosis in the Dragon Garden of the "Nova Sofiyivka" park

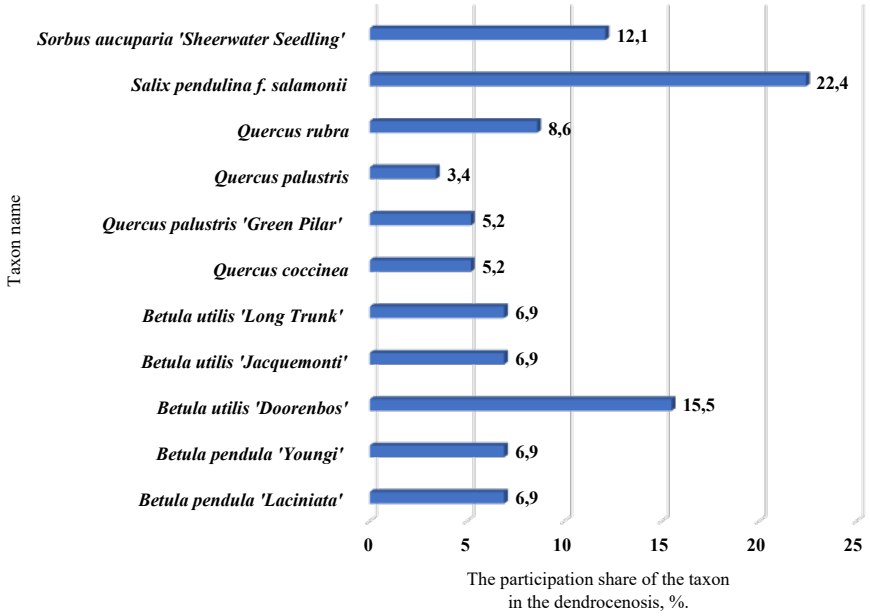

Figure 12: Species composition of the dendrocenosis in the Lake site of the "Nova Sofiyivka" park

The dendroflora of the exhibition area consists of 11 taxa belonging to 4 families: Betulaceae - 5, Fagaceae - 4, Rosaceae - 1, Salicaceae - 1.

Discussion

The entrance zones are one of the most important compositional nodes of the park. Bondar et al. (2021) indicate that these areas should be the first to be considered when preserving and implementing any reconstruction measures. The first two compositions of the "Nova Sofiyivka" park are united into a common entrance area, located outside the fence, serving as a transitional zone between the city and the park. Convenient automobile and pedestrian connections, according to Wu et al. (2023), are a priority aspect when designing a park, as they influence the overall experience and satisfaction of visitors with recreational activities in the park.

The design solution for the entrance area of the "Nova Sofiyivka" park is correct, as it fully meets the needs of visitors, efficiently distributing them across the territory and concentrating them near the entrance gates. The landscaping concept for the entrance area of the "Nova Sofiyivka" park is based on a grouped and linear arrangement of tree plants. Large arrays and groups of deciduous and flowering shrubs are seamlessly integrated with the main avenue of *Q. palustris*. Dzyba (2022) states that the most popular species for forming avenues are *Tilia cordata* Mill., *Tilia platyphyllos* Scop., *Carpinus betulus* L., *Fraxinus excelsior* L., *Aesculus hippocastanum* L., and *Picea abies* (L.) H.Karst. These species have proven to be the most promising and resilient in the conditions of street and park plantings.

The main element of the composition in the Fountain Square is four square-shaped fountains, which fully align with the theme of the exhibition area. The placement of the fountains near the park entrance helps create a pleasant atmosphere and provides an additional refreshing function (Ryndiuk & Ptashka, 2023), serves to mask the noise from the crowd of visitors (Lee & Lee, 2020), and contributes to improving the psychological well-being of the park-goers.

For landscaping the area near fountains, highly decorative plants are often used to enhance the aesthetic impression. In this regard, Kotovska & Omelianova (2021) suggest using various species and forms of *Juniperus* L., *Berberis thunbergii* 'Dart's Red Lady', *Picea abies* 'Little Gem', *Hydrangea paniculata* 'Grandiflora', and various ornamental flowering herbaceous plants for the fountain area landscaping project. In the landscaping project of the Fountain Square, the primary aesthetic impression is created by ornamental flowering shrubs, which make up about 46.0% of all the woody plants.

Regular gardens are highly valued by visitors, which is related to the peculiarities of human psychophysiology and the need for spatial organization, focusing attention on symmetrical and

asymmetrical elements of the composition, nuances, contrasts, rhythm, and establishing relationships between individual parts and the whole (Kosyk & Guzalenko, 2021). All of this is clearly reflected in the composition of the Regular Garden at the "Nova Sofiyivka" park, making the site compositionally cohesive and ideologically complete.

To create trimmed shapes and hedges, it is important to use plants that tolerate regular pruning well. Boiko et al. (2023) indicate that in the landscaping of the city of Kryvyi Rih (Ukraine), deciduous woody plants from the genera *Spiraea* L., *Berberis* L., *Symphoricarpos* Duhamel, *Philadelphus* L., *Swida* Opiz, *Forsythia* Vahl., *Laburnum* Medik, *Buxus sempervirens* L., and cultivars of the genera *Juniperus* L. and *Thuja* L. are successfully grown in hedges. Trimmed forms are the dominant feature of the composition in the Regular Garden. To create these forms, the park utilizes *C. alba* 'Elegantissima', *S. japonica* 'Little Princess', *C. betulus* 'Fastigiata', *T. europaea* 'Pallida', *T. plicata* 'Gelderland', and *T. baccata* L. Other woody plants are shaped in a landscape style, serving as a contrast in the composition.

The Fairytale Garden area is designed as a recreational zone for families with children. The plants used in the landscaping are non-toxic and do not have thorns that could harm health. Pysander et al. (2024) highlight that in the traditional design of children's playgrounds in parks in Sweden, the following species are commonly used: *Acer platanoides* L., *Quercus* spp., *Scandosorbus intermedia* (Ehrh.) Sennikov, *Aesculus hippocastanum* L., *Prunus* subg. *Prunus*, *Prunus* subg. *Cerasus*, *Malus domestica* (Suckow) Borkh., *Betula pendula* Roth, *Sorbus aucuparia* L., and *Syringa vulgaris* L. Chernonosova et al. (2022), when discussing the experience of creating recreational areas for children, emphasize the importance of making the play zone as close to nature as possible, with picturesque, curved, and uneven contours. This compositional approach was applied in the design of the Fairytale Garden area in the "Nova Sofiyivka" park.

The plant assortment typical for the Japanese and Chinese styles of Eastern landscape design, according to Zhu et al. (2022), consists of conifers, ornamental deciduous plants, and fruit plants with beautiful flowers. To create such gardens, plants like *Pinus* sp., *Juniperus* sp., *Thuja* sp., *Picea* sp., *Chamaecyparis* sp., *Acer* sp., *Rhododendron* sp., *Forsythia* Vahl, *Spiraea* L., *Chaenomeles* Lindl., *Philadelphus* L., *Hydrangea* sp., and others are commonly used. As for fruit species, these include varieties and cultivars of *Malus* Mill., *Pyrus* L., *Prunus* L., and *Amelanchier* Medik. The successful combination of coniferous plants with beautifully flowering deciduous plants allowed for the expression of the Eastern style in the themed area of the Japanese Garden in the "Nova Sofiyivka" park.

Traditionally, Ukrainian gardens featured *Pyrus* L., *Malus* Mill., *Prunus* L., *Rubus idaeus* L., *Ribes nigrum* L., *Ribes rubrum* L., *Ribes uva-crispa* L., and *Viburnum opulus* L. Along the road, there were mostly ornamental trees: *Robinia pseudoacacia* L., *Salix* L., *Fraxinus excelsior* L., *Populus* L., *Sambucus nigra* L., and others. Ornamental shrubs were represented by various *Rosa* L., *Syringa vulgaris* L., and *Philadelphus coronarius* L. (Gnatiuk & Mykhailyk, 2021).

The Dragon Garden can be considered an example of land art – a contemporary art form in which artists create installations and art objects directly in the natural environment. In the case of the Dragon Garden, elements of landscape design, sculptures, and plants are used to create a thematic space that harmoniously blends with the natural environment.

Land art projects are typically integrated into the landscape in such a way that the landscape itself becomes part of the artwork, and the Dragon Garden is an example of this approach, as it was created for the cultural and aesthetic enrichment of the natural environment. The idea prevails here over the traditional characteristics of the garden, and an important distinguishing feature of these gardens is the use of new technologies and materials (Ladygina, 2019). Plants in such installations complement inert compositions. For example, Mordatenko et al. (2019), studying the historical plantings of the Eastern ravine in the "Alexandria" park, point out the use of conifers (*Pinus sylvestris* L. and *Larix decidua* Mill.) for landscaping the Hetman Pavilion and the "Ruins" waterfall, which simulates a ruined ancient castle in the upper tier of the building. Coniferous plants have also been used in the dendrocenosis of the Dragon Garden to emphasize the monumentality of the landscape composition.

The plantings along the embankments perform ecological and aesthetic functions, create comfortable conditions for recreation, and prevent erosion processes. In turn, Ivanko et al. (2022) indicate that the dendroflora of the coastal protective strips in the northern steppe subzone of Ukraine is characterized by significant taxonomic diversity and includes 184

species (excluding their ornamental forms) from 37 families. The authors found that 45% of the species diversity of the dendroflora belongs to 4 main families: Rosaceae - 40 species, Salicaceae - 23 species, Fabaceae - 11 species, and Oleaceae - 9 species. The dendrocenosis of the Lake site includes 11 taxa, 5 of which belong to the Betulaceae family.

The analysis of species diversity in the "Nova Sofiyivka" park revealed that the range of ornamental plants allows for the creation of diverse landscape compositions and the recreation of gardens from different eras and ethnic styles. Visiting this park contributes to gaining aesthetic experience and psycho-emotional recovery for visitors.

Conclusions

The green infrastructure of the "Nova Sofiyivka" park exemplifies the adaptive use of taxonomic diversity in creating a multifunctional landscape. The park's spatial zones fulfill both aesthetic-compositional and recreational-psychological roles, contributing to a harmonious visitor experience and a balanced perception of the environment.

A well-considered integration of autochthonous and allochthonous species enhances the park's visual appeal while maintaining ecological stability. Native taxa identified include *Acer tataricum* L., *Euonymus europaeus* L. and *Salix purpurea* L. All others plantings are of allochthonous origin, with most taxa derived from artificial hybridogenesis. Among deciduous species, the most taxonomically diverse families are Rosaceae Juss. (21 taxa), Sapindaceae Juss. (12), Hydrangeaceae Dumort. (11), and Betulaceae Gray (10). Among conifers, Cupressaceae Gray dominates with 9 taxa.

Thematic areas and the dendroflora of the park clearly demonstrate the potential of landscape architecture as a tool for cultural interpretation of space. Through the integration of artistic heritage and conceptual synthesis-worthy of further academic attention and practical adoption.

Data availability

The raw data utilized in this study can be obtained on request from the corresponding author.

Conflict of interest

The authors have no conflicts of interest in this study.

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