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Article

# Analysis of species composition of urban flora of the Almaty district of Astana city

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**Abstract.** In recent years, studies of urban floras have refuted the view that urban floras are poor in terms of total number of species, and it has been found that urban floras are distinct from the environment and at the same time reflect its richness. Our paper presents the composition of urban flora of Almaty district of Astana city. It is revealed that the urban flora of Almaty district of Astana city has 125 species belonging to 95 genera and 39 families. The basis of urban flora of this area are species of woody-shrub vegetation from the families: *Rosaceae* Juss. (20; 15.8 %), *Poaceae* Barnhart (19; 15.0 %), *Asteraceae* Bercht. & J. Presl. (11; 8.7 %), *Aceraceae* Juss. (syn. *Sapindaceae* Juss.) (6; 4.7 %). In the landscaping of Almaty district of Astana city these largest families make up 108 species or 85 % of the total flora of the park. Analysis of species richness of genera of the flora of the study area revealed that out of 95 genera the largest are: *Acer* L. (6; 6.3 %), *Fraxinus* Tourn. ex L. (4; 4. 2%), *Populus* L. (4; 4.2 %), *Picea* A. Dietr. (3; 3.1 %), *Malus* Mill. (3; 3.1 %), *Spiraea* L. (3; 3.1 %). The obtained results indicate that the urban flora is characterized by a structured composition with a dominance of a limited number of taxonomic groups. This pattern reflects both intentional landscaping practices and the ecological adaptability of species to urban environmental conditions. The prevalence of woody and shrub vegetation highlights their important ecological role in maintaining environmental stability, improving air quality, and enhancing the overall sustainability of urban ecosystems.

**Keywords:** urban flora; Astana; Almaty district; family; biodiversity.

## 1. Introduction

Today, urbanization can be called one of the major trends in the world. The growth and development of cities imply the formation of unsustainable natural and anthropogenic systems. Urbanized areas consisting of buildings, structures, and, to a greater or lesser extent, disturbed natural ecosystems, are characterized by the presence of biological components of the anthropogenically altered landscape sphere. At the same time, flora and vegetation undergo cardinal transformations. The formation of urban flora (formation of urban flora) is a special case of the process of flora transformation under the influence of anthropogenic factors, and compared to the natural flora that has developed over millennia, urban flora is a new natural phenomenon (Kalfas et al., 2023; Sadyrova et al., 2023; Adger et al., 2020).

Urban flora, or the flora of cities, represents an intriguing and relatively underexplored field of botany that focuses on plant life occurring within urban environments. Cities, including the capital of Kazakhstan, Astana, constitute unique ecosystems where natural and artificial elements intertwine, creating a distinct habitat for both plants and animals. This article examines the specific characteristics of Astana's urban flora and its ecological significance within the urban landscape.

Urban floristic studies in key regions are most relevant in order to select the most suitable options. Urban flora deserves special study with special methods. The study of zonal and regional peculiarities of anthropogenic transformation of flora is important for assessing the trends in the development of flora and vegetation of a particular territory. The importance of such studies is also connected with the fact that the problem of biodiversity is considered to be one of the key issues in global ecology. One of the most important aspects of this problem is the monitoring of biodiversity in urban areas as a key condition for sustainable environmental development. The condition of natural components is also an important indicator of the quality of the urban environment, which largely determines the attractiveness and convenience of the city for urban residents (Potgieter et al., 2017).

The city of Astana has been developing as a capital city for 20 years, and this is its main goal. Studies of the city are of great importance for the development of software scientific basis for the formation of the fauna of urbanizable territories is the basis of research. Species and varieties of plants recommended for growing greenery should correspond to the climatic norm of the region (Konysbaeva et al., 2019).

Plants are the most important components of urban nature. They are producers of organic matter and oxygen, absorb and retain a large amount of dust, aerosols and various toxic substances, and have a significant impact on the microclimate by increasing humidity and ionizing the air. Green areas and natural vegetation provide habitat for birds, mammals, insects and other animals. Urban vegetation has high aesthetic and recreational value and can be used for various purposes in urban architecture and planning (Weyens et al., 2015; Fusaro et al., 2021; Yurtsev et al., 1991).

The flora of Astana has not yet been the subject of research, despite the long history of studying the flora and vegetation of the city as a whole. There is also a lack of data on the ecological state of the city's flora. Monitoring of species composition and dynamics of flora, inventory and analysis of flora of transport highways, anthropogenic and technogenic biotopes are priority tasks in this area. Data on the current state and projected changes in urban flora are necessary for comprehensive studies of the nature of the region, assessment of the ecological situation, organization of monitoring in the study area and optimization of the urban environment. The purpose of this work to present the results of the analysis of the species composition of the urban flora of one of the first and historically significant districts of Astana city, Almaty district.

## 2. Materials and methods

The term «urbanoflora» refers to the assemblage of vascular plant species occurring within a populated area that are capable of completing all or part of their life cycle without direct human intervention.

Urbanized areas, as a rule, have well-defined spatial and ecotopological structures, groups of vascular plant species corresponding to them. In the spatial structure, first of all, the city proper and its immediate surroundings (territories undeveloped or with rural-type development) are distinguished.

Generally accepted classical morphological-geographical methods combined with traditional route-reconnaissance studies (Yurtsev et al., 1991). On the territory of the city will be laid a system of routes with the expectation that, through a certain repetition and in different terms of the growing season, to survey the main variants of natural and anthropogenic habitats within the boundaries of the city of Astana. During the routes, the most characteristic habitats will be identified, a list of plant species will be compiled, geobotanical descriptions of coastal-water zones will be made, and a herbarium will be collected. These routes will cover all major variants of natural and anthropogenic habitats within the administrative boundaries of the city. study of the study area. All plant species will be recorded in an electronic map.

The main feature of the grid mapping method is a complete and uniform study of the study area. The urban area is divided into cells within which the plant species composition is identified. As a result, the authors obtain detailed information on the activity and distribution of species. The research will be accompanied by the creation of a universal database that can be used in monitoring studies of the urban flora of Astana city (Sadyrova et al., 2018).

All plant names are given according to the Plants of the World Online directory (POWO, 2022).

## 3. Results

We have studied 8 parks, 2 squares, and 1 boulevard in the Almaty district of Astana city.

Various species of woody and shrubby plants grow in the study area. Woody plants are represented by coniferous species such as common pine and common spruce.

There is a sufficient number of shrub species. Among perennial herbaceous species, there are creeping clover, meadow clover, big plantain, lanceolate plantain, creeping wheatgrass, awnless brome, white fescue, common fescue, meadow fescue, red fescue, tender wheatgrass, comb, honeysuckle (comb-like wheatgrass), meadow foxtail, meadow bluegrass, meadow timothy, and dandelion.

During the study period, we collected and identified about 125 plant species belonging to 39 families and 95 genera. As a result of herbarium material collection and flora research, we found that the flora of the study area is represented by woody-shrub and herbaceous (perennials and annuals) vegetation.

The flora of the Almaty district of Astana has 125 species belonging to 95 genera and 39 families (Table 1).

Here is a general list of tree, shrub, and herbaceous plant species growing and occurring in the study area.

**Table 1.** List of species growing в in the Almaty district of Astana city

| Species № | Species name | Life form | Ecology | Economic importance |
|---|---|---|---|---|
| *Salicaceae* Mirbel | | | | |
| 1. | *Populus italica* (Münchh.) Moench | Tree | Mesophyte | Decorative |
| 2. | *Populus alba* L. | Tree | Hygromesophyte | Decorative |
| 3. | *Salix alba* L. | Tree | Hygromesophyte | Decorative |
| 4. | *Sálix fragílis* L. | Tree | Mesophyte | Decorative |
| *Betulaceae* S.F. Gray | | | | |

| | | | | |
|---|---|---|---|---|
| 5. | *Betula pendula* Roth | Tree | Mesophyte | Medical, food, honey, fodder, decorative |
| *Ulmaceae* Mirbel | | | | |
| 6. | *Ulmus parvifolia* Jacq. | Tree | Mesophyte | Decorative |
| 7. | *Ulmus glabra* Huds. | Tree | Mesophyte | Decorative |
| 8. | *Ulmus macrocarpa* Hance | Tree | Mesophyte | Decorative |
| 9. | *Ulmus pumila* L. | Tree | Mesophyte | Decorative |
| *Elaeagnaceae* Juss. | | | | |
| 10. | *Elaeagnus commutata* Bernh. ex Rydb. | Tree | Xeromesophyte | Decorative |
| 11. | *Elaeagnus angustifolia* L. | Tree | Xerophyte | Medical, food, honey, fodder, decorative |
| 12. | *Hippophae rhamnoides* L. | Shrub or small Tree | Xeromesophyte | Medical, food, honey, fodder, decorative |
| 13. | *Shepherdia argentea* (Pursh) Nutt. | Tree | Mesophyte | Decorative |
| *Oleaceae* Hoffsgg. | | | | |
| 14. | *Fráxinus excélsior* L. | Tree | Mesophyte | Decorative |
| 15. | *Syringa josikaea* J.Jacq. ex Rchb. | Bush | Mesophyte | Decorative |
| 16. | *Syringa vulgaris* L. | Bush | Mesophyte | Medical, decorative |
| *Pinaceae* Lindley | | | | |
| 17. | *Larix sibirica* Ledeb. | Tree | Mesophyte | Decorative |
| 18. | *Picea obovata* Ledeb. | Tree | Mesophyte | Decorative |
| 19. | Pinus *pallasiana* Lamb. | Tree | Mesophyte | Decorative |
| 20. | *Pinus sylvestris* L. | Tree | Mesophyte | medicinal plant, forage plant, decorative |
| *Cupressaceae* Bartling | | | | |
| 21. | *Juniperus communis* L. | Shrub | Mesophyte | Decorative |
| 22. | *Thuja occidentalis* L. | Shrub or tree | Mesophyte | Medical, decorative |
| *Caprifoliaceae* Juss. | | | | |
| 23. | *Viburnum opulus* L. | Tree | Mesophyte | Decorative |

| | | | | |
|---|---|---|---|---|
| 24. | *Lonicera tatarica* L. | Bush | Mesoxerophyte | Honey, fodder, decorative |
| *Sapindaceae* Juss. | | | | |
| 25. | *Acer tataricum* L. | Tree | Mesoxerophyte | Medical, food, honey, fodder, decorative |
| 26. | *Acer platanoides* L. | Tree | Mesoxerophyte | Medical, food, honey, decorative |
| *Malvaceae* Juss. | | | | |
| 27. | *Tilia cordata* Mill. | Tree | Xerophyte | Medical, food, honey, decorative |
| *Fagaceae* Juss. | | | | |
| 28. | *Quercus robur* L. | Tree | Xeromesophyte | Decorative |
| *Rhamnaceae* Juss. | | | | |
| 29. | *Rhamnus cathartica* L. | shrub | Xeromesophyte | Medical, food, honey, decorative |
| *Berberidaceae* Juss. | | | | |
| 30. | *Berberis vulgaris* L. | shrub | Mesophyte | Medical, food, honey, decorative |
| *Viburnaceae* Raf. | | | | |
| 31. | *Sambucus sieboldiana* (Miq.) Graebn. | shrub | Mesophyte | Medical, honey, decorative |
| 32. | *Cornus alba* L. | shrub | Mesophyte | Honey, fodder, decorative |
| *Fabaceae* Lindl | | | | |
| 33. | *Caragana arborescens* Lam. | Bush | Mesophyte | Honey, fodder, decorative |
| 34. | *Glycyrrhiza uralensis* Fisch. ex DC. | Perennial | Mesophyte | Medical, food, fodder, decorative |
| 35. | *Lathyrus pratensis* L. | Perennial | Mesophyte | Medical, honey, fodder |
| 36. | *Lotus corniculatus* L. | Perennial | Xeromesophyte | Decorative |
| 37. | *Medicago sativa* L. | Perennial | Mesoxerophyte | Medical, honey, fodder |
| 38. | *Melilotus officinalis* (L.) Pall. | Biennial | Mesophyte | Medical, food, fodder, honey, decorative |

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|---|---|---|---|---|
| 39. | *Onobrychis arenaria* (Kit.) DC. | Perennial | Xeromesophyte | Medical, fodder, decorative |
| *Rosaceae* Juss. | | | | |
| 40. | *Amelanchier spicata* (Lam.) C. Koch. | Shrub or small tree | Mesophyte | Medical, food, decorative |
| 41. | *Malus sylvestris* (L.) Mill. | Tree | Mesophyte | Decorative |
| 42. | *Prunus virginiana* L. | Tree | Mesophyte | Food, honey, decorative |
| 43. | *Rosa rugose* Thunb. | shrub | Mesophyte | Honey, decorative |
| 44. | *R. laxa* Retz. | shrub | Mesophyte | Honey, decorative |
| 45. | *Ficaria verna* Huds. | Perennial | Mesoxerophyte | Medical, food, honey, fodder |
| 46. | *Photinia* Lindl. | Bush | Xerophyte | Decorative |
| 47. | *Prunus tenella var. tenella* | shrub | Xeromesophyte | Medical, food, honey, fodder, decorative |
| 48. | *Sonchus oleraceus* L. | Annual | Xerophyte | Medical, food, honey, fodder |
| 49. | *Sórbus aucupária* L. | Tree | Mesoxerophyte | Food, honey, decorative |
| *Poaceae* Barnhart | | | | |
| 50. | *Agrostis gigantea* Roth. | Perennial | Hygromesophyte | Fodder |
| 51. | *Alopecurus pratensis* L. | Perennial | Hygromesophyte | Fodder |
| 52. | *Avena fatua* L. | Annual | Mesophyte | Fodder |
| 53. | *Bromus inermis* (Leyss.) Holub | Perennial | Mesophyte | Fodder, decorative |
| 54. | *B. tectorum* L. | Annual | Mesophyte | Fodder |
| 55. | *Cynodon dactylon* (L.) Pers | Perennial | Xeromesophyte | Weed |
| 56. | *Festuca valesiaca* Schleich. ex Gaudin. | Perennial | Mesoxerophyte | Fodder, decorative |
| 57. | *Echinochloa crus-galli* (L.) P. Beauv. | Annual | Mesophyte | Food, fodder |
| 58. | *Helictochloa. hookeri* (Scribn.) Romero Zarco | Perennial | Mesoxerophyte | Fodder |
| 59. | *Hordeum vulgare* L. | Annual | Mesophyte | Medical, food, fodder, decorative |
| 60. | *Phleum pratense* L. | Perennial | Mesophyte | Fodder |

| | | | | |
|---|---|---|---|---|
| 61. | *Poa pratensis* L. | Perennial | Mesophyte | Fodder, decorative |
| 62. | *P. bulbosa* L. | Perennial | Mesophyte | Fodder |
| 63. | *Phragmites australis* (Cav.) Trin. ex Steud. | Perennial | Гигрофит | Medical, food, fodder, decorative |
| 64. | *Puccinellia dolicholepis* V. Krecz. | Perennial | Hygromesophyte | Fodder |
| 65. | *Setaria viridis* (L.) P. Beauv. | Annual | Mesophyte | Fodder |
| 66. | *Stellaria media* (L.) Vill. | Annual, Biennial | Mesophyte | Medical, food, honey, fodder |
| *Caryophyllaceae* Juss. | | | | |
| 67. | *Cerastium holosteoides* Fries. | Perennial, Biennial | Mesophyte | - |
| 68. | *Gypsophila paniculata* L. | Perennial | Mesoxerophyte | Medical, food, honey, fodder, decorative |
| Семейство *Liliaceae* Juss. | | | | |
| 69. | *Tulipa patens* Agardh ex Schult. | Perennial | Xerophyte | Decorative |
| *Amaranthaceae* Juss. | | | | |
| 70. | *Amaranthus retroflexus* L. | Annual | Mesophyte | Medical, food, fodder |
| 71. | *Chenopodium album* L. | Annual | Xerophyte | Weed |
| *Polygonaceae* Juss. | | | | |
| 72. | *Polygonum aviculare* L. | Annual | Xeromesophyte | Fodder |
| 73. | *Rumex confertus* Willd. | Perennial | Mesophyte | Medical, food, fodder, decorative |
| *Scrophulariaceae* Juss. | | | | |
| 74. | *Verbascum thapsus* L. | Biennial | Xeromesophyte | Medical, honey |
| *Apiaceae* Lindl. | | | | |
| 75. | *Eryngium planum* L. | Perennial | Mesoxerophyte | Medical |
| Limoniaceae Ser. | | | | |
| 76. | *Goniolimon speciosum* (L.) Boiss. | Perennial | Mesoxerophyte | Decorative |
| *Brassicaceae* Burnett | | | | |
| 77. | *Alyssum turkestanicum* Regel et Schmalh. | Annual | Мезоксерофит | Medical, honey, fodder, decorative |

| | | | | |
|---|---|---|---|---|
| 78. | *Berteroa incana* (L.) DC. | Biennial | Xeromesophyte | Medical, food, honey |
| 79. | *Camelina microcarpa* Andrz. ex DC. | Annual | Xeromesophyte | food, fodder |
| 80. | *Chorispora sibirica* (L.) DC. | Annual | Xerophyte | Medical, honey |
| 81. | *Capsella bursa-pastoris* (L.) Medik. | Annual | Xerophyte | Medical, food, honey, fodder, decorative |
| 82. | *Ch. tenella* (Pall.) DC. | Annual | Mesophyte | Honey |
| 83. | *Descurainia. Sophia* (L.) Webb ex Prantl. | Annual | Mesophyte | Medical, food, fodder |
| 84. | *Erysimum diffusum* Ehrh. | Biennial | Mesophyte | Medical, honey |
| 85. | *Thlaspi arvense* L. | Annual | Xerophyte | Medical, food, decorative |
| | *Plantaginaceae* Juss. | | | |
| 86. | *Plantago lanceolata* L. | Perennial | Mesophyte | Medical, food, fodder |
| 87. | *P. major* L. | Biennial | Mesophyte | Medical, food, fodder, decorative |
| 88. | *Veronica chamaedrys* L. | Perennial | Mesophyte | Medical, honey |
| 89. | *V. spuria* L. | Perennial | Xeromesophyte | - |
| | *Asteraceae* Bercht. & J.Presl | | | |
| 90. | *Taraxacum officinale* Weber ex F.H. Wigg. | Perennial | Mesophyte | Medical, food, honey, fodder, decorative |
| 91. | *Artemisia vulgaris* L. | Perennial | Mesophyte | Medical, food, fodder, decorative |
| 92. | *Artemisia austriaca* Jacq. | Perennial | Mesoxerophyte | Medical, fodder, decorative |
| 93. | *A. dracunculus* L. | Perennial | Xeromesophyte | Medical, food, fodder, decorative |
| 94. | *A. marschalliana* Spreng. | Subshrub | Xeromesophyte | Fodder |
| 95. | *A. scoparia* Waldst. et Kit. | Perennial | Xeromesophyte | Medical, food, honey, decorative |
| 96. | *Arctium tomentosum* Mill. | Biennial | Mesophyte | Medical, food, fodder, decorative |
| 97. | *Carduus crispus* L. | Perennial | Mesophyte | Medical, honey, fodder |

| | | | | |
|---|---|---|---|---|
| 98. | *Centaurea scabiosa* L. | Perennial | Xeromesophyte | Medical, honey, decorative |
| 99. | *Cichorium intybus* L. | Perennial | Mesophyte | Medical, food, fodder, decorative |
| 100. | *Cirsium arvense* (L.) Scop. | Perennial | Mesophyte | Medical, honey |
| 101. | *Crepis tectorum* L. | Annual, Biennial | Mesophyte | Medical, decorative |
| 102. | *Erigeron canadensis* L. | Annual | Mesophyte | Medical |
| 103. | *Lactuca serriola* Torner. | Biennial | Xeromesophyte | Food, Fodder |
| 104. | *Matricaria chamomilla* L. | Annual | Mesophyte | Medical, food, decorative |
| 105. | *Tanacetum nobilis* | Perennial | Xerophyte | Medical, food, decorative |
| 106. | *Taraxacum officinale* Weber ex F.H. Wigg. | Perennial | Mesophyte | Medical, food, fodder, honey, decorative |
| 107. | *Xanthium strumarium* L. | Annual | Xeromesophyte | Medical, decorative |
| *Papaveraceae* Juss. | | | | |
| 108. | *Chelidonium majus* L. | Perennial | Mesophyte | Medical, decorative |
| *Ranunculaceae* Juss. | | | | |
| 109. | *Ranunculus repens* L. | Perennial | Mesohygrophyte | Fodder |
| 110. | *Thalictrum minus* subsp. *saxatile* Gaudin. | Perennial | Mesophyte | Medical |
| *Urticaceae* Juss. | | | | |
| 111. | *Urtica dioica* L. | Perennial | Mesophyte | Medical, food, decorative |
| Total: 111 | | | | |

Analysis of the largest families of the flora of the study area showed that species of woody and shrubby vegetation from the families are widely used in park construction: *Asteraceae* (18; 16.2 %), *Poaceae* (17; 15.3 %), *Rosaceae* (10; 9.0 %), *Brassicaceae* (9; 8.1 %), *Fabaceae* (7; 6.3 %). The following families comprise 4 species (3.6 %) each: *Pinaceae, Salicaceae, Plantaginaceae, Ulmaceae,* and *Elaeagnaceae.* These largest families account for 81 species or 72.9 % of the park's total flora. The Oleaceae family has 3 species (2.7 %), 2 (1.8 %) species: *Ranunculaceae, Aceraceae, Caprifoliaceae, Caryophyllaceae, Sapindaceae, Cupressaceae, Viburnaceae,* and *Amaranthaceae.* These largest families account for 108 species or 85 % of the park's total flora. The remaining 13 families contain one species each. These include the following: *Betulaceae, Malvaceae, Liliaceae, Papaveraceae, Fagaceae, Viburnaceae, Rhamnaceae, Tiliaceae, Polygonaceae, Scrophulariaceae, Limoniaceae, Berberidaceae, Urticaceae, Apiaceae* (Figure 1).

A study of the structure of the major families of vascular plants revealed that they are dominated by members of the *Asteraceae, Poaceae, Rosaceae, Brassicaceae,* and *Fabaceae* families.

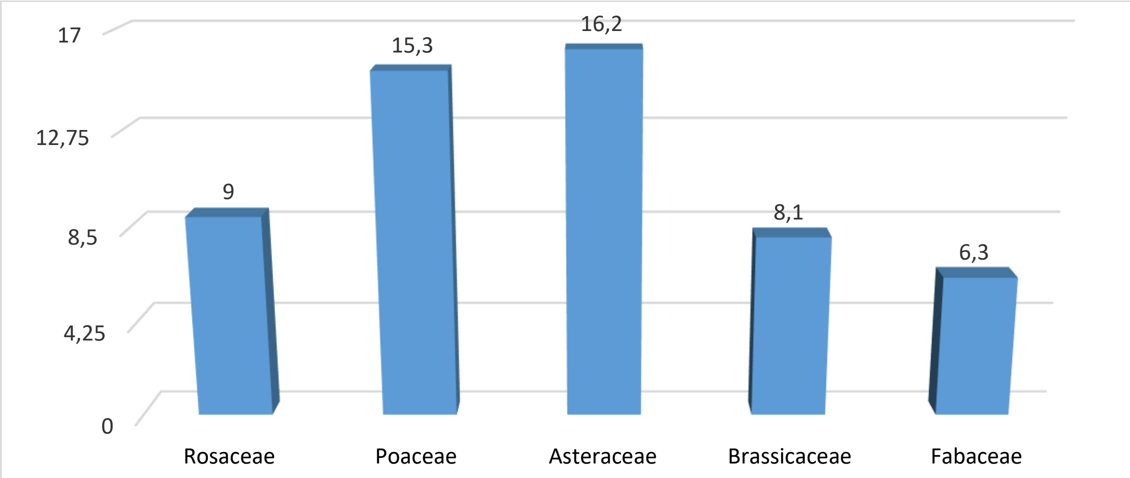


**Figure 1.** Leading families of the flora of the study area (Source: compiled by the authors)

Analysis of the species richness of genera of the flora of the study area revealed that of the 92 genera, the major genera are: *Artemisia* (5; 5.4 %), *Ulmus* (4; 4.3 %).

There are 13 genera with two species each: *Salix*, *Populus*, *Acer*, *Elaeagnus*, *Rosa*, *Syringa*, *Pinus*, *Prunus*, *Chorispora*, *Veronica*, *Poa*, *Bromus*, and *Plantago*. These 13 genera account for 14.1 % of the total flora and 74 genera (80 %) each contain one species (Figure 2).

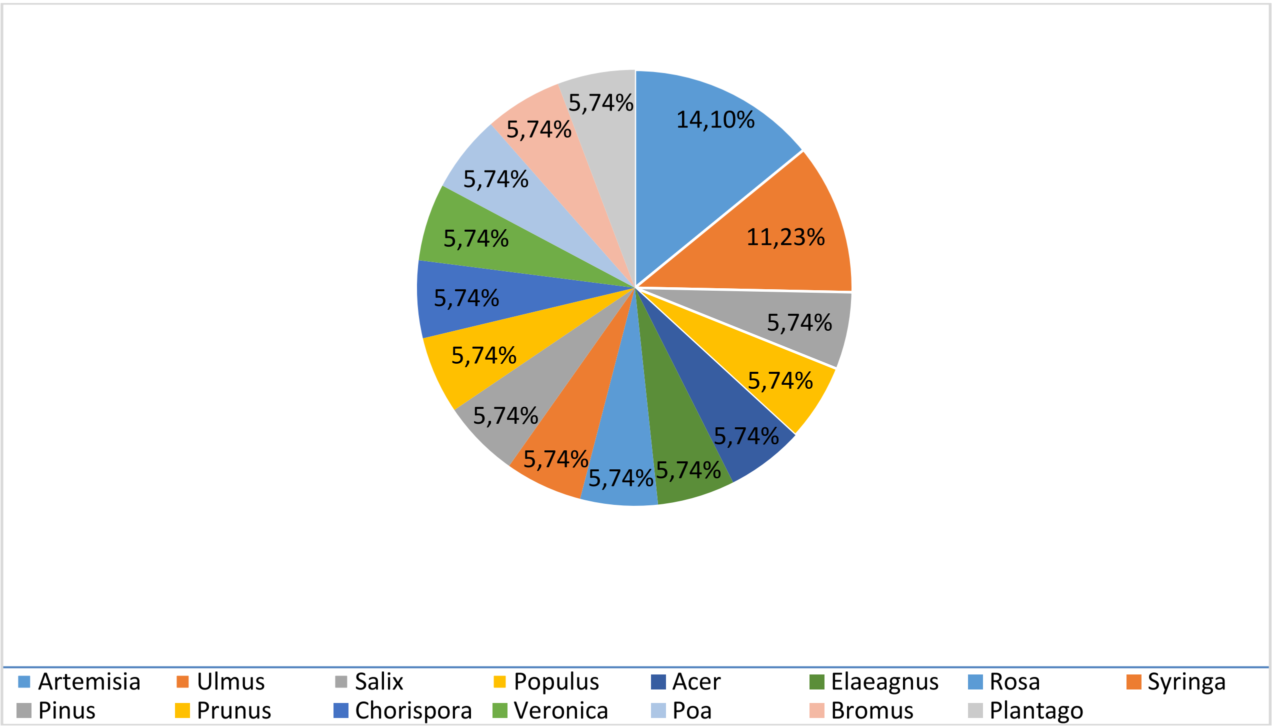


**Figure 2.** The largest genera of the flora of the Almaty district of Astana city (Source: compiled by the authors)

Analysis of life forms showed that the leading positions are occupied by perennial herbaceous forms, 57 species or 45.6 %, a small percentage (33.6 %) falls on tree forms - 42 species. And a small percentage (20.8 %) falls on shrub forms - 26 species.

It is worth noting a significant proportion of annuals (19 c.) of long vegetation and ephemerals, which is a characteristic feature of the vegetation cover of the city.

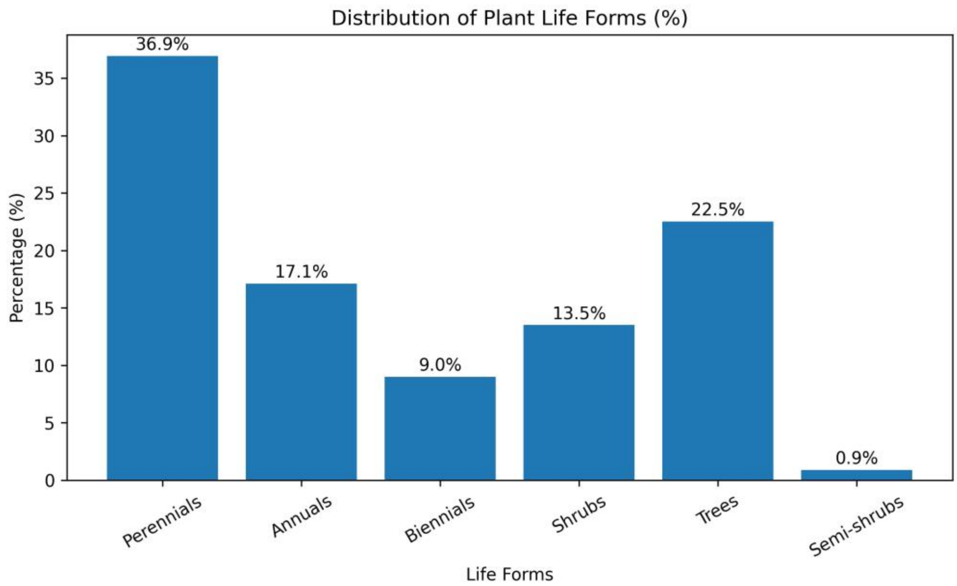


**Figure 3.** The largest genera of flora of parks in the Almaty district (Source: compiled by the authors)

According to the data presented in Figure 3, the species composition of the flora is characterized by a predominance of perennial plants, which account for 36.9 % of the total number of species. These are followed by tree species (22.5 %), annual herbs (17.1 %), and shrubs (13.5 %). Biennial plants (9.0 %) and subshrubs (0.9 %) are represented to a lesser extent. This distribution indicates the dominance of long-lived life forms in the studied ecosystem (Figure 3).

The ecological structure in relation to environmental conditions showed that in the flora, a significant part of the species belongs to mesophytes - 41 species. The second place is occupied by xeromesophytes (25 species), the third place is occupied by mesoxerophytes (20 species), xerophytes (19 species), mesohygrophytes (5 species) and hydrophytes (1 species). (Table 2).

**Table 2.** Distribution of species by ecological groups

| Ecological group | Number of species | % of total number of species |
|---|---|---|
| Xerophytes | 19 | 17.1 |
| Xeromesophytes | 25 | 22.5 |
| Mesoxerophytes | 20 | 18.0 |
| Mesophytes | 41 | 36.9 |
| Hygrophytes | 1 | 0.9 |
| Mesohygrophytes | 5 | 4.5 |
| Total: | 111 | 100 |

Among the rare and endangered species, which are an integral part of the overall problem of protection of the plant world, is *Tulipa patens* Agardh ex Schult. is noted, listed in the Red Book of Kazakhstan (2014).

One of the most important problems of fundamental and applied botany in recent times has become the «flooding» of regional floras with new alien species, as well as invasions of individual species in natural communities. The following alien species were observed in Astana city: *Acer negundo* L., *Erigeron canadensis* L., *Amaranthus albus* L.

The study of the possibilities of practical application of the flora of the city of Astana showed a significant number of species of value in economic terms: fodder, medicinal, melliferous, ornamental, food, represented in the families *Asteraceae, Fabaceae, Rosaceae, Poaceae* and *Brassicaceae* (Table 2).

Among fodder plants, the maximum number of species belongs to the families *Fabaceae, Brassicaceae* and *Asteraceae*.

## 4. Discussion

It is well known that transportation infrastructure and land-use systems in urban environments have a direct impact on the development of urban vegetation and the ecological condition of green spaces. Dambebo and Jalloh consider the transportation system to be one of the key factors contributing to air pollution and traffic congestion, especially near the city center (Dambeebo et al., 2018). This conclusion is consistent with the results of our study, as the parks, squares, and boulevards of the Almaty district of Astana directly border areas with high traffic volumes. Such conditions contribute to the formation of specific plant communities dominated by ruderal and stress-tolerant species, such as *Plantago major, Taraxacum officinale,* and members of the *Festuca* genus.

According to Collier et al. (Collier et al., 2014; Collier et al., 2020), the development of the transportation network leads to a transformation in land-use patterns and the spatial organization of the urban environment, contributing to the concentration of residential, commercial, and industrial facilities (Collier et al., 2020, Belaire et al., 2022). As a result, a mosaic-type vegetation pattern emerges, combining tree, shrub, and herbaceous components. The detection of 125 plant species indicates that even anthropogenically transformed landscapes are capable of supporting a certain level of biodiversity.

A comparative analysis with other urbanized areas in Europe and Asia confirms the universality of the identified patterns. For example, in Berlin, ruderal and neophyte species were found to dominate disturbed areas (Kowarik et al., 2011). Similar trends have been observed in London, where a high density of the road network correlates with an increase in the proportion of cosmopolitan species (Aronson et al., 2014).

Similar processes are observed in Asian megacities. In Beijing (Zhang et al., 2022), it has been shown that intensive development of transportation infrastructure contributes to the fragmentation of green spaces and the formation of plant communities dominated by pollution-tolerant species. In Seoul (Oh & Park, 2023), it was found that urbanization and road construction lead to a decline in the proportion of native species and increased biotic homogenization.

Such trends are consistent with the concept of biotic homogenization described by McKinney (2008), according to which urbanized areas in different regions become floristically similar due to the spread of broadly adapted synanthropic species. In this context, the flora of the Almaty district of Astana exhibits characteristics typical of both European and Asian cities, confirming the global nature of the impact of transport infrastructure on biodiversity.

Zhang et al. emphasize that user safety is a priority in the design of transportation infrastructure, achieved through the geometric design of roads in accordance with national and international standards (Zhang et al., 2022). However, this approach also has environmental consequences: the expansion of the road network and the reduction of green buffer zones increase habitat fragmentation and limit the dispersal of sensitive species. As Forman and Alexander (Forman et al., 1998) note, roads function as ecological barriers that increase population isolation and alter ecosystem structure.

Thus, a comparison of the data obtained with the results of studies in Europe and Asia shows that transportation infrastructure gives rise to similar patterns of urban flora transformation regardless of the region.

The «urban heat island» effect, characteristic of large urbanized areas, also has a significant impact on the structure of urban flora. Elevated temperatures near road surfaces and dense development alter the phenological cycles of plants, extending the growing season and promoting earlier seed germination. This can lead to a shift in competitive relationships between species, particularly favoring thermophilic and fast-growing plants. In Astana, with its sharply continental climate, this effect may play a particularly significant role, partially compensating for extreme climatic conditions and creating local «refugia» for certain species.

The role of soil characteristics in shaping the floristic composition deserves separate consideration. Soil compaction, characteristic of areas with heavy traffic, reduces its water permeability and aeration, which limits the development of species with deep root systems (Gregory et al., 2006; Werkenthin et al., 2014). Under such conditions, plants with shallow root systems and a high capacity for vegetative reproduction gain an advantage (Von der Lippe et al., 2007). Long-distance dispersal of plants by vehicles as a driver of plant invasions. Conservation Biology, 21(4), 986-996. Additionally, the accumulation of heavy metals and salts from road dust and de-icing agents creates specific edaphic conditions that favor the selection of tolerant species.

Another important mechanism driving the transformation of urban flora is the transport-driven dispersal of plants. Motor vehicle traffic facilitates passive seed dispersal (zoochory and anthropochory), which accelerates the spread of synanthropic and invasive species along the road network. Roads function as important dispersal corridors facilitating the establishment and spread of invasive plant species in disturbed urban and peri-urban habitats (Gelbard et al., 2003; Li et al., 2022; Lennartsson et al., 2023). Thus, transportation infrastructure serves a dual purpose: on the one hand, roads can act as barriers to certain species, while on the other, they can facilitate the rapid movement of plants between different parts of the city and surrounding areas.

Furthermore, the observed diversity (125 species) indicates a balance between colonization and local extinction processes. Despite high levels of human impact, urban ecosystems maintain a certain degree of resilience due to a constant influx of species and the availability of ecological niches. However, this resilience is functionally limited, as it is maintained primarily by species with broad ecological ranges.

Thus, the urban flora of the Almaty region is shaped by a complex of interrelated factors, including microclimatic changes, edaphic conditions, transport-mediated species dispersal, and the spatial heterogeneity of the environment. These processes determine not only taxonomic diversity but also the functional structure of plant communities, which is important to consider when developing strategies for the sustainable management of urban green infrastructure.

## 5. Conclusion

Due to the rapid urbanization of the capital, accompanied by the transformation of natural landscapes, identifying the patterns of urban flora formation has taken on particular scientific and practical significance. This study provides, for the first time, a comprehensive assessment of the floristic composition, taking into account the ratio of native, introduced, and ruderal species, which allows us to view urban flora as the result of the interaction between natural and anthropogenic factors.

It has been established that the formation of urban flora is determined by a combination of climatic conditions-a sharply continental climate-and high anthropogenic pressure, including landscaping practices and transportation infrastructure. The identified flora structure is characterized by the dominance of ecologically plastic and resilient species, indicating the operation of ecological filtration mechanisms. At the same time, there is a tendency toward an increase in overall species richness during the early stages of urbanization, followed by a transformation of the flora structure and a rise in the proportion of unique and naturalized species.

The scientific novelty of this study lies in identifying region-specific characteristics of urban flora formation in Northern Kazakhstan, where extreme climatic factors amplify the selective impact of the urbanized environment. The results demonstrate that Astana's urban flora constitutes a dynamic system currently in a stage of active formation, in which processes of introduction, naturalization, and partial loss of the native component are occurring simultaneously.

The practical significance of the study lies in substantiating the need to integrate ecological principles into urban greening strategies aimed at conserving biodiversity and enhancing the resilience of urban ecosystems. In the long term, there is a need for long-term monitoring, quantitative assessment of functional diversity, and the development of scientifically sound approaches to green infrastructure management, taking into account climatic and anthropogenic constraints.

Amid Astana's rapid urbanization, there has been an increase in the number of adventive and synanthropic plants, a trend particularly evident in disturbed urban habitats, including roadways, construction sites, and recreational areas. The spread of invasive species can alter the composition and structure of the local flora and affect the ecological stability of urban ecosystems. The results obtained serve as a basis for further research on the dynamics of the spread of invasive and adventive species, their ecological adaptability, and their impact on urban plant communities under conditions of anthropogenic impact.

**6. Supplementary Materials:** No supplementary materials are available.

**7. Author Contributions**

Conceptualization – A.K.; methodology – S.M., G.K.; data processing – M.R.; validation – G.K.; formal analysis – A.K.; investigation – S.K.; resources – S.M.; data curation – S.M., M.Sh.; writing – original draft preparation – S.M., M.Sh.; writing – review and editing S.M., M.Sh.; visualization – M.R.

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## Анализ видового состава урбанофлоры Алматинского района города Астаны

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**Аннотация.** В последние годы исследования городских флор опровергли мнение о их бедности по общему числу видов, и было установлено, что городские флоры отличаются от природных аналогов и в то же время отражают их богатство. В нашей статье представлен состав городской флоры Алматинского района города Астаны. Выявлено, что городская флора Алматинского района г. Астаны насчитывает 125 видов, относящихся к 95 родам и 39 семействам. Основу урбанофлоры данного района составляют виды древесно-кустарниковой растительности из семейств: *Rosaceae* Juss. (20; 15,8 %), *Poaceae* Barnhart (19; 15,0 %), *Asteraceae* Bercht. & J. Presl (11; 8,7 %), *Aceraceae* Juss. (син. *Sapindaceae* Juss.) (6; 4,7 %). В озеленении Алматинского района города Астаны эти крупнейшие семейства составляют 108 видов или 85 % от общей флоры парка. Анализ видового богатства родов флоры района исследования выявил, что из 95 родов крупными являются: *Acer* L. (6; 6,3 %), *Fraxinus* Tourn. ex L. (4; 4,2 %), *Populus* L. (4; 4,2 %), *Picea* A. Dietr. (3; 3,1 %), *Malus* Mill. (3; 3,1 %), *Spiraea* L. (3; 3,1 %). Полученные результаты показывают, что городская флора характеризуется структурированной композицией с доминированием ограниченного числа таксономических групп. Такая структура отражает как целенаправленные практики озеленения, так и экологическую адаптивность видов к условиям городской среды. Преобладание древесной и кустарниковой растительности подчеркивает их важную экологическую роль в поддержании экологической стабильности, улучшении качества воздуха и повышении общей устойчивости городских экосистем.

**Ключевые слова:** урбанофлора; Астана; Алматинский район; семейство; биоразнообразие.

# Астана қаласы Алматы ауданының урбанофлорасының түрлік құрамына талдау

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**Аңдатпа.** Соңғы жылдары жүргізілген қалалық флораға қатысты зерттеулер урбанофлоралардың түрлік құрамы жағынан кедей деген пікірді теріске шығарды. Зерттеулер қалалық флоралардың табиғи орта флорасынан ерекшеленетінін, сонымен бірге оның байлығын бейнелейтінін көрсетті. Біздің мақалада Астана қаласы Алматы ауданының қалалық флорасының құрамы берілген. Белгіленгендей, ауданның урбанофлорасы 125 түрді қамтиды, 95 туысқа және 39 тұқымдасқа жатады. Ауданның негізгі жасыл желегін мынадай ағаш-бұта өсімдіктері құрайды: *Rosaceae* Juss. (20 түр; 15,8 %), *Poaceae* Barnhart (19; 15,0 %), *Asteraceae* Bercht**.** & J. Presl (11; 8,7 %), *Aceraceae* Juss. (син. *Sapindaceae* Juss**.**) (6; 4,7 %). Жалпы алғанда, бұл ірі тұқымдастар 108 түрді біріктіріп, аудан флорасының шамамен 85 % құрайды. Туыстардың түрлік байлығын талдау нәтижесінде ең ірілері анықталды: *Acer* L. (6 түр; 6,3 %), *Fraxinus* Tourn. ex L. (4; 4,2 %), *Populus* L. (4; 4,2 %), *Picea* A. Dietr. (3; 3,1 %), *Malus* Mill. (3; 3,1 %), *Spiraea* L. (3; 3,1 %). Алынған нәтижелер қалалық флораның шектеулі таксономиялық топтардың басым болуымен сипатталатын құрылымдалған құрамға ие екенін көрсетеді. Мұндай құрылым қаланы көгалдандырудың мақсатты жүргізілуімен қатар, өсімдік түрлерінің қалалық орта жағдайларына экологиялық бейімделгіштігін де айқындайды. Ағашты және бұталы өсімдіктердің басым болуы олардың экологиялық тұрақтылықты қамтамасыз етудегі, ауа сапасын жақсартудағы және қалалық экожүйелердің жалпы тұрақтылығын арттырудағы маңызды рөлін көрсетеді.

**Түйін сөздер:** урбанофлора; Астана; Алматы ауданы; тұқымдас; биоалуантүрлілік.