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Comprehensive proposals for greening and urban regeneration in Zhytomyr based on a selection of perennial plants

Abstract. The rapid development of urban construction in Zhytomyr is leading to a reduction in green space below the standard level and an intensification of the urban heat island effect, which raises the air temperature in summer by 2-4°C. This has necessitated the implementation of environmentally sustainable solutions aimed at regulating the microclimate, enhancing the aesthetic appeal of the urban environment and ensuring the social well-being of residents. The aim of the study was to develop comprehensive proposals for landscape greening and the improvement of urban areas in Zhytomyr in a landscape style based on a range of perennial ornamental plants. This ensured biodiversity, continuous seasonal ornamental appeal and the functional zoning of urban space. Plants were classified according to height, light requirements, moisture requirements and ornamental characteristics. Based on an analysis of sunlight exposure in typical urban areas, a zoning scheme was developed: 60% sunny areas, 30% semi-shaded areas, and 10% riparian zones along water bodies. Planting density ranged from 4 plants/m^2 for large species to 9 plants/m^2 for low-growing groundcovers, ensuring that the plantings would close out within 1-2 years. The selection included frost-hardy, drought-tolerant and low-maintenance plant species – ornamental grasses (*Pennisetum, Festuca*), perennial herbaceous plants (*Echinacea, Salvia, Hemerocallis, Sedum*), evergreens (*Yucca, Lavandula*) and ornamental foliage plants (*Hosta*), none of which had invasive properties. In addition, nine types of greening compositions were proposed: borders (50-70 m in length), mixed borders (100-150 m^2), flower beds (10-20 m^2), alpine rock gardens (15-20 m^2), container plantings, greening around water features (20-30 m^2), ornamental groups with solitary elements (5-10 m^2), group plantings (10-15 m^2) and flower beds (0.5-1.0 m wide). All options ensured continuous seasonal ornamental appeal from May to October, with a greening level of 40% to 70%, which exceeded the minimum regulatory requirements, and required mulching and watering during dry periods. The practical value of this work lies in the ready-to-implement projects with detailed plant placement plans and the potential for adaptation to other cities in Ukraine with similar climatic conditions

Keywords: landscape style; composition options; landscape design; urban greening; biodiversity; seasonal ornamental value; environmental sustainability

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INTRODUCTION

Urban greening and the improvement of urban areas are integral components in the formation of sustainable urban environments, contributing to microclimate regulation, air pollution reduction, and the support of the population's psychological well-being. Under conditions of rapid urbanisation and intensive development in Ukrainian cities, the issue of a scientifically grounded approach to greening has become particularly relevant, as the reduction of green spaces has directly affected residents' quality of life and the ecological condition of urban environments. Urban greening contributes to microclimate regulation, air purification, and the maintenance of residents' psychological well-being. A. Addas (2023) demonstrated that urban green spaces can reduce temperatures by 2-4°C, improve air quality, and decrease social isolation. F. Zhang & H. Qian (2024) emphasised that urban green spaces play a critical role in carbon sequestration, pollution filtration, and the mitigation of the urban heat island effect, making their integration into urban planning essential. T. Semeraro *et al.* (2021) highlighted the importance of green roofs and community gardens for climate regulation, water management, and biodiversity support, which positively affects stress reduction among urban residents. L. Boyko *et al.* (2022) substantiated the principles of creating dendrological compositions and the criteria for their use in urban areas, emphasising the need to combine aesthetic and functional characteristics of plantings. X. Zhou *et al*. (2025) confirmed that the application of machine learning in optimising green spaces increases their economic efficiency and social cohesion.

The selection of plant material for urban greening is a key factor in the success of plantings. A. Hardberger *et al.* (2025) highlighted challenges in promoting the use of native plants due to social and market factors, proposing policy incentives and educational measures to overcome these barriers. An important aspect is also the selection of frost-resistant and drought-tolerant species capable of withstanding climatic fluctuations while maintaining ornamental value throughout an extended growing season. A. Pancewicz & A. Kurianowicz (2024) considered urban greening as a tool for climate adaptation, emphasising the importance of a systematic approach to the formation of green spaces under conditions of intensive development and climate change. The study by S. Chen *et al*. (2021) demonstrated the positive impact of redeveloping neglected urban areas in Berlin, significantly increasing green space and improving climatic conditions, thereby confirming the effectiveness of comprehensive greening approaches in densely built environments. The planning and evaluation of urban green spaces require systematic tools and methodological approaches. M. Panwar *et al.* (2025) developed the UGSAI index to assess the quality, quantity, and accessibility of green spaces in Delhi, identifying areas with insufficient greenery and providing recommendations for their development. R. Hansen *et al*. (2023) noted a shift from fragmented approaches to integrated green space management in European cities to ensure long-term sustainability. L. Tian (2022) highlighted the importance of aesthetic aspects in landscape design for enhancing the attractiveness of green spaces, which is particularly relevant in the development of urban greening proposals. K. Min (2025) identified key research directions focused on integrating green technologies into architecture to achieve carbon neutrality, opening new perspectives for urban greening development.

In Ukraine, greening issues are associated with fragmented regulatory frameworks, rapid urban development, and insufficient monitoring of green spaces. The lack of a systematic approach to planning has led to their reduction and deterioration in quality, negatively affecting both ecological and social conditions in cities. For the city of Zhytomyr, located in a temperate continental climate with cold winters and warm summers, a scientifically grounded selection of perennial plants – taking into account frost resistance, drought tolerance, and compliance with state building regulations – is essential. A comprehensive approach to landscape greening, based on an actual selection of plant species and the principles of landscape design, makes it possible to effectively address the shortage of green spaces in the city and to ensure their long-term ornamental value and ecological stability. The aim of this study was to develop landscape-style design projects with maximum use of available resources to achieve a balance between ecological sustainability, aesthetics, and social comfort. The objectives included analysis of plant material, the application of landscape design principles, the creation of compositional options and their regulatory assessment.

MATERIALS AND METHODS

The study was based on a selection of 14 species of perennial plants (Table 1), purchased by the municipal enterprise "Zelenbud" of the Zhytomyr City Council on 15 November 2025 from the "Dekor Zviahel Sad" farm (Zhytomyr.info, 2025). The proposals for greening were based on standard urban areas in Zhytomyr (squares, courtyards, footpaths, patios, waterfronts, and slopes). The visualisation of the landscape design schemes was carried out using Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.).

Table 1. Range of plants for greening the city of Zhytomyr

Plant name	Type	Height/width	Frost hardiness	Quantity, pcs.	Appearance
Salvia nemorosa 'Caradonna'	Perennial herbaceous	40-60/30-40 cm	High	30	

Table 1. Continued

Plant name	Type	Height/width	Frost hardiness	Quantity, pcs.	Appearance
Lychnis viscaria 'Pink Rosea Plena'	Perennial herbaceous	30-35/25-30 cm	High	35	
Pennisetum alopecuroides 'Moudry'	Ornamental grass	up to 80/ up to 80 cm	High	65	
Festuca glauca 'Elijah Blue'	Ornamental grass	15-25/20-30 cm	High	65	
Sedum hybride 'Purple Emperor'	Perennial herbaceous	40-50/35-40 cm	Zone 4 (down to -34°C)	65	
Yucca filamentosa	Evergreen perennial	foliage up to 70 cm, flowering stem up to 1.5 m	Zone 4 (down to -30°C)	20	
Echinacea purpurea 'Magnus'	Perennial herbaceous	60-90/60-70 cm	High	35	
Perovskia atriplicifolia 'Blue Spire'	Perennial herbaceous	60-70/50-60 cm	High	35	
Hosta 'Halcyon'	Perennial ornamental foliage	up to 40/40-50 cm	High	40	
Hosta 'Fire and Ice'	Perennial ornamental foliage	25/40 cm	High	40	
Hosta 'Sunset Grooves'	Perennial ornamental foliage	30-40/40-50 cm	High	40	
Hemerocallis hybrida 'Stella de Oro'	Perennial herbaceous	40-50/40-50 cm	High	60	
Lavandula angustifolia 'Elisabeth'	Evergreen perennial shrub	50-60/70-80 cm	down to -30°C	60	
Pennisetum alopecuroides 'Little Bunny'	Ornamental grass	40-50/30-40 cm	High	65	

Source: Garden Industry (n.d.)

The research stages included an analysis of the purchased selection of plants for urban greening. The plants were classified according to height (low-growing <40 cm, medium-growing 40-80 cm, tall >80 cm), light requirements (sunny, semi-shaded), moisture conditions (dry, moderate, moist), and ornamental characteristics (flowering period, foliage texture, autumn colouration). For the selected plants, the most suitable approach was the landscape style, incorporating asymmetry, multi-layering, and the imitation of natural landscapes. The majority of species had a natural, "wild" appearance, did not require regular trimming, and aligned with the concept of low-maintenance planting. Site zoning included: 60% sunny areas, 30% semi-shaded areas, and 10% waterside zones near bodies of water. Based on an analysis of insolation in typical areas of Zhytomyr, several compositional variants were proposed, including borders, mixborders, flower beds, alpine rock gardens, container plantings, waterside zones, decorative groups, and flower borders. Planting density in the design ranged from 4 to 9 plants/m^2 depending on plant size (7-9 plants/m^2 for low-growing species and 4-5 plants/m^2 for taller species). The design process also took into account compliance with state building regulations SCN B.2.2-5:2011 (2012) (minimum 40% greening, shrub distance of 1-2 m from pathways, and absence of invasive species) as well as the Order of the Ministry of Construction, Architecture, and Housing and Communal Services of Ukraine No. 105 (2006). The methods used included comparative analysis, morphological classification of plants, and landscape design planning, taking into account planting density and adaptation to specific growing conditions. The study did not involve statistical data processing, as it was based on landscape design proposals.

RESULTS AND DISCUSSION

The city of Zhytomyr is located in a temperate continental climatic zone (Zone 5), characterised by cold winters (down to -30°C), warm summers, and sufficient moisture, which determines the selection of frost-resistant and low-maintenance perennial species for urban greening. The city features a developed network of public squares, inner courtyards, and waterside areas along the Teteriv River; however, intensive construction during the 2010s-2020s has significantly reduced green space below the standard level (Wolch *et al*., 2014). The perennial plants selected for analysis were characterised by a harmonious combination of colour and texture and were organically integrated into a landscape-style design, defined by asymmetrical arrangement, a multi-layered structure, and an emphasis on textural and seasonal characteristics suitable for urban greening. Their decorative flowering period extends from May to October, ensuring both functionality and aesthetic expressiveness of plantings. Species such as *Pennisetum, Festuca,* and *Echinacea* were particularly well suited to the landscape style of urban planting. During site zoning, it is important to consider light conditions and relief: approximately 60% of the area should be allocated to sunny sites for species such as *Sedum* and *Lavandula*; around 30% to partial shade for hostas and certain ornamental grasses; and about 10% for waterside greening, using moisture-loving plants such as *Hemerocallis* and *Pennisetum*. For optimal balance, planting density should range from 4 plants/m^2 for tall grasses to 9 plants/m^2 for low-growing ground cover species. This scheme ensures canopy closure within 1-2 years and complies with the requirements of SCN B.2.2-5:2011 (2012) for minimum greening levels (≥40%). Plant grouping was carried out according to height (low plants in the foreground, taller ones in the background), colour (dominance of a purple-pink palette with yellow and silvery accents), and texture (combining soft ornamental grasses with the rigid foliage of yucca).

Plant maintenance was limited to mulching, spring pruning of grasses, and watering during prolonged dry periods. The proposed greening options included: borders (50-70 m in length, up to 40 cm in height); containers (3-5 units, volume 4-10 L); mixborders (100-150 m^2); waterside zones (20-30 m^2); flower beds (3-5 units, each 10-20 m^2); alpine rock gardens (15-20 m^2); decorative compositions (5-7 units, each 5-10 m^2); group plantings (10-15 m^2); and flower borders (0.5-1.0 m wide, up to 10 m long). Borders were considered one of the basic elements of urban greening, serving to frame pathways and lawns. Their role was to establish clear boundaries, ensure compositional rhythm, and maintain a low planting profile (up to 40 cm). For border creation, a composition of low-growing plant species was proposed, ensuring dense coverage and year-round ornamental value. On sunny sites, the base consisted of *Lychnis viscaria* 'Pink Rosea Plena' (25-35 specimens), forming pink accents from May to July, combined with *Festuca glauca* 'Elijah Blue' (25-30 specimens), which created a silvery-blue textural background. The total length of the border was 50-70 m. Table 2 summarises the structure of the border layers.

Table 2. Layered structure of the border composition planting

Layer	Type	Quantity per 10 m	Height	Colour/texture
Front (ground cover)	*Festuca glauca* 'Elijah Blue'	20 units	15-25 cm	Silvery-blue foliage
Middle (flowering)	*Lychnis viscaria* 'Pink Rosea Plena'	15 units	30-35 cm	Pink double flowers
Accent (every 2 m)	*Lavandula angustifolia* 'Elizabeth'	5 units	50-60 cm	Purple fragrant flowers

Source: compiled by the authors

The border layout was designed on the principle of asymmetrical waves, repeating every 2-3 metres. A visual focal point was created by combining the pink flowers of *Lychnis viscaria* with the bluish foliage of *Festuca glauca*, producing a rhythmic effect. The planting density was 5-7 plants/m^2, which met the regulatory requirements for

decorative density and ensured the plants would close out within 1-2 years. In Figure 1, showing the border in its entirety, the composition is based on a three-row planting scheme with a clearly defined hierarchy of colour and texture. Along the edges of the border, a frame was formed using *Festuca glauca* 'Elijah Blue', which created a light, textural background thanks to its dense, grey-blue clumps. The middle row features *Lavandula angustifolia* 'Elizabeth', which forms a purple strip and provides a vertical rhythm to the inflorescences. The central focal area is occupied by *Lychnis viscaria* 'Pink Rosea Plena', which stands out with its rich pink flowers and serves as the compositional focal point.

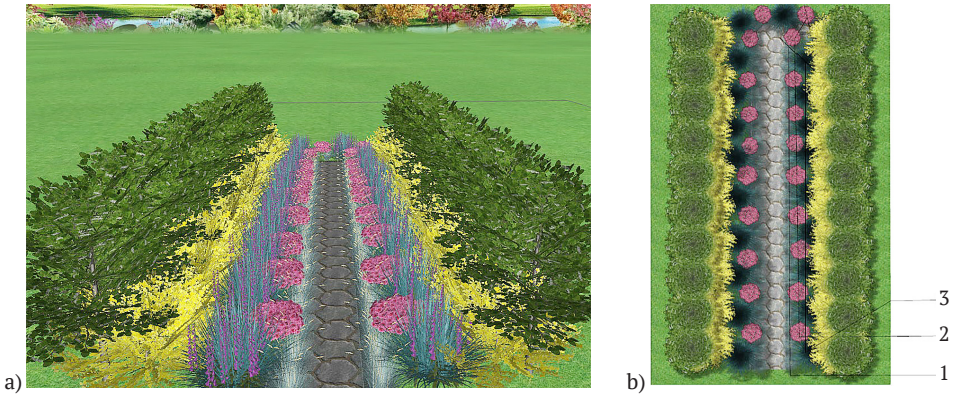

Figure 1. Border composition variant along a pedestrian pathway
Note: a – general view of the border (front view); b – plant layout (top view): 1 – *Festuca glauca* 'Elijah Blue', 2 – *Lychnis viscaria* 'Pink Rosea Plena', 3 – *Lavandula angustifolia* 'Elizabeth'
Source: compiled by the authors

For the greening of semi-shaded areas, it is advisable to plant *Hosta* 'Halcyon' (20 plants) and *Hosta* 'Fire and Ice' (20 plants), which create a striking contrast thanks to their varied foliage and provide year-round ornamental appeal. *Lavandula angustifolia* 'Elizabeth' (10 plants) can serve as an additional accent, adding a fragrant touch to the composition and characterised by abundant flowering in June-August. Containers were used for greening patios and terraces, ensuring the mobility of the compositions and a vertical structure for the plantings. O. Kosyk *et al*. (2020) confirmed the effectiveness of container planting in urban environments for paved areas and sites with complex engineering conditions, which has become typical of courtyards and pedestrian zones in Zhytomyr. *Hosta* 'Sunset Grooves', characterised by wrinkled ornamental foliage with year-round hardiness, can serve as the base element of a container planting. Complementary plants could include *Hemerocallis* 'Stella de Oro' – yellow flowers with a long flowering period (May-September), *Pennisetum alopecuroides* 'Little Bunny' with fluffy panicles flowering in September-October, and the solitary element Yucca filamentosa (an evergreen plant up to 80 cm tall) (Fig. 2). The container composition was organised in groups with height layering: low hostas were placed in the lower tier, while taller grasses occupied the upper tier. The colour scheme was maintained in a yellow-green palette with cream accents. Textural contrast was achieved by combining the smooth foliage of hostas with the fluffy inflorescences of ornamental grasses. The placement of containers was planned near benches and entrances, forming compositional focal points. The main principles of organising container plantings included mobility for seasonal rotation, textural contrast between different plant species, and the possibility of quickly replacing individual elements of the composition depending on the season. Mixborders were predominantly designed as dynamic mixed compositions with a three-layer structure, providing spatial depth and seasonal variability of the ornamental effect. The composition structure consisted of: a background layer with silvery spikes and purple inflorescences; a middle layer with vertical purple inflorescences and plants with purple foliage and decorative as well as aromatic qualities; and a foreground layer with plants featuring silvery-blue foliage and compact fluffy spikes. Table 3 presents the structured layers of the mixborder in the urban composition.

Figure 2. Variants of container compositions
Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

Table 3. Layered structure of the mixborder composition

Layer	Plants	Quantity per 10 m	Height	Seasonality
Back	*Pennisetum alopecuroides* 'Moudry' + *Perovskia atriplicifolia* 'Blue Spire'	10 + 8 units	60-80 cm	August-October
Middle	*Salvia nemorosa* 'Caradonna' + *Sedum spectabile* 'Purple Emperor'	10 + 12 units	40-60 cm	June-September
Front	*Pennisetum alopecuroides* 'Little Bunny' + *Festuca glauca* 'Elijah Blue'	10 + 10 units	15-50 cm	All year round

Source: compiled by the authors

Thus, the seasonal changes in the mixed border unfolded in stages, ensuring continuous visual appeal from June to October. In June-August, the purple vertical inflorescences of *Salvia nemorosa* 'Caradonna' and the fragrant flowering of *Lavandula angustifolia* 'Elizabeth' dominated, creating a rich colour accent in the middle ground. In August-September, these were joined by the purple foliage of *Perovskia atriplicifolia* 'Blue Spire' and the blue-grey inflorescences of *Perovskia atriplicifolia* 'Blue Spire', which enriched the colour palette with cool shades. The season culminated in October, when the silvery panicles of *Pennisetum alopecuroides* 'Moudry' in the background reached their peak decorative effect, forming a striking autumnal accent. Throughout the season, *Festuca glauca* 'Elijah Blue' and *Pennisetum alopecuroides* 'Little Bunny' in the foreground provided a stable textural backdrop. The design principles included layering to create spatial depth, a colour rhythm dominated by a violet-silver palette with purple accents, as well as continuous seasonal variation in ornamental characteristics, making the mixed border one of the most distinctive types of greening for open urban spaces in Zhytomyr – parks, squares and pedestrian areas (Fig. 3).

Figure 3. Mixborder composition variant for urban areas of Zhytomyr
Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

Mixborders provided spatial rhythm and seasonal variation of ornamental accents, integrating into the overall greening system of the area. Waterside landscaping (areas near ponds and streams) may cover an area of 20-30 m^2. When planning such areas, specific ecological conditions should be taken into account, including increased soil moisture and partial shade. A possible planting scheme may include a shoreline composition with *Hemerocallis* 'Stella de Oro' as the base element, providing floral accents along the water's edge from May to September. The semi-shaded zone may be composed of *Hosta* 'Halcyon' and *Hosta* 'Sunset Grooves', both of which provide foliage accents in partial shade and year-round ornamental value. Accent elements may be represented by ornamental grasses such as *Pennisetum alopecuroides* 'Moudry'. Table 4 summarises and structures the features of plant placement in the waterside zone.

Table 4. Grouping of plants in the waterside zone

Group	Species	Quantity	Placement	Colour/texture
Shoreline	*Hemerocallis* 'Stella de Oro'	10 units	Along the edge	Yellow flowers
Partial shade	*Hosta* 'Halcyon' + *Hosta* 'Sunset Grooves'	5 + 5 units	Closer to the water	Blue-green and yellow-green foliage
Accent	*Pennisetum alopecuroides* 'Moudry'	5 units	In groups	Silvery spikes

Source: compiled by the authors

This composition was designed according to the principle of asymmetrical grouping, imitating a natural shoreline. The main visual accent was the reflection of the yellow flowers of *Hemerocallis* in the water surface. The arrangement of plants ensured a balance between ornamental richness and ecological adaptability. The selected plants were characterised by tolerance to moderate moisture and the ability to maintain their decorative qualities in a waterside environment. Figure 4 shows a variant of waterside landscaping.

Figure 4. Waterside landscaping variant
Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

The flower bed composition may be designed according to the principle of a concentric arrangement of plants with a dominant central layer. The centre of the composition is *Echinacea purpurea* 'Magnus' – 8 plants (vertical accent, pink flowers, flowering period July-September); the middle layer includes: *Salvia nemorosa* 'Caradonna' – 6 plants (purple vertical inflorescences, June-August); *Lychnis viscaria* 'Pink Rosea Plena' – 6 plants (pink double flowers, May-July), outer tier: *Festuca glauca* 'Elijah Blue' – 8 plants (silvery-blue foliage, ornamental throughout the year), *Lavandula angustifolia* 'Elizabeth' – 6 specimens (purple fragrant flowers, June-August). The visual focus was achieved thanks to the vertical centrepiece (*Echinacea*) and the colour rhythm of the pink and purple palette. The combination of textures – the smooth leaves of lavender, the fluffy inflorescences of sage and the greyish leaves of oatgrass – provided decorative richness. The colour scheme – pink and purple – was adapted to attract pollinators (Fig. 5).

Figure 5. Circular flower bed variant (3 m) with a concentric arrangement
Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

Alternative planting arrangements may also be applied for a circular flower bed or a park flower garden, where the accent element is *Yucca filamentosa* – 1-2 specimens (vertical element). The middle layer may include *Echinacea purpurea* 'Magnus' – 5 specimens (purple flowers, summer-autumn) and *Salvia nemorosa* 'Caradonna' – 5 specimens (dark purple stems). The lower layer may consist of *Hosta* 'Halcyon' – 8 specimens (blue-green foliage, shade-tolerant) and *Sedum hybride* 'Purple Emperor' – 10 specimens (purple foliage). A border of *Festuca glauca* 'Elijah Blue' – 12 specimens creates a blue, grass-like effect. A variant of the flower bed with a concentric arrangement of plants within a single composition may also include the planting of *Lychnis viscaria* 'Pink Rosea Plena' in the central part, enhancing the pink-purple palette and ensuring dense, rhythmic flowering in the middle layer. The outer contour of the composition, formed by *Lavandula angustifolia* 'Elizabeth', creates a decorative silvery-blue textural framing layer while simultaneously emphasising the colour depth of the central part of the flower bed (Fig. 6).

a)  b) 

Figure 6. Variants of flower bed layout (top view)
Note: (a) flower bed variant with a concentric arrangement in a pink-purple palette; (b) flower bed variant with a vertical solitary element
Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

Alpine rock gardens (rockeries) were established on sloping, sunny sites with an area of 15-20 m^2, using stone material to ensure drainage and to simulate a mountainous landscape. The composition was based on a multi-layered arrangement of plants with a pronounced textural contrast between stones, succulent-like species, and vertical accents. The structure of the composition was as follows: the lower layer (*Sedum hybride* 'Purple Emperor' – 20 specimens; August-October, *Pennisetum alopecuroides* 'Little Bunny' – 15 specimens; September-October), the middle layer (*Echinacea purpurea* 'Magnus' – 15 specimens; July-September), and the upper layer (*Yucca filamentosa* – 5 specimens; evergreen vertical accent). An aromatic component was provided by *Lavandula angustifolia* 'Elizabeth' – 10 specimens, with a flowering period from June to August (Table 5).

Table 5. Layered structure of the alpine rock garden (variant for an area of 5 m²)

Level	Species	Quantity	Height	Texture
Upper	*Yucca filamentosa*	2 units	50-70 cm	Sword-shaped foliage
Middle	*Sedum* 'Purple Emperor' + *Echinacea* 'Magnus' + *Salvia*	8 + 6 + 8 units	30-60 cm	Purple foliage and pink flowers
Lower	*Pennisetum* 'Little Bunny' + *Lavandula* 'Elizabeth'	8 + 5 units	15-40 cm	Fluffy spikes and aromatic foliage

Source: compiled by the authors

Figure 7 shows the scheme of an alpine rock garden, where the stone substrate between layers imitates a natural mountainous landscape and ensures proper drainage. The combination of stone, succulent-like plants, and ornamental grasses creates visual depth and a naturalistic style adapted to the climatic conditions of Zhytomyr. Ornamental compositions within the landscape were formed as 5-7 compositional groups, each with an area of 5-10 m². These compositions functioned as focal accents within different functional zones and were based on a combination of vertical dominants, foliage plants, and grasses, ensuring rhythm, textural richness, and seasonal ornamental value. Accent groups with a vertical dominant included: *Yucca filamentosa* – 10 specimens (evergreen vertical accent); *Sedum spectabile* 'Purple Emperor' – 15 specimens (purple foliage, ornamental value from August to October); *Pennisetum alopecuroides* 'Moudry' – 25 specimens (silvery spikes, September-October). Shade compositions provided contrasting foliage and ornamental value in partial shade; thus, the following species were used: *Hosta* 'Fire and Ice' – 20 specimens, *Hosta* 'Halcyon' – 10 specimens, and *Hosta* 'Sunset Grooves' – 10 specimens. The compositions were designed in circular or triangular configurations with vertical dominants (*Yucca*) and the integration of ornamental grasses, which respond to wind movement, creating a dynamic visual rhythm.

Figure 7. Alpine rock garden scheme with a three-tier structure
Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

Visual balance was achieved through the combination of foliage and grass textures, repetition of forms, and colour harmony. The colour palette was maintained in a purple-pink range with yellow accents. The compositions ensured continuous seasonal ornamental interest and required minimal maintenance (mulching and watering during dry periods). For example, in a composition with a central solitary element, the area may be 3 m², with a triangular structure featuring a central accent and peripheral framing. The solitary element (central feature), *Yucca filamentosa*, served as the dominant element of the composition due to its evergreen, sword-shaped foliage, establishing an architectural rhythm. The accompanying plants (middle layer) included *Sedum* 'Purple Emperor', *Pennisetum* 'Moudry', and *Lavandula angustifolia* 'Elizabeth', while the peripheral framing consisted of *Hosta* 'Fire and Ice' and *Festuca glauca* 'Elijah Blue'. Planted along the edges of the composition, they enhanced contrast through variegated foliage and provided a smooth transition to the surrounding area (Table 6).

Table 6. Structure of a decorative composition with a central solitary element

Composition layer	Species	Quantity	Placement	Decorative function
Solitary element (dominant)	*Yucca filamentosa*	1 unit	Centre	Evergreen vertical accent
Middle layer (accompanying)	*Sedum* 'Purple Emperor' + *Pennisetum* 'Moudry' + *Lavandula angustifolia* 'Elisabeth'	5 + 5 + 2 units	Around the solitaire	Textural contrast: purple foliage + silvery spikes + aromatic accent
Lower layer (framing)	*Hosta* 'Fire and Ice' + *Festuca glauca* 'Elijah Blue'	5 + 3 units	Along the periphery	Contrasting variegated foliage, transition to the adjacent area

Source: compiled by the authors

The composition shown in Figure 8 was characterised by a balanced combination of architectural form, textural contrast and seasonal variation. The evergreen *Yucca filamentosa* provided a year-round decorative base, whilst *Sedum hybride* 'Purple Emperor' and *Pennisetum alopecuroides* 'Moudry' reached their peak in August-October, creating a purple-silver autumnal accent. *Hosta* 'Fire and Ice' and *Festuca glauca* 'Elijah Blue' remained decorative throughout the growing season, enhancing the contrast and lending the composition a sense of completeness. The triangular configuration of the composition, with a vertical solitary plant at its centre, provided a consistent architectural focal point and a natural transition to adjacent landscaping elements. The colour palette featured a contrasting combination of purple-silver hues with the blue-green foliage of the hostas, maintaining aesthetic expressiveness. Such compact accent compositions are particularly effective for landscaping building entrances, key points along pedestrian routes and rest areas in the courtyards of Zhytomyr, where green space is limited but required a clear artistic solution.

Figure 8. Scheme of a decorative composition:
triangular structure with a vertical solitary element, textural framing, and foliage complement
Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

A group planting scheme for a public garden (covering an area of 10-15 m^2) – suitable for parks with partial shade – combined ornamental grasses, shade-tolerant deciduous species and flowering accents (Fig. 9). Layered structure: upper layer (height 80-120 cm) *Pennisetum alopecuroides* 'Moudry' – 3 plants; *Perovskia atriplicifolia* 'Blue Spire' – 3 plants; middle layer (height 50-80 cm) *Echinacea purpurea* 'Magnus' – 6 plants, *Lychnis viscaria* 'Pink Rosea Plena' – 5 plants; lower layer (height 20-50 cm) *Hosta* 'Sunset Grooves' – 8 plants, *Sedum hybride* 'Purple Emperor' – 7 plants, *Festuca glauca* 'Elijah Blue' – 10 plants. Fragrant accent: *Lavandula angustifolia* 'Elizabeth' – 5 plants.

Figure 9. Scheme of group planting for a public square:
a multi-layered composition with ornamental grasses, flowering accents, and shade-tolerant foliage species
Note: (a) composition variant with a warm pink-purple colour palette; (b) composition variant with a cool blue-violet colour palette
Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

The planting scheme was characterised by high resistance to pests and diseases, drought tolerance (watering required only during prolonged dry periods), minimal maintenance requirements, and provided seasonal variation in ornamental features and a natural, ecological appearance throughout the growing season. A flower

border is a linear planting along a pedestrian path, 0.5-1.0 m wide and 10 m long, designed for semi-shaded areas. The composition was structured on the principle of rhythmic alternation of plants of different heights, ensuring visual dynamism, seasonal variability, and textural richness. The structure of the composition consisted of a main row (vertical accent): *Perovskia atriplicifolia* 'Blue Spire' – 4 specimens (blue-grey inflorescences, July-September); a middle row (flowering elements): *Hemerocallis hybrida* 'Stella de Oro' – 10 specimens (yellow flowers, repeat flowering May-September), *Lychnis viscaria* 'Pink Rosea Plena' – 8 specimens (pink double flowers, May-July); a lower row (foliage and aromatic elements): *Hosta* 'Fire and Ice' – 12 specimens (ornamental throughout the season), *Lavandula angustifolia* 'Elizabeth' – 10 specimens (fragrant purple flowers, June-August); and a border (ground cover element): *Pennisetum alopecuroides* 'Little Bunny' – 15 specimens (dwarf grass, ornamental September-October) (Fig. 10).

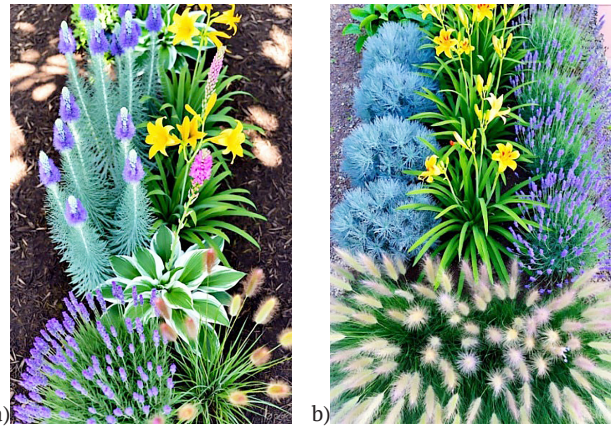

Figure 10. Flower border design: linear composition with a multi-layered structure

Note: (a) flower border variant with a warm pink-yellow colour palette (side view); (b) flower border variant with a cool blue-yellow colour palette (top view)

Source: Realtime Landscaping Architect 2025 (Idea Spectrum) (n.d.)

The composition was designed as a rhythmic line featuring alternating layers of height, with tall plants serving to divide the space, medium-sized plants providing colour intensity, and low-growing plants creating a textural and aromatic backdrop. The design of the composition ensured the integrity of the colour palette, low maintenance requirements and ecological adaptability. The proposed comprehensive landscape greening and urban improvement schemes for Zhytomyr, based on a selection of perennial plants, demonstrated a high level of integration of ecological, aesthetic and functional aspects, in line with contemporary urban greening trends. In particular, the use of a landscape style featuring asymmetrical layout, multi-layered composition and an emphasis on seasonal ornamental value was consistent with the findings of C.O. Fernandes *et al*. (2025), who scientifically substantiated the selection of plant species as a key factor in creating sustainable and comfortable urban landscapes. The selection of frost-hardy, drought-tolerant species (*Pennisetum, Festuca, Sedum*) was consistent with the strategies of C.Y. Jim (2013) for compact cities, where the emphasis was on low-cost maintenance of plantings, and also corresponded to the principles of creating ecologically adaptive urban plantings outlined by M. Ramaiah & R. Avtar (2019). The developed design options (borders, mixborders, flower beds, alpine rock gardens, container plantings, waterside zones, decorative groups, and flower borders) ensured full utilisation of the selection of perennial plants, achieving a greening level of 40-70%, which exceeded the minimum requirements of state building regulations (SCN B.2.2-5:2011, 2012). Increased greening of urban areas helped to reduce the urban heat island effect and increase the accessibility of green spaces for the population, as confirmed by the findings of J.R. Wolch *et al*. (2014), who emphasised the importance of balanced planning of green spaces to prevent inequality in access to environmental resources. In this context, the proposed solutions enabled the effective integration of planting with amenities – footpaths, benches and riverside areas along the Teteriv River. I. Anguelovski *et al*. (2018) cautioned that the development of green spaces can lead to gentrification and the exclusion of vulnerable groups; thus, when implementing proposals for the city of Zhytomyr, it is important to ensure equal access for residents to green spaces. S. Tappert *et al.* (2018) confirmed that public involvement in the planning of urban green spaces enhances their functionality and reduces conflicts of use. The zoning of areas based on lighting and planting density (4-9 plants/m^2) took into account the ecological adaptability of species to local climatic conditions. A comprehensive assessment of the quality of green areas, using a methodology developed by W. Halecki *et al.* (2023) for urban parks, confirmed the validity of this approach for ensuring the long-term functionality of plantings. The use of a variety of perennial plants ensured biodiversity and continuous flowering from May to October, which supported pollinators and contributed to the psychological well-being of residents. Furthermore, the authors M. Ramaiah & R. Avtar (2019) emphasised that, in the context of rapid urbanisation, integrated planning of green spaces has become a prerequisite for combating pollution and climate change. Potential limitations included dependence on soil quality and climatic fluctuations in Zone 5, which required further monitoring of the plantings. Compared to approaches to the systematic management of green spaces, proposals for the city of Zhytomyr could be expanded through public engagement and the use of geographic information systems for planning, in accordance with the provisions of Law of Ukraine No. 2807-IV (2005). O. Zibtseva & V. Yukhnovskyi (2019) confirmed that the discrepancy between regulatory indicators and the actual state of greening in Ukrainian cities had become a systemic problem, the resolution of which required comprehensive, scientifically grounded approaches. Overall, the proposed approach proved effective as a

comprehensive solution for improving the quality of the urban environment in Zhytomyr, ensuring compliance with regulatory requirements, ecological sustainability and the aesthetic appeal of the green spaces. The types of landscape compositions developed in the study covered all typical urban spaces and were adapted to specific conditions of light, humidity and terrain, making them suitable for implementation in other Ukrainian cities with similar climatic conditions.

CONCLUSIONS

The study developed comprehensive proposals for the landscaping and improvement of urban areas in Zhytomyr in a landscape style, based on a selection of 14 species of ornamental perennials. The selected range of frost-hardy, drought-tolerant and low-maintenance species ensured continuous decorative flowering from May to October, thereby enhancing the biodiversity of the urban environment. The proposed plantings met the regulatory requirements for minimum greening levels and required minimal maintenance – mulching and watering only during dry periods. Various types of compositions were developed for typical urban spaces in Zhytomyr – squares, courtyards, pedestrian zones and the banks of the Teteriv River: borders and flowerbeds featuring low-growing groundcover and grass species; mixed borders and ornamental groups featuring multi-layered combinations of grasses, perennial herbaceous and aromatic plants; flowerbeds with a concentric arrangement of flowering and foliage species; alpine rock gardens with succulent-like and vertical architectural elements; container plantings of mobile evergreen and flowering species; landscaping along driveways using moisture-loving and shade-tolerant plants; group plantings for partially shaded park areas featuring shade-tolerant deciduous and grass species. All options ensured colour harmony in a purple-pink palette with yellow and silvery accents, with a greening level of 40 to 70 per cent, exceeding the minimum requirements of national building regulations. The proposed solutions contributed to improving the microclimate, reducing the urban heat island effect, supporting biodiversity and pollinators, creating recreational areas, and enhancing the social well-being of residents, all with minimal maintenance costs. Future research prospects include monitoring the survival rates of the proposed plant combinations in the urban environment of Zhytomyr, expanding the range to include native species, and developing digital tools based on geographic information systems to optimise the placement of green spaces in the urban environment.

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Комплексні пропозиції з ландшафтного озеленення та благоустрою міських територій Житомира на основі асортименту багаторічних рослин

Анотація. Швидкий розвиток міської забудови міста Житомир призводить до скорочення площі зелених насаджень нижче нормативного рівня та посилення ефекту міського теплового острова, що підвищує температуру повітря влітку на 2-4 °С. Це зумовило необхідність впровадження екологічно стійких рішень, спрямованих на регулювання мікроклімату, підвищення естетичної привабливості міського середовища та забезпечення соціального благополуччя мешканців. Метою дослідження була розробка комплексних пропозицій з ландшафтного озеленення та благоустрою міських територій Житомира у пейзажному стилі на основі асортименту багаторічних декоративних рослин. Це забезпечило біорізноманіття, безперервність сезонної декоративності та функціональне зонування міського простору. Було здійснено класифікацію рослин за висотою, потребами в освітленні, вологості та декоративними характеристиками. На підставі аналізу інсоляції типових міських територій було розроблено схему зонування: 60 % сонячних ділянок, 30 % – напівтіньових, 10 % – прибережних зон водойм. Щільність посадки варіювалася від 4 рослин/м^2 для великих видів до 9 рослин/м^2 для низькорослих ґрунтопокривних, що забезпечувало змикання насаджень протягом 1-2 років. До асортименту увійшли морозостійкі, посухостійкі та невибагливі в догляді види рослин – декоративні злаки (*Pennisetum, Festuca*), багаторічні трав'янисті (*Echinacea, Salvia, Hemerocallis, Sedum*), вічнозелені (*Yucca, Lavandula*) та декоративно-листяні (*Hosta*), що не мали інвазивних властивостей. Також, було запропоновано дев'ять типів озеленювальних композицій: бордюри (50-70 м завдовжки), міксбордери (100-150 м^2), клумби (10-20 м^2), альпійські гірки (15-20 м^2), контейнерні насадження, озеленення при водоймах (20-30 м^2), декоративні групи з солітерними елементами (5-10 м^2), групові насадження (10-15 м^2) та рабатки (шириною 0,5-1,0 м). Усі варіанти забезпечували безперервну сезонну декоративність з травня по жовтень, рівень озеленення від 40 % до 70 %, що перевищувало мінімальні нормативні вимоги, та потребувало мульчування та поливу в посушливі періоди. Практична цінність роботи полягає у готових до впровадження проєктах із детальними схемами розміщення рослин і можливістю адаптації до інших міст України зі схожими кліматичними умовами

Ключові слова: пейзажний стиль; варіанти композицій; ландшафтний дизайн; міське озеленення; біорізноманіття; сезонна декоративність; екологічна стійкість