Article Type: Research Article

J Name: Modern Phytomorphology

Short name: MP

ISSN: ISSN 2226-3063/eISSN 2227-9555

Year: 2026

Volume: 20

Page numbers: 638-642

DOI: 10.5281/zenodo.21888210
(10.5281/zenodo.2026-20-638-642)

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RESEARCH ARTICLE

Structural differentiation of the floristic core of herbaceous urban ecosystems in recreational areas of north-eastern Ukraine

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Received: 28.05.2026, Manuscript No. mp-26-189801 | **Editor Assigned:** 01.06.2026, Pre-QC No. mp-26-189801 (PQ) | **Reviewed:** 17.07.2026, QC No. mp-26-189801 (Q) | **Revised:** 24.07.2026, Manuscript No. mp-26-189801 (R) | **Accepted:** 05.08.2026 | **Published:** 10.08.2026

Abstract

The article deals with analysis of herbaceous flora of semi-natural meadow-type grasslands as an indicator of ecological plasticity and adaptive potential of urban ecosystems. In the recreational areas of Sumy, located within the north-eastern forest-steppe of Ukraine. The floristic core includes 97 vascular plant species from 73 botanical genera and 19 families. The taxonomic spectrum with a predominance of *Asteraceae, Poaceae*, and *Fabaceae* is combined with the dominance of perennial hemicryptophytes and the aboriginal fraction, which indicates the preservation of the meadow coenosophyte-forming basis of the grasslands.

At the same time, the participation of short-cycle monocarpic, ruderal, apophytic and adventive species reflects recreation-driven transformation of the vegetation cover. The assessment of relative ecological niche width showed that most species have intermediate ecological plasticity. The highest proportion of stenobiontic species was associated with aeration of soil, indicating the sensitivity of the floristic structure to substrate compaction and sward disturbance. The results emphasise the indicator value of structural floristic analysis for assessing the state of urban herbaceous communities and the provision of their ecosystem services.

Keywords: Flora, Herbaceous, Biodiversity, Urban ecosystems, Ecological scales, Anthropogenic impact, Ecosystem services

Introduction

Semi-natural herbaceous urban phytocoenoses occupy a specific position within the urban vegetation cover. They combine features of native meadow communities and anthropogenically transformed grasslands, formed by recreation, mowing, and changes in soil physical properties. Such communities can support local biodiversity, form open recreational spaces and provide a range of ecosystem services; however, the realization of these functions largely depends on ecologically sound management (Fekete, et al. 2024). Therefore, their floristic analysis should include not only an inventory of species composition, but assessment of the structural organization of the floristic core as an indicator of stability, transformation and the functional potential of urban ecosystems as well. European studies confirm that the management regime of urban grasslands substantially affects their species composition and spatial heterogeneity. Reducing mowing frequency in urban grasslands promotes rapid biodiversity increases and enhances of vegetation

heterogeneity (Sehrt, et al. 2020), whereas diversified management regimes may reduce the establishment of non-native species (Gros, et al. 2023). This is especially important for recreational areas, since their vegetation cover is formed under the combined influence management practices, trampling, local substrate exposure, and mosaic pattern of soil-ecological conditions. As a result, the floristic structure of such grasslands reflects not only the persistence of meadow species, but also the degree of recreation-driven transformation of the sward.

In Ukraine, as part of the eastern European urban landscape, herbaceous urban phytocoenoses in recreational areas often combine remnants of a semi-natural meadow component with signs of synanthropization and local invasion-driven transformation. A relevant comparative background is provided by studies of recreational zones in Kharkiv, where synanthropic flora and vegetation were analysed with regard to their taxonomic, biomorphological and ecological structure, and the invasive component was interpreted not only by the number of species, but by its role in transformed urban habitats as well (Kazarinova and Zviahintseva, 2021). A broader Ukrainian context is formed by modern studies on synanthropization of flora, phytoinvasions and urban floras, which emphasize the dynamic interaction between adventive and apophytic components in disturbed habitats (Shevera, et al. 2025).

For interpreting the ecological structure of such communities, the ecological scales of Didukh are of particular importance. They allow to move from the inventory of species composition to the quantitative characterization of ecological amplitudes of species according to the main edaphic and climatic factors (Didukh, 2011). In recent studies, the synphytoindication approach has been used to reveal the ecological differentiation of biotopes and plant communities, which is methodologically relevant for the analysis of mosaic urbanized grasslands (Didukh, et al. 2023). In combination with indicators of the width of the realized ecological niche, this approach allows us to assess not only the belonging of species to particular ecological groups, but also their ecological plasticity within a specific floristic complex (Skliar, 2014, Bondariev and Skliar, 2025).

Thus, the analysis of structural differentiation of the floristic core of herbaceous urban ecosystems should include the taxonomic, biomorphological, chorological and ecological structure of flora, as well as signs of its synanthropization, particularly the ratio between native and adventive fractions and the apophytization of the local floristic component. This approach makes it possible to consider the studied flora not merely as a list of species, but also as an indicator of the preservation of the meadow coenotic basis, the recreation-driven transformation of the sward, and the adaptive potential of communities under urban environmental conditions.

Materials and Methods

The study was conducted in recreational areas of Sumy city (Sumy region, Ukraine, north-eastern forest-steppe of Ukraine). The analysis focused on semi-natural meadow-type grasslands that have formed or persisted in the urban environment under recreational impact. These grasslands were considered anthropogenically formed but subsequently spontaneously transformed communities, whose species composition is maintained mainly by secondary successional processes rather than by targeted management.

Geobotanical surveys were carried out during the growing seasons of 2023-2025 according to generally accepted methods (Yakubenko, et al. 2018). Based on the vegetation descriptions, a floristic list was compiled in accordance with current taxonomic nomenclature (IPNI, 2025). Biomorphological, individual ecological, and biogeographical characteristics of species were determined using FloraVeg.EU (Database of European vegetation, habitats and flora) (Chytrý, et al. 2024). Life-form spectra were analysed according to the system of C. Raunkiær (Raunkiær, 1934). Arealological groups were determined according to the chorological scheme of H. Meusel and co-authors (Meusel, et al. 1965-1992).

The ecological structure of flora was assessed using the ecological scales of Didukh (Didukh, 2011, Didukh, et al. 2023). To characterize species ecological plasticity, the Relative Width of ecological Niche (RWN) was calculated following the approach of V. H. Skliar, with subsequent refinement (Skliar, 2014, Bondariev and Skliar, 2025), using the formula:

$RWN=[(Max-Min+1)/N_{grade}] \times 100\ \%$, where Max and Min are the maximum and minimum score values of the corresponding ecological factor for a species, and N_{grade} is the number of grades in the corresponding Didukh scale.

Results and Discussion

The floristic core of the studied recreational urban ecosystems comprised 97 species of herbaceous vascular plants. The studied habitats represent open urban grasslands with varying degrees of preservation of the meadow component and varying intensity of recreational transformation. The analysis was aimed at determining the taxonomic, biomorphological, ecological and synanthropic structure of the flora, as well as its indicator value for assessing the state of herbaceous urban phytocenoses.

The taxonomic structure of the floristic core was characterised by the concentration of a considerable proportion of species in several leading families. In total, 73 botanical genera belonging to 19 families were recorded. The highest species richness was found in *Asteraceae* (24.7%), *Poaceae* (21.6%) and *Fabaceae* (10.3%) families. This distribution reflects the combination of a cereal coenoforming meadow core, a legume component with a significant participation of forbs, a significant part of which is associated with open, disturbed or secondarily transformed urban habitats. The noticeable participation of *Brassicaceae, Polygonaceae, Plantaginaceae* and some *Amaranthaceae* species further indicates the presence of a ruderal-synanthropic component in the studied flora.

The biomorphological structure of the floristic core indicates the predominance of perennial herbaceous species capable of maintaining coenotic stability within urbanized grasslands (Tab. 1). The dominance of perennial hemicryptophytes is consistent with the participation of typical grass coenosis-formers and common co-dominants of semi-natural meadow phytocoenoses and lawn-type communities, including *Poa pratensis* L., *Festuca pratensis Huds.*, *Dactylis glomerata* L. and *Elymus repens* (L.) Gould. This spectrum indicates the preservation of the meadow basis of the floristic core even under recreational transformation.

Table 1. Biomorphological, ecological and chorological structure of the floristic core of semi-natural meadow-type grasslands in urban recreational areas.

Structural trait	Species group	Share, (%)
Life cycle duration	Perennials	71.1
	Annuals, biennials and annual-biennial forms	28.9
Raunkiær life forms	Hemicryptophytes	74.2
	Therophytes	18.6
	Cryptophytes	4.1
	Chamaephytes	3.1
Geographical range type	Eurasian	46.4
	Circumboreal	20.6
	European	16.5
	Euro-siberian	11.3
	American	5.2
Ecological groups by water regime	Mesophytes	49.0
	Xeromesophytes	26.0
	Hygromesophytes	9.4
	Xerophytes	9.4
	Hygrophytes	6.2
Ecological groups by soil trophicity	Megatrophs	45.5
	Mesotrophs	31.8
	Oligotrophs	22.7

Short-cycle monocarpic species formed a smaller, but indicator-relevant part of the species composition (28.9%). Their occurrence is associated with sward thinning, local exposure of the substrate, trampling and reduced competitive influence of perennial meadow species. Species such as *Capsella bursa-pastoris* (L.) Medik., *Descurainia sophia* (L.) Webb ex Prantl, *Polygonum aviculare* L. and *Poa annua* L. do not determine the overall biomorphological profile of the flora, but indicate the presence of disturbed patches within recreational areas. The chorological spectrum was characterized by the predominance of Eurasian, circumboreal and European species.

The classification of ecological groups by soil water regime shows that flora has a mesophytic-xeromesophytic character. The predominance of mesophytes and xeromesophytes corresponds to the conditions of urban grasslands, where moderately humid areas are combined with drier, compacted or partially degraded fragments. The participation of hygromesophytes and hygrophytes reflects the mosaic pattern of microrelief, especially near watercourses. The prevalence of megatrophs and mesotrophs indicates relatively high soil trophicity in a considerable proportion of the habitats, whereas the oligotrophic component is associated with poorer or more strongly degraded soil cover.

In the semi-natural grasslands of the recreational studied areas, synanthropization is expressed not only through the presence of adventive species but through the apophytization of the native component as well. Under trampling, mowing and sward thinning, some native meadow and ruderal-meadow species are retained in secondarily transformed urban habitats. This explains the predominance of the native fraction in the floristic core (87,8%), whereas adventive species accounted for only 12.2%. Thus, the studied urban phytocoenoses are not characterised by a high proportion of alien species, but their structure already reflects recreation-driven transformation of the sward. Although adventive species are not highly represented in the flora, they have indicator value, since species such as *Ambrosia artemisiifolia* L., *Asclepias syriaca* L., *Solidago canadensis* L., *Erigeron canadensis* L. and *E. annuus* (L.) Desf. are often associated with increased invasion risk due to their ability to form local patches with high projective cover in thinned and recreationally transformed fragments.

The ecological characterisation of the floristic core makes it possible to assess how far the species forming the studied urban phytocoenoses are able to survive under variable ecological conditions of an anthropogenically transformed environment. For this purpose, the relative width of ecological niche, RWN (Skliar, 2014, Bondariev and Skliar, 2025), was calculated for five ecological factors according to Didukh scales: Soil humidity, nitrogen content, aeration of soil, acidity and light in the community (Didukh, 2011) (Tab. 2).

Table 2. Relative width of species ecological niches within the floristic core by selected ecological factors

Ecological factor/Number of grades	Floristic range, scores (min-max)	RWN of the flora, %	Predominant species RWN class		Species share, %		
			RWN interval	Species share	Steno-biontic	Intermediate niche-width	Eury-biontic
Hd/23 Soil humidity	Feb-19	78.26	30-40%	38.14%	2.06	97.94	0.00
Nt/11 Nitrogen content	01-Nov	100.00	50-60%	42.27%	0.00	93.81	6.19
Ae/15 Aeration of soil	Mar-15	86.67	30-40%	50.52%	44.33	55.67	0.00
Rc/13 Acidity	Jan-13	100.00	30-40%	41.24%	2.06	93.82	4.12
Lc/9 Light in community	03-Sep	77.78	40-50%	60.42%	5.21	94.79	0.00

Note: Hd, Nt, Ae, Rc-calculated for 97 species, Lc-calculated for 96 species. Floristic range indicates the minimum and maximum score values recorded within the studied floristic core (Didukh, 2011). RWN: Relative Width of Niche (Skliar, 2014, Bondariev and Skliar, 2025).

The ecological characterization of the floristic core makes it possible to assess how far the species forming the studied urban phytocoenoses are able to persist under variable ecological conditions of an anthropogenically transformed environment. For this purpose, the Relative Width of Ecological Niche (RWN) was calculated for five ecological factors: Soil humidity, soil nitrogen content, aeration and acidity of soil, light in the community. Species with RWN<30% were regarded as stenobiontic, those with RWN>70% as eurybiontic, and values of 30-70% as intermediate niche width (Tab. 2).

For the selected ecological factors, the floristic core covered a considerable part of the corresponding scales. The widest range (100%) was observed for the entire floristic core for soil nitrogen content and soil acidity. This indicates the presence of floristic components associated with different trophic and acid-base soil conditions. For soil humidity and light in community, the scale coverage was also high, reaching 78.26% and 77.78%, respectively. At the same time, the majority of species, according to these factors, belonged to the group with an intermediate niche width. Thus, the floristic core was characterised not by the dominance of species with extreme ecological strategies, but by the prevalence of species with moderate ecological plasticity. Such species can persist on anthropogenically transformed substrates that are often mosaic in moisture and trophic conditions. The most contrasting structure was recorded in terms of soil aeration. Despite the high RWN of the floristic core for this factor (86.67%), the proportion of stenobiontic species reached 44.33%, clearly distinguishing it from the other analyzed ecological factors. This distribution may indicate increased sensitivity of a considerable part of the species composition to changes in the physical state of the soil, particularly compaction, sward disturbance and changes in the air regime of the substrate.

Overall, the analysis of relative niche width as an indicator of species ecological plasticity showed that the floristic component of the studied herbaceous urban ecosystems is formed mainly by species with intermediate niche width. This is consistent with the previous characterisation of the species composition, in which the coenosis-forming meadow basis is combined with species of disturbed habitats and a small but indicator-relevant adventive fraction. This structure indicates the preservation of the functional potential of the grass cover, but at the same time indicates its sensitivity to further recreational load, soil compaction, and the spread of invasion-active species.

Conclusion

The results indicate that the herbaceous flora of recreational urban ecosystems in the studied region retains a distinct meadow basis, which is manifested in the predominance of perennial hemicryptophytes, a significant participation of cereal coenosis-forming organisms, and the dominance of the aboriginal fraction.

At the same time, the taxonomic, biomorphological and ecological structure of the flora reflects recreation-driven transformation of the sward: The role of short-cycle monocarpic species, ruderal elements, apophytic native species and locally active adventive taxa increases. According to the relative niche width, most species are characterised by intermediate ecological plasticity, whereas the highest proportion of stenobiontic species was recorded for aeration of soil, indicating the importance of the physical state of the substrate in maintaining the floristic structure of these communities. The preservation of the meadow coenosis-forming basis, control of invasive species and regulation of recreational pressure are necessary not only for maintaining species composition, but also for supporting the ecosystem services of urban herbaceous communities, including soil-cover stabilisation, maintenance of local biodiversity and the recreational and aesthetic value of green areas.

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