

SPECIES COMPOSITION OF TREE VEGETATION IN THE CITY OF SOFIA

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Abstract. The article examines the diversity of tree species in part of Sofia, Bulgaria, spanning approximately 60 km². A total of 91 species from 53 genera and 25 families were identified. Dominating in the area is *Fraxinus excelsior*, which constitutes 494 individuals, representing 12.7% of the total number of trees. The genus *Fraxinus* is the most abundant, with five species accounting for 22.21% of all trees observed. Although these proportions marginally surpass the thresholds outlined by the 10/20/30% rule, they do not yet indicate significant concern. Nonetheless, the high prevalence of *Fraxinus excelsior* and its genus raises alarms about potential increased risks of disease and environmental stress. Other frequently encountered species include *Prunus cerasifera*, *Quercus robur*, *Aesculus hippocastanum*, *Juglans regia*, *Fraxinus oxycarpa* and *Tilia cordata*. Two invasive species were found in notable quantities: *Robinia pseudoacacia* (163 individuals) and *Ailanthus altissima* (88 individuals).

Keywords: Urban forest, tree species composition, Sofia

INTRODUCTION

The diversity of trees in urban environments is crucial for multiple ecological, social, and health-related reasons. Urban forests, characterized by a variety of tree species, provide essential ecosystem services that enhance the quality of life for city residents and contribute to environmental sustainability. Maintaining a diverse urban forest is essential for building resilience against pests and diseases. The lack of tree diversity puts urban forests at risk from both abiotic (e.g. climate change) and biotic (e.g. pest invasions) impacts [1]. Planting only one or few species increases vulnerability to pest outbreaks and pathogens, potentially resulting in significant tree loss and diminished ecosystem function. By incorporating a variety of tree species, urban planners can develop a more resilient urban forest that is less prone to these threats [2]. This is especially critical in the face of climate change, which may intensify the effects of pests and diseases on urban trees [3].

The diversity of tree species in urban areas improves the ecosystem services, like enhancing air quality by filtering pollutants and capturing particulate matter [4], managing stormwater runoff, mitigating flooding, and alleviating urban heat island effects [5]. A mix of tree species also supports a broader range of wildlife, including birds and beneficial insects, which depend on trees for shelter and nourishment [6]. Furthermore, having a range of tree species enhances the overall biodiversity of urban ecosystems. Diverse tree populations support a greater variety of organisms, from soil microbes to larger wildlife, thus contributing to the ecological health of urban environments [7]. According to Sikorska et. al. [8],

by promoting a diverse array of species, genera, and families, urban planners can reduce also the likelihood of invasive species establishing themselves and spreading within urban landscapes. The social and psychological advantages of tree diversity are also significant. Studies show that access to diverse green spaces can enhance mental health and overall well-being for urban dwellers [9]. Trees add aesthetic value to neighborhoods, which can lead to increased property values and foster community pride [10].

To manage and improve diversity, there has been wide-spread acceptance of the 10/20/30% 'rule of thumb' proposed by Santamour [11], which states that municipal forests should comprise no more than 10% of any species, 20% of any genus or 30% of any family [12]. This rule is particularly relevant in urban settings where tree diversity can significantly influence ecosystem services, community health, and urban sustainability.

MATERIALS AND METHODS

The study focuses on an area of approximately 60 km² within the city of Sofia, Bulgaria. It is located mainly in the western half of the city, covering southern and western neighborhoods, as well as the central area. The research focuses on the species composition of tree vegetation in accessible green spaces, such as parks, gardens, inter-block spaces, street and alley plantings, yards, etc. The study was conducted using the transect method, with transects selected through systematic-random sampling to capture the full diversity of species in the surveyed area. A total of 80 transects, each 200 meters long, were examined (Fig. 1).



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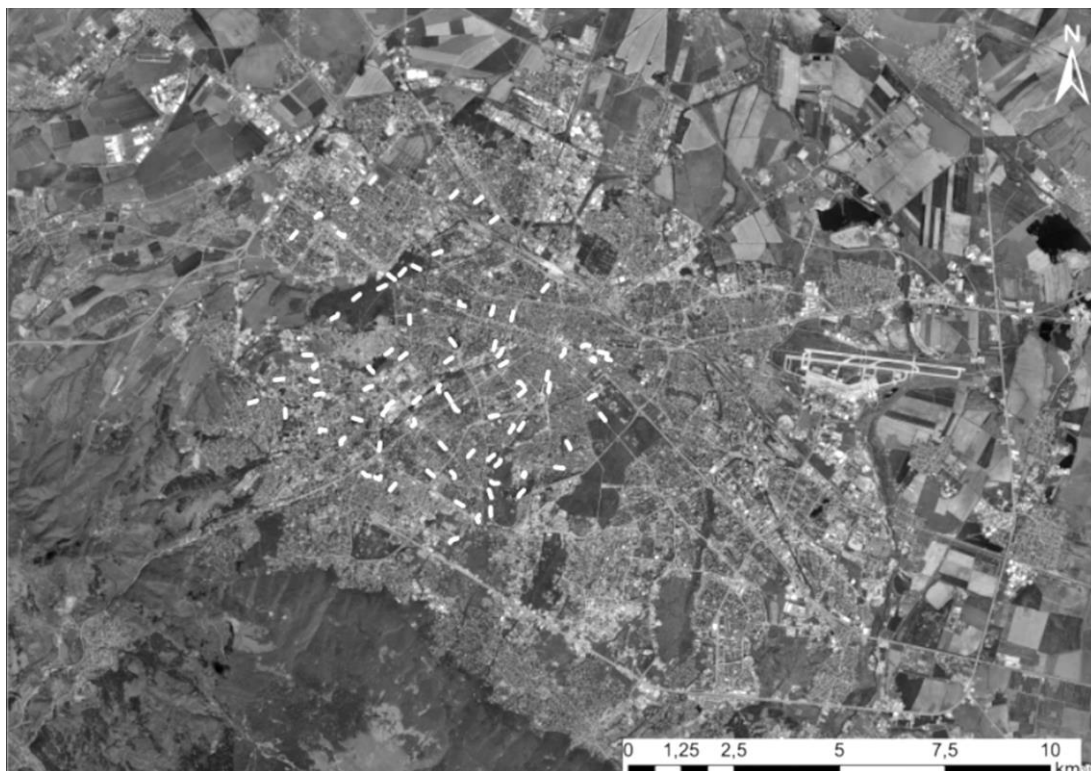


Fig. 1. Location of the surveyed transects

RESULTS

A total of 3891 trees from 91 species have been identified (Table 1), with 22 of them represented by more than 50 individuals. The most commonly used species for landscaping in the surveyed transects is *Fraxinus excelsior*, with 494 individuals found, representing 12.7% of the total number of trees. This species grows in all types of green spaces, including parks, gardens, inter-block spaces, along streets and boulevards. The remaining species are represented by less than 10% of the overall count. The second

most numerous species is *Prunus cerasifera*, which in many cases is self-seeded and has a sprouting character, with 363 individuals recorded. More than 100 individuals have also been identified from the species *Quercus robur*, *Aesculus hippocastanum*, *Juglans regia*, *Fraxinus oxycarpa*, *Tilia cordata*, *Robinia pseudoacacia*, *Betula pendula*, *Picea abies*, and *Acer platanoides*. Two invasive tree species are present in relatively high numbers: *Robinia pseudoacacia* (163 trees) and *Ailanthus altissima* (88 trees).

Table 1. Tree species identified in the surveyed transects

No	Species	Genus	Family	Number	%
1	<i>Fraxinus excelsior</i>	Fraxinus	Oleaceae	494	12.70
2	<i>Prunus cerasifera</i>	Prunus	Rosaceae	363	9.33
3	<i>Quercus robur</i>	Quercus	Fagaceae	216	5.55
4	<i>Aesculus hippocastanum</i>	Aesculus	Sapindaceae	177	4.55
5	<i>Juglans regia</i>	Juglans	Juglandaceae	174	4.47
6	<i>Fraxinus oxycarpa</i>	Fraxinus	Oleaceae	172	4.42
7	<i>Robinia pseudoacacia</i>	Robinia	Fabaceae	163	4.19
8	<i>Tilia cordata</i>	Tilia	Tiliaceae	157	4.03
9	<i>Acer platanoides</i>	Acer	Sapindaceae	151	3.88
10	<i>Betula pendula</i>	Betula	Betulaceae	144	3.70

No	Species	Genus	Family	Number	%
11	<i>Picea abies</i>	Picea	Pinaceae	141	3.62
12	<i>Populus alba</i>	Populus	Salicaceae	123	3.16
13	<i>Tilia platyphyllos</i>	Tilia	Tiliaceae	106	2.72
14	<i>Fraxinus ornus</i>	Fraxinus	Oleaceae	95	2.44
15	<i>Fraxinus americana</i>	Fraxinus	Oleaceae	90	2.31
16	<i>Pinus sylvestris</i>	Pinus	Pinaceae	90	2.31
17	<i>Ailanthus altissima</i>	Ailanthus	Simaroubaceae	88	2.26
18	<i>Platanus occidentalis</i>	Platanus	Platanaceae	70	1.80
19	<i>Thuja orientalis</i>	Thuja	Cupressaceae	59	1.52
20	<i>Salix alba</i>	Salix	Salicaceae	56	1.44
21	<i>Gleditsia triacanthus</i>	Gleditsia	Fabaceae	54	1.39
22	<i>Picea pungens</i>	Picea	Pinaceae	51	1.31
23	<i>Catalpa bignonioides</i>	Catalpa	Bignoniaceae	47	1.21
24	<i>Prunus avium</i>	Prunus	Rosaceae	47	1.21
25	<i>Pinus nigra</i>	Pinus	Pinaceae	45	1.16
26	<i>Populus tremula</i>	Populus	Salicaceae	45	1.16
27	<i>Malus domestica</i>	Malus	Rosaceae	41	1.05
28	<i>Thuja occidentalis</i>	Thuja	Cupressaceae	38	0.98
29	<i>Chamaecyparis lawsoniana</i>	Chamaecyparis	Cupressaceae	25	0.64
30	<i>Acer pseudoplatanus</i>	Acer	Sapindaceae	21	0.54
31	<i>Pseudotsuga menziesii</i>	Pseudotsuga	Pinaceae	20	0.51
32	<i>Acer campestre</i>	Acer	Sapindaceae	19	0.49
33	<i>Taxus baccata</i>	Taxus	Taxaceae	18	0.46
34	<i>Maclura pomifera</i>	Maclura	Moraceae	17	0.44
35	<i>Tilia tomentosa</i>	Tilia	Tiliaceae	15	0.39
36	<i>Fraxinus orientalis</i>	Fraxinus	Oleaceae	13	0.33
37	<i>Syringa vulgaris</i>	Syringa	Oleaceae	13	0.33
38	<i>Cedrus atlantica</i>	Cedrus	Pinaceae	11	0.28
39	<i>Ginkgo biloba</i>	Ginkgo	Ginkgoaceae	11	0.28
40	<i>Platanus orientalis</i>	Platanus	Platanaceae	11	0.28
41	<i>Acer negundo</i>	Acer	Sapindaceae	10	0.26
42	<i>Morus nigra</i>	Morus	Moraceae	9	0.23
43	<i>Sequoiadendron giganteum</i>	Sequoiadendron	Cupressaceae	9	0.23
44	<i>Ulmus glutinosa</i>	Ulmus	Ulmaceae	9	0.23
45	<i>Abies alba</i>	Abies	Pinaceae	8	0.21
46	<i>Abies concolor</i>	Abies	Pinaceae	7	0.18
47	<i>Cupressus sempervirens</i>	Cupressus	Cupressaceae	7	0.18
48	<i>Ficus carica</i>	Ficus	Moraceae	7	0.18
49	<i>Pinus strobus</i>	Pinus	Pinaceae	7	0.18
50	<i>Ulmus laevis</i>	Ulmus	Ulmaceae	7	0.18
51	<i>Acer tataricum</i>	Acer	Sapindaceae	6	0.15
52	<i>Cydonia oblonga</i>	Cydonia	Rosaceae	6	0.15
53	<i>Quercus cerris</i>	Quercus	Fagaceae	6	0.15
54	<i>Salix caprea</i>	Salix	Salicaceae	6	0.15
55	<i>Aesculus rubicunda</i>	Aesculus	Sapindaceae	5	0.13
56	<i>Cedrus deodara</i>	Cedrus	Pinaceae	5	0.13
57	<i>Celtis australis</i>	Celtis	Cannabaceae	5	0.13
58	<i>Cercis siliquastrum</i>	Cercis	Fabaceae	5	0.13
59	<i>Cornus mas</i>	Cornus	Cornaceae	5	0.13
60	<i>Morus sp.</i>	Morus	Moraceae	5	0.13

No	Species	Genus	Family	Number	%
61	<i>Pinus peuce</i>	Pinus	Pinaceae	5	0.13
62	<i>Prunus serulata</i>	Prunus	Rosaceae	5	0.13
63	<i>Quercus frainetto</i>	Quercus	Fagaceae	5	0.13
64	<i>Albizia julibrissin</i>	Albizia	Fabaceae	4	0.10
65	<i>Juniperus skyrocket</i>	Juniperus	Cupressaceae	4	0.10
66	<i>Liquidambar styraciflua</i>	Liquidambar	Altingiaceae	4	0.10
67	<i>Pyrus communis</i>	Pyrus	Rosaceae	4	0.10
68	<i>Sophora japonica</i>	Styphnolobium	Fabaceae	4	0.10
69	<i>Acer saccharinum</i>	Acer	Sapindaceae	3	0.08
70	<i>Corylus avellana</i>	Corylus	Betulaceae	3	0.08
71	<i>Hibiscus syriacus</i>	Hibiscus	Malvaceae	3	0.08
72	<i>Paulownia tomentosa</i>	Paulownia	Paulowniaceae	2	0.05
73	<i>Thuja plicata</i>	Thuja	Cupressaceae	2	0.05
74	<i>Acer monspessulanum</i>	Acer	Sapindaceae	1	0.03
75	<i>Acer palmatum</i>	Acer	Sapindaceae	1	0.03
76	<i>Alnus glutinosa</i>	Alnus	Betulaceae	1	0.03
77	<i>Catalpa longissima</i>	Catalpa	Bignoniaceae	1	0.03
78	<i>Cornus sanguinea</i>	Cornus	Cornaceae	1	0.03
79	<i>Crataegus monogyna</i>	Crataegus	Rosaceae	1	0.03
80	<i>Koelreuteria paniculata</i>	Koelreuteria	Sapindaceae	1	0.03
81	<i>Laburnum anagyroides</i>	Laburnum	Fabaceae	1	0.03
82	<i>Laurocerasus officinalis</i>	Prunus	Rosaceae	1	0.03
83	<i>Liriodendron tulipifera</i>	Liriodendron	Magnoliaceae	1	0.03
84	<i>Magnolia kobus</i>	Magnolia	Magnoliaceae	1	0.03
85	<i>Mespilus germanica</i>	Mespilus	Rosaceae	1	0.03
86	<i>Picea sbies</i>	Picea	Pinaceae	1	0.03
87	<i>Populus sp.</i>	Populus	Salicaceae	1	0.03
88	<i>Prunus persica</i>	Prunus	Rosaceae	1	0.03
89	<i>Rhus typhina</i>	Rhus	Anacardiaceae	1	0.03
90	<i>Sorbus aria</i>	Sorbus	Rosaceae	1	0.03
91	<i>Thuja pyramidalis</i>	Thuja	Cupressaceae	1	0.03
Total				3891	100

The identified species belong to 53 genera (Table 2). The most represented genus is *Fraxinus*, with 864 individuals, accounting for 22.2% of the total trees identified. The next most represented

genus is *Prunus*, with 417 individuals (10.7% of the trees). The remaining genera constitute less than 10% of the tree vegetation in the surveyed transects.

Table 2. Tree genera identified in the surveyed transects

No	Genus	Number of species	%
1	<i>Fraxinus</i>	864	22.21
2	<i>Prunus</i>	417	10.72
3	<i>Tilia</i>	278	7.14
4	<i>Quercus</i>	227	5.83
5	<i>Acer</i>	212	5.45
6	<i>Picea</i>	193	4.96
7	<i>Aesculus</i>	182	4.68

No	Genus	Number of species	%
8	<i>Juglans</i>	174	4.47
9	<i>Populus</i>	169	4.34
10	<i>Robinia</i>	163	4.19
11	<i>Pinus</i>	147	3.78
12	<i>Betula</i>	144	3.70
13	<i>Thuja</i>	100	2.57
14	<i>Ailanthus</i>	88	2.26
15	<i>Platanus</i>	81	2.08
16	<i>Salix</i>	62	1.59
17	<i>Gleditsia</i>	54	1.39
18	<i>Catalpa</i>	48	1.23
19	<i>Malus</i>	41	1.05
20	<i>Chamaecyparis</i>	25	0.64
21	<i>Pseudotsuga</i>	20	0.51
22	<i>Taxus</i>	18	0.46
23	<i>Maclura</i>	17	0.44
24	<i>Cedrus</i>	16	0.41
25	<i>Ulmus</i>	16	0.41
26	<i>Abies</i>	15	0.39
27	<i>Morus</i>	14	0.36
28	<i>Syringa</i>	13	0.33
29	<i>Ginkgo</i>	11	0.28
30	<i>Sequoiadendron</i>	9	0.23
31	<i>Cupressus</i>	7	0.18
32	<i>Ficus</i>	7	0.18
33	<i>Cornus</i>	6	0.15
34	<i>Cydonia</i>	6	0.15
35	<i>Celtis</i>	5	0.13
36	<i>Cercis</i>	5	0.13
37	<i>Albizia</i>	4	0.10
38	<i>Juniperus</i>	4	0.10
39	<i>Liquidambar</i>	4	0.10
40	<i>Pyrus</i>	4	0.10
41	<i>Styphnolobium</i>	4	0.10
42	<i>Corylus</i>	3	0.08
43	<i>Hibiscus</i>	3	0.08
44	<i>Paulownia</i>	2	0.05
45	<i>Alnus</i>	1	0.03
46	<i>Crataegus</i>	1	0.03
47	<i>Koelreuteria</i>	1	0.03
48	<i>Laburnum</i>	1	0.03
49	<i>Liriodendron</i>	1	0.03
50	<i>Magnolia</i>	1	0.03
51	<i>Mespilus</i>	1	0.03
52	<i>Rhus</i>	1	0.03
53	<i>Sorbus</i>	1	0.03
Total		3891	100

The identified species belong to 25 families (Table 3). The most represented family is Oleaceae, with 877 individuals, accounting for 22.5% of the total trees identified. This is followed by the Rosaceae family, represented by 471 individuals

(12.1% of the trees), and the Sapindaceae family, with 395 individuals (10.05% of the trees). The remaining families constitute less than 10% of the tree vegetation in the surveyed transects.

Table 3. Families identified in the surveyed transects

No	Family	Number of species	%
1	Oleaceae	877	22.54
2	Rosaceae	471	12.10
3	Sapindaceae	395	10.15
4	Pinaceae	391	10.05
5	Tiliaceae	278	7.14
6	Fabaceae	231	5.94
7	Salicaceae	231	5.94
8	Fagaceae	227	5.83
9	Juglandaceae	174	4.47
10	Betulaceae	148	3.80
11	Cupressaceae	145	3.73
12	Simaroubaceae	88	2.26
13	Platanaceae	81	2.08
14	Bignoniaceae	48	1.23
15	Moraceae	38	0.98
16	Taxaceae	18	0.46
17	Ulmaceae	16	0.41
18	Ginkgoaceae	11	0.28
19	Cornaceae	6	0.15
20	Cannabaceae	5	0.13
21	Altingiaceae	4	0.10
22	Malvaceae	3	0.08
23	Magnoliaceae	2	0.05
24	Paulowniaceae	2	0.05
25	Anacardiaceae	1	0.03
Total		3891	100

DISCUSSION

The tree vegetation largely follows the 10/20/30% rule [11]. The only exception among the species is *Fraxinus excelsior*, which constitutes 12.7% of the tree vegetation. Correspondingly, the genus *Fraxinus* is also an exception to the rule, accounting for 22.2% of the tree vegetation in the surveyed transects. None of the families exceed 30% – the most represented family is Oleaceae, which makes up 22.5% of the tree vegetation in the transects.

The presence of *Fraxinus excelsior* at 12.7% and the genus *Fraxinus* at 22.21% in the surveyed transects, while only slightly above the thresholds of

the 10/20/30% rule, still raises concerns. Although the exceedance is limited, the concentration of a single species and genus could lead to increased vulnerability to pests, diseases, and environmental changes. *Fraxinus excelsior* is susceptible to pathogens such as the invasive fungus *Hymenoscyphus fraxineus*, which causes ash dieback. This disease has caused widespread mortality of ash trees across Europe, posing a significant threat to the species. Even a modest concentration of *Fraxinus excelsior* in urban areas can facilitate the rapid spread of the disease, as the pathogen easily moves between closely located trees [13, 14]. While the slight exceedance in *Fraxinus*

concentration does not immediately suggest critical issues, it still may pose risks. Continuous monitoring and the introduction of more diverse species should be prioritized to enhance the resilience and ecological balance of urban forests.

The detected invasive tree species *Robinia pseudoacacia* and *Ailanthus altissima* are among the species that pose the greatest threat and have the most significant negative impact on biodiversity, nature, and humans. They are included in the "Top 10" list of the most harmful invasive species in Bulgaria [15]. Their aggressive spread and ability to adapt to a wide range of environmental conditions make them problematic in both urban and natural ecosystems. The presence of *Robinia pseudoacacia* and *Ailanthus altissima* in the surveyed area highlights the complexities of managing urban biodiversity. While these species offer certain ecological benefits, their invasive nature poses significant risks to local ecosystems. Therefore, proactive monitoring and management strategies are essential to mitigate their impacts and preserve urban biodiversity.

CONCLUSION

The study conducted on the species composition of the tree vegetation in accessible green spaces in a part of Sofia, covering an area of approximately 60 km², identified the presence of 91 species from 53 genera and 25 families. The most widespread species is *Fraxinus excelsior*, with 494 individuals or 12.7% of the total trees. The genus *Fraxinus*, represented by a total of 5 species, is the most widespread genus, including 22.21% of all trees in the surveyed area. Although these percentages slightly exceed the threshold set by the 10/20/30% rule and do not yet pose critical concerns, the concentration of *Fraxinus excelsior* and the genus *Fraxinus* raise potential risks of increased vulnerability to diseases and environmental factors. Other common species include *Prunus cerasifera*, *Quercus robur*, *Aesculus hippocastanum*, *Juglans regia*, *Fraxinus oxycarpa*, *Robinia pseudoacacia*, *Tilia cordata*, etc., all falling within the acceptable limits. Two invasive species were detected with considerable numbers – 163 individuals of *Robinia pseudoacacia* and 88 of *Ailanthus altissima*. To mitigate future risks associated with susceptibility to pathogens and environmental changes, and those from the spread of invasive species, it is essential to monitor species concentration and the overall health of the trees to detect any emerging issues early and take appropriate measures.

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