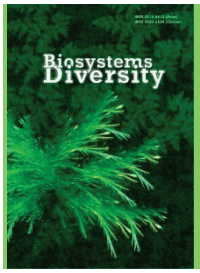

Biosystems Diversity

ISSN 2519-8513 (Print)
ISSN 2520-2529 (Online)
Biosyst. Divers.,
2023, 31(3), 319–326
doi: 10.15421/012337

Decorative perennials of the regional flora for recreation landscapes in the forest-steppe zone

R. K. Matyashuk, I. F. Pirko, L. M. Gubar, I. V. Tkachenko

Institute of Evolutionary Ecology of the National Academy of Sciences of Ukraine, Kyiv, Ukraine

Article info

Received 28.06.2023
Received in revised form 01.08.2023
Accepted 09.08.2023

Institute of Evolutionary Ecology of the National Academy of Sciences of Ukraine, Acad. Lebedev st., 37, Kyiv, 03143, Ukraine.
Tel: +38-095-204-38-95.
E-mail: ogubar@gmail.com

Matyashuk, R. K., Pirko, I. F., Gubar, L. M., & Tkachenko, I. V. (2023). Decorative perennials of the regional flora for recreation landscapes in the forest-steppe zone. Biosystems Diversity, 31(3), 319–326. doi:10.15421/012337

This work is devoted to the preservation of biodiversity and the prospects of its integration into projects for the improvement of recreational landscapes and greening facilities of modern cities. It is a continuation of the study of the bioecological potential of regional plant resources for landscaping recreational areas. To represent the existing plant diversity of the forest-steppe zone of Ukraine, a fund of species of decorative perennials was used. At this stage of the research, the decorative and bioecological characteristics of 147 herbaceous perennials of the spontaneous flora of the Feofania tract are given, which determine their economic value. The phenorhythmotypical composition, ecological and cenotic timing, colour spectrum and seasonal colour dynamics were considered. The phenorhythmotypical spectrum of this artificial population is shown, in which long-vegetating species predominate, ensuring the formation of compositions with a closed grass stand and a continuous and long-lasting decorative effect. Critical, from the point of view of competitive relationships, a group of species characterized by active dispersal is identified and options for their optimal use are presented. The ecological and cenotic diversity of the studied population, which is representative for the forest-steppe zone, is shown, which makes it possible to select the optimal multicomponent assortment for areas with different ecological conditions. The colour spectrum of the studied group and its dynamics during the growing season, which are comparable for geophilic and sciophilous species, are considered. A conceptual approach to the selection of promising species of regional flora for the creation of decorative locations in city parks is considered. In general, the expediency of using local plant resources as an optimal source of forming a basic assortment of decorative perennials for regional landscaping is shown on the example of the study of some aspects of the aesthetic and bioecological potential of decorative perennials of the spontaneous flora of the Feofania tract. We consider the integration of the existing biodiversity of the regional flora into the architectural environment an important practical component of biodiversity conservation.

Keywords: natural resources; phenorhythmotype; biomorph; ecological and coenotic groups; colour spectrum; colour dynamics.

Introduction

Green areas, and especially the objects of the Nature Reserve Fund of Ukraine, located in the territories of large urban agglomerations, have outstanding universal value as important centers of flora and fauna conservation, ensuring the stability of the functions of urbanized ecosystems (Kowarik et al., 2020; Kunakh et al., 2022). As a community of living organisms, city parks are certainly an ecological system (Yorkina et al., 2022). Parks provide a wide range of ecosystem services in the urban environment, are a key recreational resource, playing an important role in improving the environment and landscape conditions, as well as in disseminating information about the nature of the region (Lindemann-Matthies et al., 2010). Such territories are reserves of natural species and groups and, in addition to the utilitarian recreational function, they have a universal value as elements of "natural heritage" in conditions of anthropogenic transformation, contributing to environmental educational work (Pashkevich, 2020).

The integration of existing biodiversity into design projects for the formation of a new or improvement of the existing architectural environment is becoming more and more relevant when developing modern strategies for the development of cities. (Habitat, 2016; Opoku, 2019). There are examples of developing a conceptual approach to select target species for wildlife-friendly design, using a regional species pool as a starting point to generate a list of potential native species, taking into account distribution and local habitat characteristics (Apfelbeck et al., 2019). In addition to the importance of preserving the existing biodiversity, in particular plants, it expands the possibilities of using their aesthetic and bio-ecological potential. Spontaneous flora, as a source of evolutionarily adapted aboriginal and acclimatized adventive species, attracts the attention of many researchers who deal with issues of ecological design and landscaping (Kühn, 2006; Tredici, 2014; Bretzel et al., 2016; Marchenko, 2016). It is even considered expedient to use spontaneous vegetation as elements of greening the environment formed in the conditions of urboecosystems, referring to its naturalness and economy (Iuliana, 2011; Hitchmow, 2020). But the aesthetics of this kind of object, which depends primarily on the floral composition of their components, is ambiguously evaluated (Guo et al., 2018). Therefore, the most justified approach is the introduction into the regional assortment of ornamental plants of species of spontaneous flora, which, in addition to a high degree of adaptability, are distinguished by sufficient aesthetics, the formation from them of artificial plantations, both traditional and those that imitate natural phytocenoses, including spontaneous groups (Wilde et al., 2015; Pergl et al., 2016; Oleksiichenko, Gatalska, 2017). The most interesting group of plants in this regard are herbaceous perennials, the use of which allows one to create long-term, multi-component and colourfully saturated dynamic landscape compositions that are close to natural ones in their harmony. Artificial plantings with a high level of naturalness, along with minimally transformed natural landscapes, are the most in demand for modern megacities, in particular, to improve the visual quality of the landscapes of urban recreation areas (Oleksiychenko & Mavko, 2015; Vakulyk, 2018; Ponomaryova et al., 2021). Flower compositions created from perennials are a harmonious addition to recreational facilities of the park and forest park type, where they are indispensable in the formation of highly aesthetic elements of the near-term landscape, while their use is more long-term and less resource-intensive (Bessonova et al., 2022). The integration of representatives of regional flora into design compositions has an important educational, educational and ecological significance (Pirko, 2013).

The natural flora of the Kyiv agglomeration is a very valuable source for such use, as it represents more than 47% of the floral diversity of the

Forest Steppe of Ukraine. According to Yakubenko (2007), the flora of this part of Ukraine is represented by 1,382 species of flowering and higher spore plants, which belong to 549 genera and 134 families of higher spore, gymnosperms, and angiosperms. The natural flora of Kyiv is represented by 926 species belonging to 115 families, 400 genera and 5 divisions (Grechyshkina, 2010). The composition of the adventitious fraction of this territory includes 536 species belonging to 297 genera and 71 families (Yavorska & Mosyakin, 2001). The studied flora includes 650 species of vascular plants, from 337 genera and 94 families (Konyakin & Gubar, 2022). Its composition includes dozens of species of decorative herbaceous perennials, among which 13 are rare, which, due to their adaptive characteristics, can serve as a basic component of the regional assortment of flower and ornamental plants (Matiashuk et al., 2021). The purpose of this work is to substantiate the prospects of using this group of plants for greening recreational areas and other landscape objects in the conditions of the forest-steppe zone, considering their economic value, determined on the basis of the study of decorative and bioecological features.

Materials and methods

The vegetation research was carried out on the territory of the park-monument of landscape art of national importance Feofaniya (PMLANI Feofaniya), which is located on the southeastern outskirts of Kyiv at a distance of 15 km from the city center. The local climate is temperate continental, characterized by mild unstable winters. Springs are relatively dry; summers are warm with sufficient rainfall. According to the physical and geographical zonality, the local landscape Feofaniya is located in Vasylkiv-Kaharlyk landscape district of the Kyiv Upland landscape region, in the Forest-Steppe zone of Ukraine. The Feofaniya tract, with an area of 150 hectares, was declared an object of the Nature Reserve Fund of Ukraine in 1972. The Feofaniya tract within the park area is represented by natural hornbeam-oak forests (*Carpinetalia betuli* P. Fukarek, 1968) with a high density of ancient trees and secondary hornbeam forests. There are wetland areas and fragments of steppe meadows combined with artificial phytocenoses, the cascade of Feofaniya ponds, and numerous natural springs and streams (Konyakin & Gubar, 2022) (Fig. 1).

The research material is decorative herbaceous perennials of the spontaneous flora of the Feofaniya tract. The collected material was planted on the project site of 1800 m^2 in the park part of Feofaniya (Fig. 1). The botanical names and taxonomic status of the species are given according to the international online database of the world flora. The main phenorhythmotypes, given according to Borisova (1972), are interpreted as evolutionarily produced adaptive reactions of plant organisms to the dynamics of the main limiting environmental factors in the conditions of the seasonal climate.

Biomorphs of the studied species are given according to literature data (Raunkier, 1905; Ecoflora of Ukraine, 2000; Didukh, 2011). Ecocoenotic groups were understood as groups of plants that are similar in response to a set of environmental factors and confined to groups of a certain type (Nitsenko, 1969). When studying the colour and colour spectrum, the main tone of the flower (inflorescence) was taken into account, regardless of its saturation, brightness, purity and the presence of additional colours.

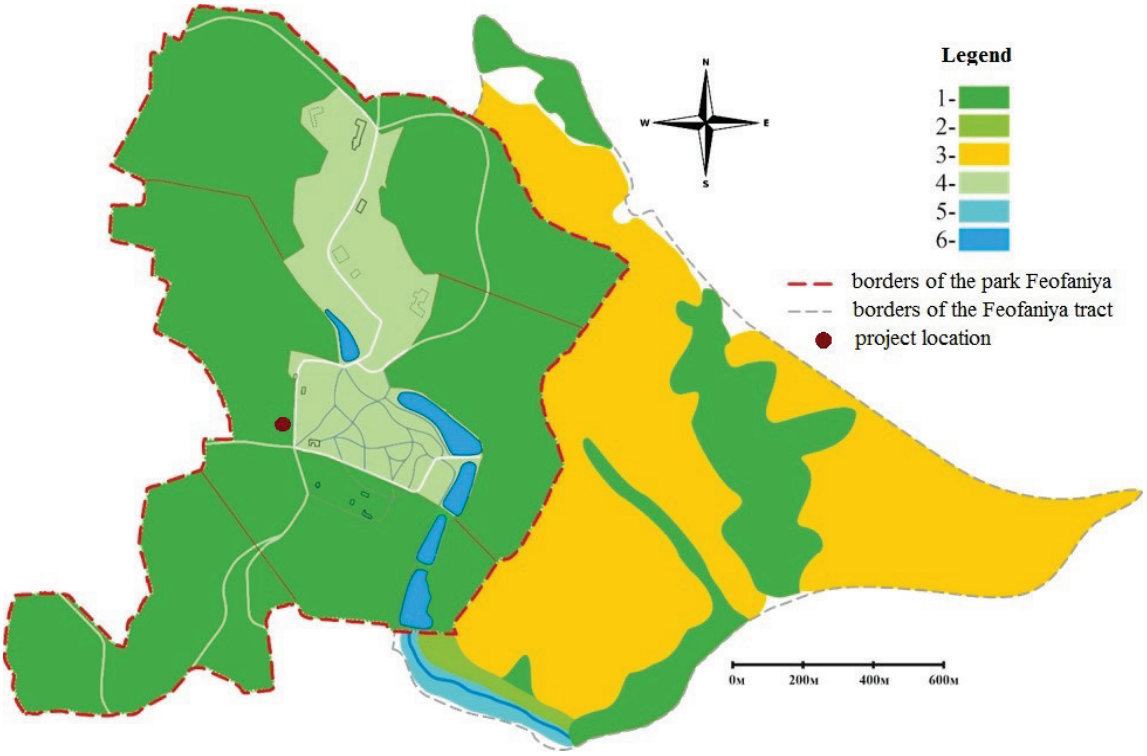

Fig. 1. Main biotopes of the Feofaniya tract and surrounding areas (Konyakin & Gubar, 2022): *1* – phanerophytic type biotopes (G); *2* – herb-gramineous, meso- and xerotic biotopes dominated by hemicryptophytes, generated in conditions of moderate or insufficient moisture (meadows, steppes) (E); *3* – biotopes generated by human economic activity (fallows) (I), *4* – the same, park and garden (I) biotopes; *5* – overwetted gramineous type biotopes, wetland and shoreline-aquatic vegetation (D); *6* – biotopes of continental water bodies (C); *7* – Feofaniya stream (Vita river basin)

Results

Among the decorative perennials of the spontaneous flora of the Feofaniya tract, 6 phenorhythmic groups are distinguished: ephemeroids (spring-green), hemiephemeroids (spring-early summer green), short-vegetating (spring-summer green), long-vegetating (spring-summer-autumn green, summer-winter green, evergreen). Most of the studied species are long-vegetating (112 species – 76%) (Table 1), which is due to the climatic conditions of the forest-steppe. Despite the diversity of the tract's biotopes, among the studied ornamental perennials, all ephemeral and most shortvegetation species are confined to forest ecotopes, which is related to their evolutionary formation in conditions of insufficient lighting.

Plant species with an ephemeral phenorhythmotype are very valuable, as they allow prolongation of the decorative period of landscaping objects for 2–3 months due to vegetation and flowering in the pre-spring and early spring stages (Fig. 1). In March–April, mass flowering is mainly provided by ephemeroids, despite their mostly short flowering period. Very promising for landscaping are *Anemone ranunculoides*, *Isopyrum thalictroides*, *Cardamine bulbifera*, *C. quinquefolia*.

Table 1
Biological features of decorative perennials determining their functional value

Family	Plant species	Phenorhythm type	The flowering stage	Plant height, cm	Flower colour	Coeno-morphs
Amaryllidaceae J.St.-Hil.	*Galanthus nivalis* L.	spring-green	I–IV	8–20	white	Sil
	Galanthus plicatus M. Bieb.	spring-green	I–IV	12–30	white	Sil
	Allium ursinum L.	spring-summer green	V–VI	10–40	white	Sil
	Allium angulosum L.	spring-summer green	VI	25–60	lilac	Pr
Apiaceae Lindl.	*Eryngium planum* L.	summer-winter green	VI–VII	30–80	light blue	St, Pr, Ru
	Sanicula europaea L.	summer-winter green	V–VII	40–80	white	Sil
Apocynaceae Juss.	*Vinca minor* L.	evergreen	V–VI	15–20	violet	Sil
Aristolochiáceae Juss.	*Asarum europaeum* L.	evergreen	IV–V	10–20	purple	Sil
Asparagaceae Juss.	*Polygonatum multiflorum* (L.) All.	spring-summer green	V–VI	30–60	white	Sil
	Polygonatum odoratum (Mill.) Druce	spring-summer green	V–VI	10–50	white	Sil
	Convallaria majalis L.	spring-summer green	V–VI	15–30	white	Sil
	Maianthemum bifolium (L.) Schmidt	spring-summer green	V–VII	12–25	white	Sil
	Scilla bifolia L.	spring-green	IV	10–15	light blue	Sil
Asteraceae Giseke	*Achillea millefolium* L.	summer-winter green	VI–VII	70–80	white	St, Pr, Ru
	Achillea nobilis L.	summer-winter green	VI–VIII	40–70	white	St
	Artemisia austriaca Jacq.	summer-winter green	LDP	20–70	yellow	St, Ru
	Artemisia pontica L.	summer-winter green	LDP	25–80	yellow	St
	Coreopsis auriculata L.	spring-summer-autumn greens	IV	10–30	yellow	St
	Eupatorium cannabinum L.	spring-summer-autumn greens	VI	75–200	lilac	Pr
	Solidago virgaurea L.	spring-summer-autumn greens	VII	60–100	yellow	Pr
	Tanacetum vulgare L.	spring-summer-autumn greens	VI	40–150	yellow	Pr
	Helichrysum arenarium (L.) Moench	summer-winter green	VI	30–40	yellow	St
	Inula helenium L.	summer-winter green	VII	100–180	yellow	Pr
	Pilosella officinarum Vaill.	summer-winter green	V–VIII	5–30	yellow	St
Athyriaceae Alston	*Athyrium filix-femina* (L.) Roth.	spring-summer green	LDP	30–150	–	Sil
Boraginaceae Juss.	*Pulmonaria obscura* Dumort.	spring-summer-autumn greens	V	10–30	blue	Sil
	Pulmonaria angustifolia L.	spring-summer-autumn greens	IV–V	20–30	blue	Sil, Pr, Ru
	Symphytum officinale L.	spring-summer-autumn greens	V–VI	75–100	violet	Sil
Brassicaceae Burnett	*Cardamine bulbifera* (L.) Crantz	spring-early summer greens	IV–V	30–70	pink	Sil
	Cardamine quinquefolia (M.Bieb.) Schmalh.	spring-early summer greens	IV–V	20–35	pink	Sil
Campanulaceae Juss.	*Campanula bononiensis* L.	spring-summer-autumn greens	VI–VII	50–120	violet	Pr
	Campanula glomerata L.	spring-summer-autumn greens	VI–VII	30–50	violet	Pr
	Campanula rapunculoides L.	spring-summer-autumn greens	VI–VII	80–130	violet	Pr
	Campanula persicifolia L.	spring-summer-autumn greens	V–VI	80–100	violet	Pr
Caryophyllaceae Juss.	*Saponaria officinalis* L.	spring-summer-autumn greens	VII–VIII	70–80	pink	Pr, Ru
	Stellaria holostea L.	summer-winter green	V–VI	15–35	white	Sil
	Silene viscaria (L.) Jess.	summer-winter green	V–VI	30–90	pink	Pr, St
Crassulaceae J.St.-Hil.	*Sedum maximum* (L.) Suter	spring-summer-autumn greens	VI–X	40–80	white	Sil
	Sedum telephium L.	spring-summer-autumn greens	VII–VIII	20–60	pink	Sil
	Sedum acre L.	evergreen	V	3–7	yellow	St
Cyperaceae Juss.	*Carex sylvatica* Huds.	summer-winter green	V–VII	30–100	green	Sil
	Carex digitata L.	summer-winter green	V–VI	10–50	brown	Sil
	Carex spicata Huds	spring-summer-autumn greens	V–VI	20–80	green	Sil
Cystopteridaceae Schmakov	*Cystopteris fragilis* (L.) Bernh.	spring-summer green	LDP	10–25	–	Sil
	Gymnocarpium dryopteris (L.) Newman	spring-summer green	LDP	30–40	–	Sil
Dryopteridaceae Herter	*Dryopteris carthusiana* (Vill.) Fuchs	spring-summer green	LDP	50–80	–	Sil
	Dryopteris austriaca (Jacq.) Woyn et al.	spring-summer green	LDP	30–150	–	Sil
	Dryopteris filix-mas (L.) Schott.	spring-summer green	LDP	50–100	–	Sil
Dennstaedtiaceae Lotsy	*Pteridium aquilinum* (L.) Kuhn	spring-summer green	LDP	60–155	–	Sil
Euphorbiaceae Juss.	*Euphorbia cyparissias* L.	spring-summer-autumn greens	V–VI	15–30	yellow	Sil, Pr,St, Ru
	Euphorbia seguieriana Neck.	spring-summer-autumn greens	V–VII	15–60	yellow	St
	Euphorbia semivillosa (Prokh.) Krylov	spring-summer-autumn greens	V–VI	45–120	yellow	St
Fabaceae Lindl.	*Lupinus polyphyllus* Lindl.	spring-summer green	V–VI	70–150	violet	Pr, Ru
	Lathyrus niger (L.) Bernh.	spring-summer green	VI–VII	30–80	lilac	Sil
	Lathyrus tuberosus L.	spring-summer green	VI–VII	30–80	pink	Sil, Pr
	Lathyrus vernus (L.) Bernh.	spring-early summer greens	IV–V	30–40	purple	Sil
	Lotus corniculatus L.	spring-summer-autumn greens	V– X	30–40	yellow	Pr
	Medicago falcata L.	spring-summer-autumn greens	VI–VII	40–80	yellow	Pr, St
	Medicago sativa L.	spring-summer-autumn greens	VI –VIII	80–150	violet	Pr
	Onobrychis viciifolia Scop.	spring-summer-autumn greens	V–VI	15–50	pink	St
	Securigera varia (L.) Lassen	spring-summer-autumn greens	VI–VIII	30–100	pink	Pr
	Trifolium alpestre L.	spring-summer green	VI–VII	15–20	pink	Pr
	Trifolium medium L.	spring-summer green	V–VI	20-80	lilac	Pr
Fumariaceae Bercht. & J. Presl	*Corydalis cava* (L.) Schweigg. et Koerte.	spring-green	IV–V	15–35	lilac	Sil
	Corydalis intermedia (L.) Merat	spring-green	IV–V	5–20	pink	Sil
	Corydalis solida (L.) Clairv.	spring-green	IV	10–20	lilac	Sil
Geraniaceae Juss.	*Geranium pratense* L.	spring-summer-autumn greens	VI–VIII	40–100	lilac	Pr
	Geranium palustre L.	spring-summer-autumn greens	VI–IX	30–70	pink	Pr, Pol
	Geranium sanguineum L.	spring-summer-autumn greens	VI–VII	20–50	lilac	Pr
Iridaceae Juss.	*Iris pseudacorus* L.	spring-summer green	V–VI	50–100	yellow	Pol
	Crocus heuffelianus Herb.	spring-green	III–IV	10–20	violet	Sil, Pr
Lamiaceae Martinov	*Ajuga reptans* L.	summer-winter green	V–VI	15–20	blue	Sil
	Ajuga genevensis L.	summer-winter green	V–VII	5–40	blue	Sil, Ru
	Salvia pratensis L.	spring-summer-autumn greens	VI–VIII	30–70	violet	Pr
	Salvia verticillata L.	spring-summer-autumn greens	VI-IX	60–70	violet	Pr, Ru
	Stachys officinalis (L.) Trevis	spring-summer-autumn greens	VII–VIII	30–60	lilac	Sil, Pr

Family	Plant species	Phenorhythm type	The flowering stage	Plant height, cm	Flower colour	Coeno-morphs
	Lamium galeobdolon (L.) L.	summer-winter green	V	10–20	yellow	Sil
	Lamium maculatum L.	spring-summer-autumn greens	V–VII	20–60	lilac	Sil
	Melissa officinalis L.	spring-summer-autumn greens	VIII-IX	70-80	lilac	Sil, Pr, Ru
	Glechoma hederaceae L.	summer-winter green	V	3-10	lilac	Sil
	Mentha × *piperita* L.	spring-summer-autumn greens	VI-IX	30–100	violet	Ru, cultigen
	Nepeta cataria L.	summer-winter green	VI–VII	40–100	white	Sil, Pr, Ru
	Prunella vulgaris L.	spring-summer-autumn greens	VII-IX	5–30	violet	Sil, Pr, Ru
	Phlomoides tuberosa (L.) Moench	spring-summer-autumn greens	V–VIII	40–150	lilac	Pr, St
	Teucrium chamaedrys L.	summer-winter green	VII–VIII	10–100	pink	Sil
	Thymus pulegioides ssp. *pannonicus* (All.) Kerguelen	evergreen	VI–VIII	12–40	pink	St, Sil
	Thymus serpyllum L.	evergreen	VI–VII	5-10	lilac	St
	Origanum vulgare L.	spring-summer-autumn greens	VI–VII	50–70	pink	Pr
Liliaceae Juss.	*Gagea lutea* (L.) Ker Gawl.	spring-green	III–IV	15–20	yellow	Sil
	Gagea minima (L.) Ker Gawl.	spring-green	IV–V	7–20	yellow	Sil
	Lilium martagon L.	spring-summer green	VI–VII	50–150	purple	Sil
Lythraceae J. St.-Hill.	*Lythrum salicaria* L.	spring-summer-autumn greens	VII–VIII	80–140	lilac	Pr
Malvaceae Juss.	*Althaea officinalis* L.	spring-summer-autumn greens	VI–VIII	60–200	pink	Pr, St
	Lavatera thuringiaca L.	spring-summer-autumn greens	VI-IX	50–125	pink	Pr
Melanthiaceae Batsch ex Borkh.	*Paris quadrifolia* L.	spring-summer green	VI–VIII	20–45	black	Sil
Onagraceae Juss.	*Epilobium angustifolium* L.	spring-summer-autumn greens	VII–VIII	50–180	pink	Sil
Orchidaceae Juss.	*Cephalanthera longifolia* (L.) Fritsch	spring-summer green	V–VII	15–60	white	Sil
	Neottia nidus-avis (L.) Rich.	spring-summer green	V–VII	20–45	brown	Sil
Plantaginaceae Juss.	*Veronica austriaca* L.	spring-summer-autumn greens	V–VII	30–70	blue	Sil
	Veronica chamaedrys L.	summer-winter green	VI–VII	10–50	light blue	Sil, Pr, St
	Veronica officinalis L.	summer-winter green	V–VI	15-30	lilac	Sil
	Veronica longifolia L.	summer-winter green	VII–VIII	40–120	blue	Pr, Pol
	Veronica prostrata L.	summer-winter green	VI	5–30	blue	Pr, St
	Linaria vulgaris Mill.	summer-winter green	VII–VIII	30–60	yellow	Pr, St
Poaceae Barnhart	*Agropyron cristatum* (L.) Gaertn.	spring-summer-autumn greens	VI–VIII	20–70	green	St
	Agrostis stolonifera L.	summer-winter green	VI–VIII	15–40	green	Pr, Pol
	Alopecurus pratensis L.	spring-summer-autumn greens	VI	50–120	green	Pr
	Brachypodium sylvaticum (Huds.) P. Beauv.	spring-summer-autumn greens	VII–VIII	30–125	green	Sil, Pr
	Calamagrostis epigejos (L.) Roth	spring-summer-autumn greens	VI–VIII	80–150	green	Sil
	Dactylis glomerata L.	summer-winter green	VI–VII	35–150	green	Pr, Ru
	Deschampsia caespitosa (L.) P. Beauv.	summer-winter green	VI	30–120	green	Sil, Pr
	Festuca valesiaca Schleich. ex Gaudin	summer-winter green	V–VI	10–50	green	St
	Koeleria pyramidata (Lam.) P.Beauv.	summer-winter green	VI–VII	30–90	green	Sil, Pr, St
	Melica nutans L.	spring-summer-autumn greens	V–VI	20–60	violet	Sil
	Milium effusum L.	summer-winter green	V–VII	70–150	green	Sil
	Molinia caerulea (L.) Moench	spring-summer-autumn greens	VII–IX	40–120	violet	Sil, Pr, Pol
Polemoniaceae Juss.	*Phlox paniculata* L.	spring-summer-autumn greens	VII–VIII	70–150	lilac	Ru, cultigen
Polygonaceae Juss.	*Persicaria amphibia* (L.) Delarbre.	spring-summer-autumn greens	VI–IX	50–150	pink	Pr, Pol, Aq
Primulaceae Batsch ex Borkh.	*Lysimachia nummularia* L.	summer-winter green	VI	7–10	yellow	Sil, Pr, Pol
	Lysimachia punctata L.	spring-summer-autumn greens	VI–VII	50–60	yellow	Pr
	Lysimachia vulgaris L.	spring-summer-autumn greens	VI–VIII	50–100	yellow	Pr, Pol
	Primula veris L.	summer-winter green	IV–V	5–30	yellow	Sil
Ranunculaceae Juss.	*Anemone ranunculoides* L.	spring-green	IV–V	30	yellow	Sil
	Actaea spicata L.	spring-summer green	V–VI	50–70	white	Sil
	Clematis recta L.	spring-summer-autumn greens	VI–VIII	100–150	white	Sil, Pr
	Ficaria verna Huds.	spring-early summer greens	IV–V	10–30	yellow	Sil
	Isopyrum thalictroides L.	spring-green	IV–V	20-40	white	Sil
	Ranunculus acris L.	spring-summer-autumn greens	VI	20–50	yellow	Pr
	Ranunculus auricomus L.	spring-summer-autumn greens	IV–VI	20–40	yellow	Pr
	Ranunculus illyricus L.	spring-summer-autumn greens	IV–VI	20–50	yellow	St
	Ranunculus repens L.	spring-summer-autumn greens	VI	10–20	yellow	Pr
	Thalictrum minus L.	spring-summer-autumn greens	VI–VII	30–40	green	Sil
Rosaceae Juss.	*Filipendula vulgaris* Moench	spring-summer-autumn greens	VI	80-100	white	Pr
	Fragaria vesca L.	summer-winter green	V–VI	5–30	white	Sil
	Fragaria viridis Duchesne	summer-winter green	V–VII	5–20	white	Sil
	Geum rivale L.	summer-winter green	V–VII	25–75	purple	Pr
	Potentilla anserina L.	spring-summer-autumn greens	V–IX	10–20	yellow	Pr, Ru
	Potentilla incana P.Gaertn. et al.	spring-summer-autumn greens	V	5–10	yellow	Pr
	Potentilla erecta (L.) Raeusch.	summer-winter green	V–IX	15–50	yellow	Pr
Rubiaceae Juss.	*Galium odoratum* (L.) Scop.	summer-winter green	IV–VI	10-60	white	Sil
Saxifragaceae Juss.	*Chrysosplenium alternifolium* L.	spring-summer green	IV–VI	5–15	yellow	Sil, Pr, St
Scrophulariaceae Juss.	*Verbascum nigrum* L.	spring-summer-autumn greens	VI–VII	50–120	yellow	Pr
Violaceae Batsch	*Viola hirta* L.	spring-early summer greens	IV–V	5–10	violet	Sil
	Viola mirabilis L.	spring-summer-autumn greens	IV–V	6–40	violet	Sil
	Viola suavis M. Bieb.	spring-summer green	III–IV	10–25	light blue	Sil
	Viola odorata L.	spring-summer-autumn greens	IV–V	10-15	violet	Sil
	Viola reichenbachiana Jord. ex Boreau	spring-summer-autumn greens	V	15–35	violet	Sil

Note: Sil – sylvant, Pr – pratant, St – stepant, Pol – polydant, Aq – aquant, Ru – ruderal; LDP – leafy decorative plants.

In general, the use of leafy decorative species in perennial flower beds allows one to maintain a decorative effect in periods when the number of flowering species is minimal. Prolongation of the decorative effect in the second half of summer and phenological autumn is provided by long-vegetating species (Fig. 2), which have a late flowering period (Table 1). Evergreen plants also have a certain importance in prolonging the vegetation and decorative effect in the early spring and late autumn periods, but only in combination with summer-winter green species, or in monoculture. In the conditions of broad-leaved forests, which include the oak-hornbeam and oak formations of the Feofania tract, many species from

other rhythmological groups are adapted to early flowering in the period from snowmelt to the beginning of bud development in the oak (the edificator of these ecosystems, Fig. 2). Usually, favourable lighting conditions in the thickets last until the end of May. Therefore, the majority of herbaceous perennials of forest phytocenoses finish completely, or begin their generative development precisely in this period and finish in June, for example: *Galium odoratum*, *Chrysosplenium alternifolium*, *Lysimachia nummularia*, *Veronica officinalis*, or at the latest in July – *Thalictrum minus*, *Cephalanthera longifolia*, *Lilium martagon*, etc. Such a feature of the grass cover of forest phytocenoses – a bright burst and gradual fading of flowering, as well as the complete dying of ephemeroids and hemiephemeroids by mid-summer, makes it necessary to form a significant part of the assortment from deciduous or habitually decorative plants (ferns, sedges, grasses, etc.).

Of the individual habitual features of the studied decorative perennials, only the typical height of plants and the spectrum of life forms were considered. Undoubtedly, more important is the spatial and structural organization of the shoot system of plants, which determines the appearance, and therefore the decorativeness of the plant as a whole. But the habit of plants is determined by a number of characteristics of shoot types: growth, branching of the main structural units, features of articulation and spatial arrangement of modules of different ranks, etc., therefore, the description and systematization of habitual (biomorphological) characteristics is a complex multifactorial task, which ultimately does not facilitate the visualization of the described objects and their classification according to this feature. By height, we grouped the studied species into five groups (Fig. 3). It is natural that species with a short vegetation period (spring-green, spring-early summer-green), as well as wintergreen, adapted to overwintering under snow cover, are mostly low-growing plants (Fig. 3). Among long-vegetating species, there is a wide spectrum in height, including tall plants ($61 \leq h \leq 100$ cm) and very tall (100 cm < h). At the same time, tall plants prevail both within their phenorhythmotypes (spring-summer-autumn green, summer-winter green) and within the population as a whole.

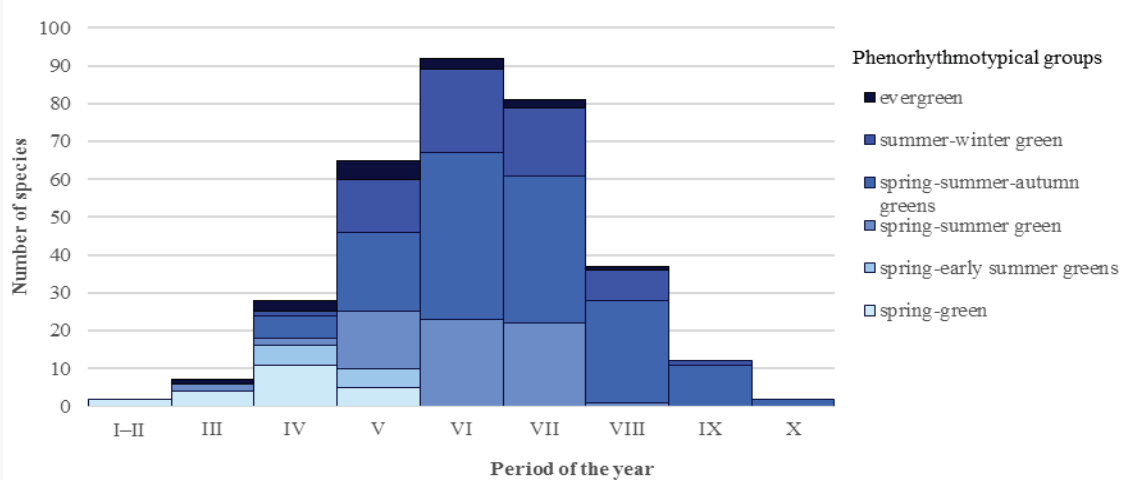

Fig. 2. Dynamics of the number of flowering species of decorative perennials by phenorhythmotypical groups

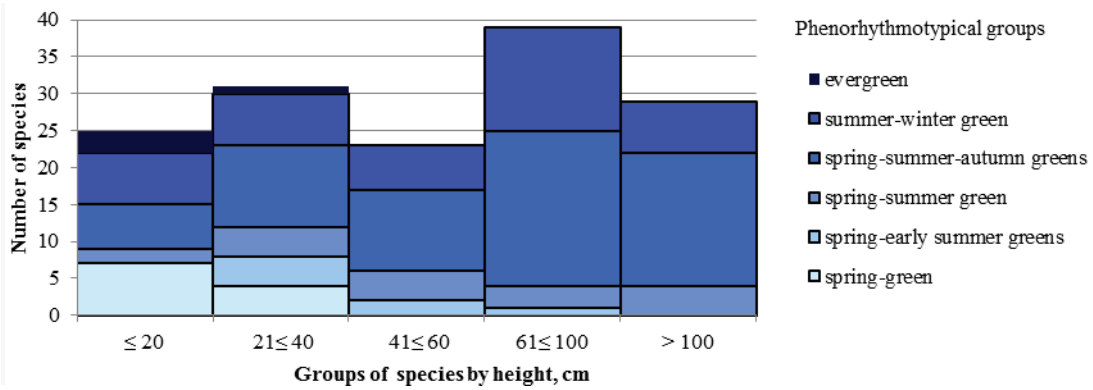

Fig. 3. Distribution of decorative perennials by height within phenorhythmotypic groups

In the spectrum of life forms of the studied population, hemicryptophytes prevail (120 species – 82%), which, like cryptophytes, are well adapted to the unfavourable conditions of the seasonal climate. This type of life form is the leading one in most cenoflores of the temperate zone. Among the hemicryptophytes, there are plants with almost all types of root systems, but species with a rhizome system dominate (88 species – 60%). There are 19 species of cryptophytes (13%), 17 of them are geophytes, among which bulbous ones predominate. Two cryptophytes are quite ecologically plastic. Thus, *Iris pseudacorus*, widely distributed in decorative horticulture, is a helophyte in natural conditions, but in culture it grows as a geophyte, capable of withstanding arid conditions for quite a long time. The species *Persicaria amphibia* is generally polymorphic and has two natural ecomorphs: aquatic (var. *emersa*) and terrestrial (var. *Stipulacea*). Chamaephytes are represented by 5 species (3%), which is quite typical for the temperate zone, where the share of chamaephytes does not exceed 4%. The group of succulents (3 species) is the least numerous. From the given data, it is clear that the ratio of life forms of perennials, artificially selected for decorative features from the spontaneous flora of the Feofania tract, is typical for the flora of the forest-steppe zone.

When studying the methods of vegetative and seed reproduction of the studied species, a critical group of vegetatively mobile plants, from the point of view of competitive relationships, was singled out, in particular, species with stolon-like organs, including: epigeogenic – *Vinca minor*, *Ajuga reptans*, *Lamium galeobdolon*, *Veronica officinalis*, *Ranunculus repens*, *Fragaria viridis*, *Lysimachia nummularia* and hypogeogenic – *Convallaria majalis*, *Maianthemum bifolium*, *Pilosella officinarum*, *Stellaria holostea*, *Trifolium alpestre*, *Mentha* × *piperita*, *Melissa officinalis*, *Agrostis stolonifera*, *Epilobium angustifolium*, *Lysimachia punctata*, *Anemone ranunculoides*. All these species can be used in monoculture plantings (groups, curtains, blocks). If it is necessary to plant them in mixed groups, their active reproduction and settlement should be limited in order to avoid suppression or elimination of other types of cultural groups. Con-

trol of settlement is also necessary for species with active seed reproduction (*Sedum acre*, *Agropyron cristatum* and representatives of the *Viola* L. genus). Low-growing vegetatively mobile species used as ground cover can be used to sod the lower tier in cultural phytocenoses. For this purpose, ephemeroid species that actively reproduce due to hypogeogenic organs (*Gagea lutea*, *G. minima*, *Ficaria verna*) can be used.

When studying the colour spectrum of the studied population of plants, all species, with the exception of leafy ornamentals, grasses and sedges, are grouped by the main tone in the colour of the flower (inflorescence). As a result, 9 groups were selected (Fig. 4), among which the group of species with yellow colour is the most numerous.

In general, the dominance of yellow is typical for ornamental plants. This is due, probably, to the fact that when selecting plants for decorative features both among natural species and among artificially created selection material, even on a subconscious level, preference is given to this bright and light colour, which on a psycho-physiological level has a positive emotional impact on a person.

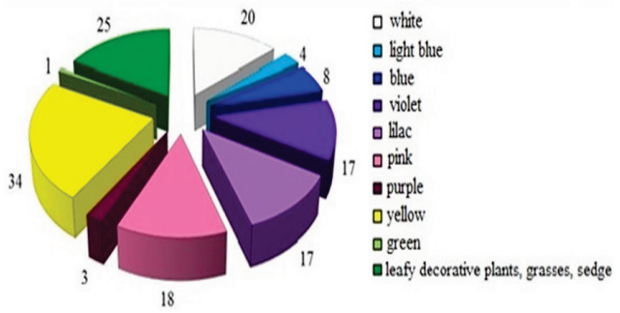

Fig. 4. The ratio of decorative perennials by flower colour (inflorescence)

The flowering phase, as well as the entire rhythm of the seasonal development of plants, is determined by the features of the ontogenetic development of the species (the age of the plants, the timing of the laying of flower buds – in the current or previous vegetation), other biological factors that determine the level of viability (accumulation of a sufficient amount of plastic substances) and environmental factors, associated with fluctuations in meteorological conditions during the growing season and in previous seasons. Therefore, the phenodates of the beginning of flowering and its duration vary greatly from year to year. Scattering of phenodates in some cases is observed within a month, and sometimes more. In this regard, to analyze the dynamics of flowering, we used the terms within which the flowering of one or another species occurs. At the same time, if flowering phenodates vary greatly by year, flowering groups (simultaneously flowering species) remain constant. Single flowering, which in some spring-summer and spring-summer-autumn species after mass flowering sometimes lasts until the end of the growing season, as well as repeated weak flowering, which is observed under certain conditions in summer-evergreen species, was not considered. As a result, it is shown that the totality of studied species covers the entire vegetation period from the pre-spring stage to the phenological autumn inclusively by the terms of flowering (Fig. 5).

The pattern of development of natural herbaceous communities in the seasonal climate of the temperate zone is preserved in the studied population, which consists in a gradual increase in the number of flowering species from spring to summer, and then a fairly rapid decrease. But if in the general population of decorative perennials of the spontaneous flora of Feofaniya, dominated by heliophilous species, the peak of flowering (the maximum number of species) occurs in June, then in the separately considered forest species, a different picture is observed – their flowering begins much earlier, its peak occurs in April-May and the remaining species bloom by mid-summer (Fig. 6).

The group of forest edge species, despite the fact that it is in a transitional position between sciophilous and heliophilic plants in relation to light, is closer to heliophilic (meadow, steppe) groups in terms of flowering phenospectrum and colour spectrum (Fig. 7).

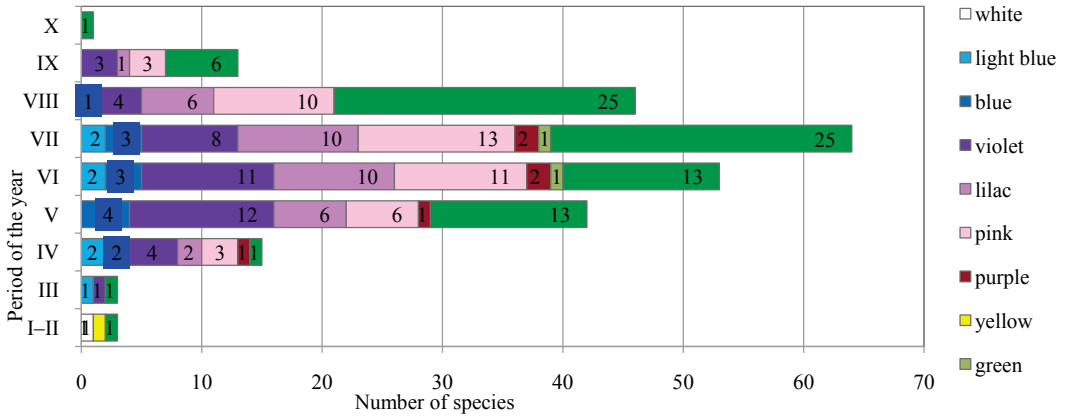

Fig. 5. Dynamics of flowering and colour spectrum of decorative perennials during the growing season

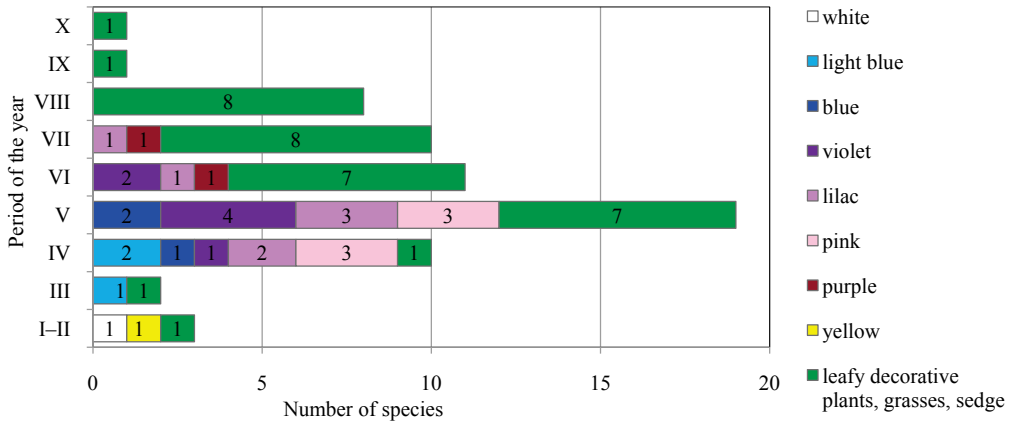

Fig. 6. Dynamics of flowering and colour spectrum during the vegetation period of decorative perennials of the flora of the forest ecotopes

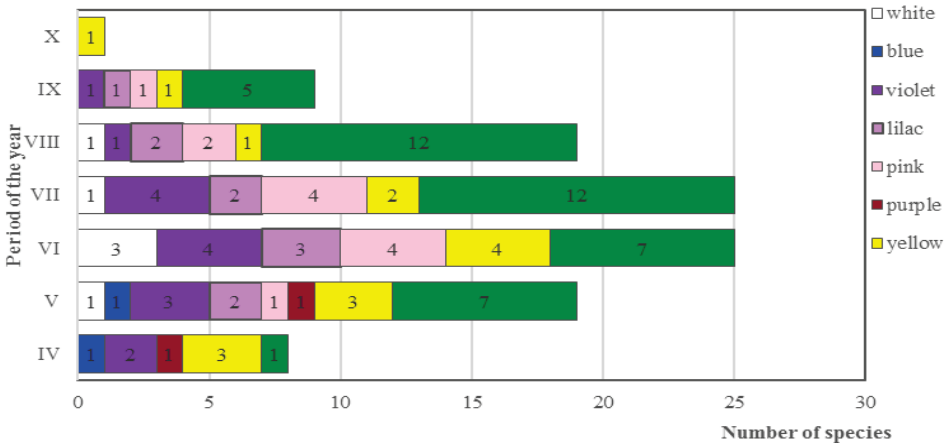

Fig. 7. Dynamics of flowering and colour spectrum of decorative perennials of the flora of the edge ecotopes during the growing season

A characteristic feature of these groups of plants is the later onset of vegetation and flowering, which is determined by lower temperatures and humidity in the conditions of "open" ecotopes.

Discussion

One of the main problems in working with perennials is the limited, in most cases, period of their flowering, and for some groups (ephemeroids, hemiephemeroids) – the short vegetation period. In the first case, there is a need to involve plants with a prolonged period of decorativeness due to the vegetative sphere (habitual features), or to combine species with different flowering phenodates, in the second – a combination of mutually complementary phenorhythmic groups. They are not clearly deterministic, and when climatic conditions change, seasonal changes in plants are observed, up to a change in the phenorhythmotype, which was shown by Karpisonova (1985) based on the study of rhythmological features of plants in the conditions of an introductory experiment. It should also be noted that such changes are not abrupt and occur in one direction or another to the closest phenorhythmotypical group in terms of duration of vegetation. But in places of natural growth, under the influence of annual fluctuations in meteorological conditions, variations in phenodates and the duration of vegetation are observed within the same phenorhythmic group. Therefore, in this study, the phenorhythmotypical spectrum is considered as an indicator that determines, first of all, seasonal dynamics and the duration of the decorative effect of landscaping objects, not related to phenodata, but to the stages of seasonal development.

All the species selected by us can be used to form quite picturesque, although not long-lasting, curtains at the beginning of the growing season. Ephemeroids, after dying off and decomposition of the above-ground part, add a significant amount of nutrients to the soil, especially potassium and nitrogen compounds. They contribute to the preservation of elements of mineral nutrition, especially light-moving compounds that are easily washed out by meltwater, again including them in the general cycle of substances of the plant community. Ephemeroids create a certain problem in the formation of landscaping objects, since their above-ground part, having quickly finished vegetation, as a rule, gradually withers and dies within a month, reducing the decorative effect of the location. Therefore, it is advisable to create multi-tiered plantings using long-vegetating spring-summer greens (ferns, lilies, tussocks) and spring-summer-autumn green forest (sciophilous) species (sedges, *Thalictrum*, cereals, etc.), which begin vegetation at the time when ephemeroids enter the resting stage.

For example, species of the genus *Galanthus* L., which begin to bloom in the pre-spring stage, can be combined with various types of ferns, in which regrowth begins at the end of the snowdrop vegetation.

Such a trend is significantly reflected in the colouristic aspect of landscaping objects, since it is floral and decorative plants that are the main carriers of bright accents. Given the fact that floral and decorative plants belong to the category of variable carriers of colour (Oleksiichenko & Mavko, 2015), the design of seasonal colour compositions and the selection of plants of the appropriate colour range directly depends on the colour spectrum of simultaneously flowering plants, which, with a sharp reduction in the number of flowering species, inevitably leads to its limitation. Therefore, to maintain and continue the decorative effect of landscaping objects in the conditions of forest ecotopes, it is necessary to attract shade-tolerant late-flowering introducents. Leafy decorative plants, as well as cereals and sedges can provide a minimal colour effect.

Another feature of forest species is the predominance of white flowers (Nasymovych, 1986). The colour white is neutral, its monochrome compositions do not look impressive enough in daylight. However, it combines well in a composition with any other colour, especially from a cold colour range, advantageously shading and emphasizing it, so the predominance of white-coloured species does not reduce the aesthetic value of this group of plants.

In general, the colour spectrum of the studied group of plants consists of 10 basic tones, not including shades. The only thing missing is the orange-red colour gamut, which is not typical for the flora of the forest-steppe (Nasymovych, 1986). The available spectrum is sufficient for the formation of both harmonious (white-blue-blue, white-lilac-violet, white-pink-purple, etc.) and contrasting (yellow-purple-pink, yellow-lilac-violet, etc.) compositions. The most colourful periods for sciophilous species occur at the end of spring, for geophilous species at the beginning of summer.

Conclusion

In the studied population, 6 phenorhythmotypic groups were identified: ephemeroids (spring-green), hemi-ephemeroids (spring-early summer-green), short-vegetating (spring-summer-green) and long-vegetating (spring-summer-autumn green, summer-winter-green, evergreen), which cause a wide phenospectrum of plant flowering from the pre-spring stage to the phenological autumn.

The study of the phenospectrum of plants within phenorhythmotypic groups and the dynamics of associated phenobiomorphs by seasonal stages of development showed that the proposed assortment is sufficient for the formation of landscaping objects with a closed grass stand and a decorative effect throughout the growing season, starting from the pre-spring stage. The composition of the collection includes species that, thanks to their habitual features, are able to provide a conditional decorative effect even in late autumn and winter.

The studied population is characterized by a wide ecological and coenotic amplitude and includes species that can be used in the conditions of 4 ecotopes: forest, forest edge, meadow and steppe. All types of ephemeroid phenorhythmotypes and a significant number of short-vegetating plants are confined to the forest ecotope.

The colour spectrum of the studied group of plants is quite representative, due to the absence of an orange-red colour gamut, which is not characteristic of the forest-steppe flora.

The peculiarity of the grass cover of forest phytocenoses – a bright burst and gradual fading of the colour spectrum, as well as the complete dying of ephemeroids and hemiephemeroids by mid-summer, makes it necessary to form a significant part of the assortment using long-vegetating deciduous and habitually decorative plants (ferns, sedges, grasses,

etc.), or involving sciophile introducents. The studied population includes a critical, from the point of view of competitive relationships, group of vegetatively mobile plants, which includes species with epigeogenic and hypogeogenic stolon-like organs of vegetative reproduction, as well as species with active seed reproduction, for which options for optimal use are presented.

Thus, as a result of the study of the decorative and bioecological characteristics of 147 herbaceous perennials of the spontaneous flora of the Feofania tract, it is shown that the studied population is characterized by great diversity according to the considered characteristics that determine the economic value. This allows them to be used effectively as a basic regional assortment for the formation of stable, long-vegetating, multi-component landscape compositions in the conditions of 4 ecotopes, characteristic of recreational areas.

References

Apfelbeck, B., Jakoby, C., Hanusch, M., Steffani, E. B., Hauck, T. E., & Weisser, W. W. (2019). A conceptual framework for choosing target species for wildlife-inclusive urban design. Sustainability, 11(24), 6972.

Bessonova, V. P., Yakovlieva-Nosar, S. O., & Ivanchenko, O. E. (2022). Analiz kvitnykovoho ozelenennia u parkakh i skverakh Pravoberezhzhia mista Dnipra [Analysis of flower landscaping in parks and squares of the Right Bank of Dnipro city]. Scientific Bulletin of the National Forestry University of Ukraine, 32(1), 51–61 (in Ukrainian).

Borysova, Y. V. (1972). Sezonnaya dinamika rastitelnogo soobshhestva [Seasonal dynamics of vegetable association]. In: Field geobotany. Nauka, Leninhrad. Vol. 4. Pp. 5–136 (in Russian).

Bretzel, F., Vannucchi, F., Romano, D., Malorgio, F., Benvenuti, S., & Pezzarossa, B. (2016). Wildflowers: From conserving biodiversity to urban greening – a review. Urban Forestry and Urban Greening, 20, 428–436.

Didukh, Y. P. (2011). [The ecological scales for the species of Ukrainian flora and their use in synphytoindication]. Phytosociocentre, Kyiv.

Didukh, Y. P. (Ed.). (2000). Ekoflora Ukrajiny [Ecoflora of Ukraine]. Vol. 1. Phytosociocentre, Kyiv (in Ukrainian).

Grechyshkina, Y. V. (2010). Pryrodna flora sudynnykh roslyn m. Kyjiva [The natural flora of vascular plants of Kyiv]. M. G. Kholodny Institute of Botany, Kyiv (in Ukrainian).

Guo, P., Yu, F., Ren, Y., Liu, D., Li, J., Ouyang, Z., & Wang, X. (2018). Response of ruderal species diversity to an urban environment: Implications for conservation and management. International Journal of Environmental Research and Public Health, 15(12), 28–32.

Hitchmough, J. (2020). Sowing beauty. Creation of flowering sowing meadows. Chitarium, Kharkiv.

Iuliana, P., Adelina, D., Valentine, S., Doina, C., & Georgel, M. (2011). Ecological and aesthetic role of spontaneous flora in urban sustainable landscapes development. Journal of Plant Development, 18, 169–177.

Karpysonova, R. A. (1985). Travyanistye rastenija shirokolistvennykh lesov SSSR (ekologo-floristicheskaya i introduktsionnaya kharakteristika) [Herbaceous plants of broad-leaved forests of the USSR (ecological-floristic and introduction characteristics)]. Nauka, Moscow (in Russian).

Koniakin, S., & Gubar, L. (2022). Spontaneous flora of the local landscape Feofaniya (Kyiv, Ukraine). Plant Introduction, 93/94, 46–61.

Kowarik, I., Fischer, L. K., & Kendal, D. (2020). Biodiversity conservation and sustainable urban development. Sustainability, 12(12), 4964.

Kühn, N. (2006). Intentions for the Unintentional: Spontaneous vegetation as the basis for innovative planting design in urban areas. Journal of Landscape Architecture, 1, 46–53.

Lindemann-Matthies, P., Junge, X., & Matthies, D. (2010). The influence of plant diversity on people's perception and aesthetic appreciation of grassland vegetation. Biological Conservation, 143(1), 195–202.

Marchenko, A. B. (2016). Dekoratyvni kvitkovi roslyny v strukturi urboflory Lisostepu Ukrajiny [Decorative floral plants in the urban flora structure of the Forest-Steppe zone of Ukraine]. Bulletin of Poltava State Agrarian Academy, 1–2, 36–43 (in Ukrainian).

Matiashuk, R., Gubar, L., & Pirko, I. (2021). Essay on the prospects for the use of decorative perennials of the spontaneous flora of the local landscape Feofaniya. Plant Introduction, 91/92, 54–63.

Nasimovich, Y. A. (1986). Biologicheskoe znachenie okraski tsvetka [The biological significance of the colour of the flower]. Bulletin of the Moscow Society of Naturalists, Department of Biology, 91(5), 82–93 (in Russian).

Oleksiichenko, N. O., & Gatalska, N. V. (2017). Pokomponentnyj pidkhid doslidzhennia i estetyky landshaftu [Component approach of landscape aesthetics research]. Biological Resources and Nature Managment, 9(5–6), 131–140 (in Ukrainian).

Oleksiychenko, N., & Mavko, M. (2015). Formuvannia ta otsiniuvannia kolorytu parkovykh landshaftiv mista Kyjiva [Formation and evaluation of landscape colouring of Kyiv parks]. Proceedings of the Forestry Academy of Sciences of Ukraine, 13, 49–54 (in Ukrainian).

Opoku, A. (2019). Biodiversity and the built environment: Implications for the Sustainable Development Goals (SDGs). Resources, Conservation and Recycling, 141, 1–7.

Palmer, E. J. (1930). The spontaneous flora of the Arnold arboretum. Journal of the Arnold arboretum, 11(2), 63–119.

Pashkevych, N. (2020). Biotopy parku-pamiatky sadovo-parkovoho mystetstva Feofaniia [The biotopes of the park-monuments of the garden art Feofania]. Ecological Sciences, 28, 263–268 (in Ukrainian).

Pergl, J., Sádlo, J., Petřík, P., Danihelka, J., Chrtek Jr., J., Hejda, M., Moravcová, L., Perglová, I., Štajerová, K., & Pyšek, P. (2016). Dark side of the fence: Ornamental plants as a source of wild-growing flora in the Czech Republic. Preslia, 88(2), 163–184.

Pirko, I. F. (2013). Osnovye printsypy i algoritmy modelirovanija mnogokomponentnykh tsvetnikov iz mnogoletnikov [Basic principles and an algorhythm of modelling of the multi-species flower beds of perennials]. Industrial Botany, 13, 259–269 (in Ukrainian).

Ponomaryova, O. A., Mylnikova, O. A., & Linnik, A. A. (2021). Asortyment ta stan kvitnykovykh nasadzhen Sobornoho raionu m. Dnipro [Assortment and condition of flower beds in the Sobornіy district of Dnipro city]. Scientific Reports of the National University of Bioresources and Nature Management of Ukraine, 5, 13 (in Ukrainian).

Radchenko, V. G., Burda, R. I., Pashkevych, N. A., Koniakin, S. N., Krakhmalnyi, O. F., Gaponova, L. P., Matiashuk, R. K., Shupova, T. V., & Dubrovsky, Y. V. (2019). Park-pamiatka sadovo-parkovoho mystetstva Feofanija – oseredok biotychnoho riznomanittia urbanoekosystemy Kyjiva [Park-monument of landscape art Feofania – a refugium of the biotic diversity of the urban ecosystem of Kyiv]. Ecological Sciences, 25, 138–146 (in Ukrainian).

Tredici, P. (2014). The flora of the future: Celebrating the botanical diversity of cities. Places Journal, April.

Vakulyk, I. I. (2018). Parkovi zony m. Kyjiva yak sehment suchasnoji industriji [Park zones of Kyiv as a segment of modern industry]. ScienceRise, 49, 54–57 (in Ukrainian).

Wilde, H. D., Kamal, J. K. G., & Colson, G. (2015). State of the science and challenges of breeding landscape plants with ecological function. Horticulture Research, 2, 14069.

Yakubenko, B. E. (2007). Pryrodni kormovi uhiddia Lisostepu Ukrajiny: Flora, roslynnist', dynamika, optymizatsija [The natural fodder lands of the Forest steppe of Ukraine (flora, vegetation and dynamics)]. M. M. Gryshko Natinal Botanical Garden, Kyiv (in Ukrainian).

Yavorska, O. G., & Mosyakin, S. L. (2001). Adventyvna fraktsija synantropnoji flory Kyjivs'koji ahlomeratsiji [The alien fraction of the urban flora of the Kyiv region]. Scientific Notes of the National University "Kyiv-Mohyla Academy", Biology and Ecology, 19, 55–68 (in Ukrainian).

Yorkina, N., Goncharenko, I., Lisovets, O., & Zhukov, O. (2022). Assessment of naturalness: The response of social behavior types of plants to anthropogenic impact. Ekológia (Bratislava), 41(2), 135–146.