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#### **SADRŽAJ:**

	Str.
<b><i>Izvorni znanstveni rad (original scientific paper)</i></b>	
<i>Zvezda Bogevska, Olga Najdenovska, Marina Stojanova, Monika Stojanova, D. Ristikj</i> The influence of microbial inoculums on yield and yield components of rocket ( <i>Eruca sativa</i> Mill.) .....	01–09
<i>Martina Shotaroska, B. Simovski, T. Nikolovski, Katerina Chonevska, I. Minčev, V. Stojanovski</i> Urban Dendroflora of the Macedonia Park in the City of Skopje, North Macedonia .....	10–28
<i>B. Dorbić, Tea Zemunović, Emilija Friganović, Elma Temim, Ž. Španjol, Katica Arar</i> Stavovi i percepcije kninskih srednjoškolaca o uzgoju i primjeni sobnog bilja Attitudes and perceptions of the Knin-based secondary school pupils concerning the growing and use of indoor plants .....	29–45
<b><i>Pregledni rad (scientific review)</i></b>	
<i>B. Dorbić, A. Uremović, I. Gugić, Emilija Friganović</i> Ljekovita i uzgojna saznanja o bademu i orahu Medicinal and breeding knowledge of almond and walnut .....	46–54
<b><i>Upute autorima (instructions to authors)</i></b> .....	55–56

## Urban Dendroflora of the Macedonia Park in the City of Skopje, North Macedonia

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Minčev<sup>2</sup>, Vladimir Stojanovski<sup>4</sup>

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### Abstract

Subject of research in this article is the urban dendroflora of the Macedonia Park, situated on about 50,000 m<sup>2</sup> in the Macedonian capital city of Skopje, i.e., identification and presence of the recent woody plants. Thus, observed are morphological and ecological features of the woody plants and their current state in this urban environment. The investigation relates to a seven-year period (since the establishment of the Park in 2012 up to late 2019). After the field research and the inventorisation of the woody plants in the Park, 82 taxa were identified, represented in 1,318 individuals. Most represented tree species is the hybrid *Platanus* × *hispanica* Mill. ex Münchh. with 103 individuals (7.81% of the overall urban dendroflora). Most frequent tree including infraspecific taxa is *Fraxinus excelsior* L. (including *F. e.* ‘Globosa’, *F. e.* ‘Jaspidea’, and *F. e.* ‘Pendula’) with a total number of 146 individuals (11.08%). Concerning other growth form, the mini and small tree roses of hybrid *Rosa Floribunda* Group outnumber all ornamental woody species with 225 bushes (17.07%). Climbers are represented with 3 taxa (3.66% of identified taxa) in pergolas (*Wisteria sinensis* /Sims/ Sweet, *Parthenocissus quinquefolia* /L./ Planch.), and wire cage topiary (*Hedera helix* L.). Likewise, 87 individuals (6.60%) of 10 species (12.19%) occur as remnants of the greening in the past of which 3 species are used as a green core of a small sacral architecture: *Cupressus sempervirens* var. *horizontalis* (Mill.) Loudon (with 10 trees), *Platycladus orientalis* (L.) Franco (3), and *Pinus nigra* J.F.Arnold (1). In general, the urban dendroflora is properly selected and used for greening, although certain species and individuals are withering (e.g. *Betula pendula* ‘Youngii’, *Juniperus scopulorum* ‘Skyrocket’, *F. e.* ‘Jaspidea’) or unsuitably used for avenue and in small alpine-like garden.

**Keywords:** urban dendroflora, ornamental woody plants, Macedonia Park, Skopje.

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## Introduction

The Macedonia Park is established in the municipality of Karposh in the Macedonian capital city of Skopje. This starts back in 2012 when first microlocation of the Park is designed (Figures 1,a and 2). To be more precise, the Park as a whole consists of three microlocations (parts). The first and the second part are territorial continuum divided by street (Figure 3), but the third microlocation is completely physically apart, and therefore it is not investigated.



**Figure 1.** Landscape plan of the Macedonia Park designed by PE Parks and Greenery.  
**Slika 1.** Krajobrazno planiranje parka "Makedonija", dizajn JP "Parkovi i zelenilo".

The City of Skopje, the city Public Enterprise Parks and Greenery and the Municipality of Karposh worked together as public stakeholders to improve the landscape of previously established poplar plantation in 1960's (Shotaroska, 2018). These short-lived poplar trees with brittle branches and plate-root system (Džekov, 1988) became dangerous and risky in the park to drive by or walk in. Of course, the old poplar clone stands were far more aged at that moment and had already achieved the goal they were planted for in the past: fast-growing species for instant greenery and wood. Likewise, in the past century there was railway infrastructure for the narrow-gauge train passing through the Macedonia Park.

The Macedonia Park is designed by the PE Parks and Greenery mainly as landscape garden, but there are certain formal garden elements (Figure 1). In this regard, the first selection of the plant species was to combine these two types of garden compositions. However, during the years, various woody ornamentals are being incorporated in the landscape. Nowadays, this Park is one of the newly established multipurpose and multifunctional green city spaces on a satisfying area of about five

hectares, slowly but assuredly gaining its physiognomy to fulfil various needs of citizens of different age in an urban environment.

The first part established in 2012 has trim trails, fitness workouts (Figures 1, a and 2), pet parks, flowerbeds, leisurely squares and pergolas (Figure 7), small alpine-like garden (Figure 9) and trees in lines (Figure 5). In addition, children's velodrome has been made in 2016. This is the recreational part of the Park, and along its entire length white gravel trim trail in the form of the letter 'S' is made (Figure 1, a). Parallel to this is the asphalt trail that serves as a bike path, roller-skating or for family walk. For the plant care in this part of the Park on an area of about 25,000 m<sup>2</sup>, an irrigation supply network with 220 sprinklers was installed.

The second part of the Park established in 2015 represents green belt of several parcels of regular and irregular shapes, mainly a grassy area with flower ornaments (Figure 1, b). It has white gravel walkways (Figure 4) and trim trails, and asphalt sidewalks (Figure 11, a) with trees in lines (Figure 11, b). Beside fitness workouts, there are many flowerbeds and couple of wooden gazebos for leisure and chess play (Figure 4). Children's playground is made of wood elements and form a castle. For the plant care in this part of the Park on an area of approximately 25,000 m<sup>2</sup>, an irrigation supply network with 192 sprinklers was installed.

In addition, the Macedonia Park contains a third part established in 2017 that is not investigated in this research because it is physically separated from the rest. Roughly, it covers an area of 10,000 m<sup>2</sup>, of which about 4,000 m<sup>2</sup> is children's playground, fountain and pedestrian pavements.

Since the establishment of this urban green space, Parks and Greenery as a public enterprise of the City of Skopje is responsible for the maintenance of the Park.

So far, the first (and unpublished) research made for the woody ornamentals in the Park is the bachelor thesis of Shotaroska (2018) defended at the Ss. Cyril and Methodius University in Skopje, Hans Em Faculty of Forest Sciences, Landscape Architecture and Environmental Engineering (the former Faculty of Forestry in Skopje). Now, this article deepens the scientific knowledge (especially in infraspecific taxa and cultivars), gives fresh information and up-to-date input about all woody plants in the Park. In fact, this scientific article is the first published data for the Park and represent the first official inventory of the urban dendroflora as a point from which may help elaborate future development plans for the Park. Furthermore, presented results for the abundance and the environmental characteristics of the species in this investigation will help the legal authorities (Parks and Greenery in particular) to properly maintain the existing woody plants and the plant collection in general (according to species' morphoecological features). With additional details, the results can be of use for the Green Cadastre project of the City of Skopje (2017-). Eventually, it will be the basis of



further research concerning the urban dendroflora of the Park (e.g. review after five or ten years, since the comparison line is now drawn).



**Figure 2.** View of the Macedonia Park, 2018.  
**Slika 2.** Pogled na park "Makedonija", 2018 g.

## Materials and Methods

Subject of research is the urban dendroflora, i.e., species identification with systematic affiliation and number of individuals of the recent woody plants in the Macedonia Park (urban dendroflora inventory). Therefore, observed are morphological and ecological features of the woody ornamentals, including their current state in this urban environment. The investigation relates to a seven-year period since the establishment of the first part of the Park in 2012 (until late 2019).

For the GPS location and aerial observation of the territory of the Park, application tools, geographic referenced data and orthophoto imagery of geospatial software application Google Earth Pro, version 7.3.2.5776 (Google LLC, 2019) are used.

For species' features and growth forms, certain recent and past literature for (urban) dendrology is used: Džekov (1988), Erhardt et al. (2002), Idžojtić (2013, 2009, 2005), Marinelli (ed., 2004), Royal Horticulture Society (RHS, 2002), Šilić (1990), Vidaković and Franjić (2004), and Vukićević (1982). For nomenclature and taxonomy of the woody species, the plant database of World Flora Online (WFO, 2019) is used (as an updated version of The Plant List /2013/, version 1.1), and for the lower (hort.) taxa and the English common names the online Internet database of the Royal Horticulture Society (RHS, 2019c). In addition, the Ninth Edition of the International Code of Nomenclature for Cultivated Plants (ISHS, 2016) is consulted.

Likewise, after the field investigation, to clarify identification of certain ornamental woody plants found in the Park, morphological analyses in the microscopy laboratory of Ss. Cyril and Methodius University in Skopje, Hans Em Faculty of Forest Sciences, Landscape Architecture and Environmental Engineering are made.

For the abiotic factors (climate and soil conditions) of the broader area of the city, data from the Study on Greening and Afforestation of the City of Skopje (Hadji Pecova et al., 2015) is used.

### Investigation area

The investigation area covers a territory of about 50,000 m<sup>2</sup>. In fact, the Macedonia Park consists of two almost equal parts of 25,000 m<sup>2</sup> (Figure 3), not taking into account the third physically divided microlocation.

Mitropolit Teodosij Gologanov Blvd. borders the whole Park on the north side. The first part of the Park is bordered partly by restaurants and the 100 Trees Park on the east side, Jurij Gagarin Str. on the south side (Figure 5), and Bradfordska Str. on the west side as borderline with the second part of the Park. In continuation to the west, the second part of the Park is bordered in the south by restaurant and individual housing, objects for collective housing and Jurij Gagarin / Mile Popjordanov Str., and westerly by individual houses.



**Figure 3.** Orthophoto imagery of the Macedonia Park investigation area (Google Earth Pro, 2019)<sup>5</sup>.

**Slika 3.** Ortofotografija istraživanog područja parka "Makedonija" (Google Earth Pro, 2019)<sup>5</sup>.

One of the most important abiotic factors that significantly affect the urban dendroflora on this location are processed. Certain climate conditions on site such as high summer temperatures, high insulation, and urban heat islands in summer and the effect of cold air lake in winter create unfavourable conditions (Study on Greening and Afforestation of the City of Skopje, 2015). Therefore, most important and critical climatic phenomena to be observed in relation to the growth and development of the ornamental woody plants in urban environment are insulation, temperature regime (with mean annual, mean month, and absolute maximum and minimum temperatures), precipitation (with humidity), and wind.

<sup>5</sup> Orthophoto imagery date: 16<sup>th</sup> September 2019. Retrieved with Google Earth Pro, version 7.3.2.5776. GPS: 41° 59' 48.98"N, 21° 24' 10.78"E. Maxar Technologies 2019.



According to the climate data from the Study on Greening and Afforestation of the City of Skopje (2015), the average annual amount of insolation is 2,114 hours at the Star Aerodrom climatological station and 2,083.9 hours at the Petrovec Airport. The sunniest are the summer months of July and August with 317.6 and 308.4 hours, respectively. In December and January there are 57 and 65 hours average monthly sunlight, respectively.

The mean annual air temperature in the Skopje Valley is 12.4 °C, with a very pronounced annual flow of the air temperature ranging from 0.0 °C in January to 23.6 °C in July. The mean maximum air temperature is between 4.2 °C in the coldest month - January, and 30.6 °C in the warmest month - August. Specific is the variation of the temperature regime and rapid changes in the air temperature in a short period. Summer months have high temperatures - the average monthly temperatures are 20.7 °C in July and 20.2 °C in August. The absolute annual maximum temperature is very high, reaching up to 40.6 °C and the differences with the absolute annual minimum temperature of -25.7 °C are very high. Important for the selection of plants is the occurrence of spring and autumn frosts. The average spring frost date in Skopje occurs between 8<sup>th</sup> and 13<sup>th</sup> April. The average date of the first autumn frost occurs between 22<sup>nd</sup> and 26<sup>th</sup> October. The average length of the ice period is between 165 and 173 days.



**Figure 4.** Allée with *Morus alba* and wooden gazebo for leisure and chess play, 2019.

**Slika 4.** Aleja s *Morus alba* i drveni gazebo za odmor i igranje šaha, 2019 g.

The entire Skopje valley is dominated by altered continental and maritime pluviometric regime with maximum rainfall during May or June, as well as in the autumn months (November). The annual amount of precipitation varies between 500 and 600 mm. But, certain places have rainfalls lower than 500 mm a year. Furthermore, the mean monthly rainfalls in May varies between 51 (Volkovo) and 70 mm (Gorno Vodno). In August, the mean monthly rainfalls vary from 21.5 to 38.8 mm, respectively. Drought and drought periods are one of the specific features of the climate in the city of Skopje, and most commonly occur in summer. Summer dry periods, accompanied by high air temperatures and low relative humidity, pose a risk on vegetation development. The longest period of no precipitation (dry season) of a total of 46 days was recorded in 1969. On average every fifth year in Skopje there is

heavy rain with intensity of 251.6 l/s/ha, and every 10 years the average intensity during 5 minutes is 408.0 l/s/ha. The average annual humidity in Skopje is 68-70 %.

Winds of different directions and different strength occur in the city. The most frequent direction of flow, in the western part of the city, is from the W and W-SW direction. In the eastern parts, the most frequent winds are from N-NE direction and S-SE direction. In the central parts of the city, there are prevailing winds from the NW and W quadrant with an average wind speed of 2.0 m/s. Strong cyclonic winds that occur in that part of the city increase the possibility to inflict damage on the vegetation, in particular to individual trees on open spaces in this relatively new established urban dendroflora of the Park (Figure 9). However, in the central city core, the winds have lowest values, i.e., 1.5 m/s as mean monthly (1.0 m/s in October, 2.1 m/s in April on average). In addition, anticyclone state of occurrence often affect negatively with extreme microclimate in Skopje as an urban environment – heat waves in summer and the effect of cold air lake in winter. Eventually, these phenomena lead to the atmospheric and ecologic occurrence of smog.

The Skopje Valley is well known of the occurrence of fog and temperature inversion, during which the air pollution has increased parameters. Although the Macedonia Park it is not close to, the foggiest days in Skopje occur in Star Aerodrom suburb with 81 day a year. Other climatological stations show smaller number of foggy days varying (Drachevo 18, Petrovec 29, Trubarevo 32). Foggiest months are December with 18 days in average, and January and November with 16 and 14, respectively. Beside radiation fog and the effect of cold air lake in winter, during summer the effect of urban heat island is pretty much present. Without aeration, the air pollution derived from the industry and the traffic causes tropical night phenomenon (air temperatures above 20 °C).

Most of the soils in the urban suburbs of Skopje have anthropogenic influence. The modern way of landscaping urban areas is based on the use of soil substrates that are favourable to the needs of a particular species. Therefore, ornamental species are planted in pre-prepared soils that contain natural macro- and microelements, have good aeration and permeability, adequate drainage and pH values. These features enable uninterrupted plant growth and good root development. In the area where the Macedonia Park is located, mostly are soils of river sediments (alluvial soils derived from neighboring Vodno Mountain and gravel) and urbisol. However, during this investigation, presence of coal beneath the surface of the soil on many places in the Park is found, due to the past railway infrastructure.



**Figure 5.** Single tree-lined avenue with *Platanus × hispanica* on Jurij Gagarin Str., 2018.  
**Slika 5.** Jednoredni drvodred *Platanus × hispanica* u ulici "Jurija Gagarina", 2018 g.



**Figure 6.** *Fraxinus excelsior* 'Globosa' with mini and tree roses of the Floribunda Group, 2018.  
**Slika 6.** *Fraxinus excelsior* 'Globosa' s patuljastim i ružama stablašicama hibridne grupe "Floribunda", 2018 g.

## Results

### Inventory of the urban dendroflora

Along the Mitropolit Teodosij Gologanov Blvd. where the Macedonia Park is located was formerly poplar clone stand, which is now completely replaced by a number of different species in the improved park. The Canadian poplars as Italian female clones (*Populus × canadensis* Moench 'I214') that were planted in the 60's of the last century were cut because they posed a threat to the citizens. They had outgrown their physiological age, many of them were withering, their branches were broken by winds, and it was not uncommon for a whole tree to fall down or on a nearby-parked vehicle.

Nevertheless, in 2015 exotic tree species in line were planted – the subtropical palm trees *Trachycarpus fortunei* (Hook.) H.Wendl. In less than two years since the introduction, the Chusan palms were replaced with deciduous broadleaves (mainly *Acer* spp.), due to lack of adaptability of the

individuals to various biotic and abiotic influence that is not a specific subject of investigation in this research as non-existent urban dendroflora in the Park.

The research of the urban dendroflora in the Macedonia Park dates from the first part of the Park being established in 2012 and covers the time until the completion of this scientific article. However, some trees originate since the time of the poplar clones and the memorial trees around the monument dedicated to the WWII hero Kuzman Josifovski – Pitu, and some have been planted in the meantime by the citizens of the immediate surroundings or before the completion of the Park as a whole (Figure 3). The newest data is from 29<sup>th</sup> November 2019 when 15 trees of *Cupressus × leylandii* A.B.Jacks. & Dallim. and 30 individuals of *Thuja occidentalis* ‘Brabant’ were planted.

To this date, 82 taxa of recent woody plants were identified in the Park, represented in a total of 1,318 individuals. The list of the taxa and the number of individuals (where applicable) is presented in Table 1, ordered alphabetically by species’ scientific name.

**Table 1.** Inventory of the urban dendroflora of the Macedonia Park in the city of Skopje.

**Tablica 1.** Popis urbane dendroflore na istraživanom području parka "Makedonija" u Skoplju.

Scientific name	Number of individuals
<i>Acer platanoides</i> ‘Crimson King’	1
<i>Acer platanoides</i> L.	30
<i>Acer pseudoplatanus</i> ‘Atropurpureum’	7
<i>Acer pseudoplatanus</i> L.	35
<i>Aesculus hippocastanum</i> L.	1
<i>Albizia julibrissin</i> Durazz.	8
<i>Betula pendula</i> Roth	4
<i>Betula pendula</i> ‘Youngii’	20
<i>Buxus microphylla</i> Siebold & Zucc.	border hedges
<i>Buxus sempervirens</i> L.	border hedges
<i>Catalpa bignonioides</i> ‘Nana’	4
<i>Catalpa bignonioides</i> Walter	7
<i>Celtis australis</i> L.	3
<i>Chamaecyparis lawsoniana</i> ‘Alumii’	8 (small alpine-like garden)
<i>Chamaecyparis lawsoniana</i> ‘Ellwoodii’	10 (small alpine-like garden)
<i>Chamaecyparis pisifera</i> ‘Boulevard’	8 + border hedges
<i>Cotoneaster horizontalis</i> Decne.	small alpine-like garden
<i>Cupressus × leylandii</i> A.B.Jacks. & Dallim.	17
<i>Cupressus sempervirens</i> var. <i>horizontalis</i> (Mill.) Loudon <sup>6</sup>	10 (memorial)
<i>Elaeagnus angustifolia</i> L.	5
<i>Euonymus alatus</i> (Thunb.) Siebold	6 (small alpine-like garden)
<i>Euonymus fortunei</i> ‘Emerald ‘n’ Gold’ (v)	border hedges
<i>Euonymus fortunei</i> ‘Emerald Gaiety’ (v)	border hedges
<i>Fraxinus americana</i> L.	6
<i>Fraxinus excelsior</i> ‘Globosa’	92
<i>Fraxinus excelsior</i> ‘Jaspidea’	25
<i>Fraxinus excelsior</i> ‘Pendula’	5
<i>Fraxinus excelsior</i> L.	24
<i>Ginkgo biloba</i> ‘Globosa’	5

<sup>6</sup> RHS accepted name: <https://www.rhs.org.uk/Plants/5080/i-Cupressus-sempervirens-i-var-i-horizontalis-i/Details> (RHS, 2019a)

Scientific name	Number of individuals
<i>Ginkgo biloba</i> L.	18
<i>Gleditsia triacanthos</i> L.	1
<i>Hedera helix</i> L.	topiary wire cage
<i>Hypericum calycinum</i> L.	border hedges
<i>Jasminum nudiflorum</i> Lindl.	4 (small alpine-like garden)
<i>Juglans regia</i> L.	8
<i>Juniperus communis</i> ‘Hibernica’	8 (small alpine-like garden)
<i>Juniperus horizontalis</i> Moench	small alpine-like garden
<i>Juniperus scopulorum</i> ‘Skyrocket’	30
<i>Koelreuteria paniculata</i> Laxm.	22
<i>Lavandula angustifolia</i> Mill.	border hedges
<i>Liquidambar styraciflua</i> L.	28
<i>Liriodendron tulipifera</i> L.	77
<i>Lonicera ligustrina</i> var. <i>yunnanensis</i> Franch.	small alpine-like garden
<i>Magnolia kobus</i> × <i>stellata</i>	38
<i>Metasequoia glyptostroboides</i> Hu & W.C.Cheng	6
<i>Morus alba</i> L.	13 (chess gazebo)
<i>Parthenocissus quinquefolia</i> (L.) Planch.	18 (pergolas)
<i>Photinia</i> × <i>fraseri</i> ‘Red Robin’	3
<i>Picea glauca</i> var. <i>albertiana</i> ‘Conica’	2 (small alpine-like garden)
<i>Picea pungens</i> Engelm.	2
<i>Pinus mugo</i> Turra	2 (alpine-like garden)
<i>Pinus nigra</i> J.F.Arnold	3 (1 memorial + 1 small alpine-like garden)
<i>Platanus</i> × <i>hispanica</i> Mill. ex Münchh.	103
<i>Platanus occidentalis</i> L.	3
<i>Platanus orientalis</i> L.	2
<i>Platycladus orientalis</i> (L.) Franco	4 (3 memorial trees)
<i>Platycladus orientalis</i> ‘Aurea Nana’	6 (small alpine-like garden)
<i>Prunus</i> ‘Kanzan’ (d)	69
<i>Prunus cerasifera</i> ‘Nigra’	34
<i>Prunus cerasifera</i> ‘Pissardii’	1
<i>Quercus robur</i> (Fastigiata Group) ‘Koster’	4
<i>Quercus rubra</i> ‘Aurea’	3
<i>Quercus rubra</i> L.	9
<i>Robinia pseudoacacia</i> L.	6
<i>Rosa Floribunda</i> Group	225 (157 mini + 68 small tree roses)
<i>Salix alba</i> ‘Tristis’ ambig.	6
<i>Santolina rosmarinifolia</i> subsp. <i>rosmarinifolia</i> <sup>7</sup>	small alpine-like garden
<i>Sorbus aucuparia</i> L.	38
<i>Sorbus intermedia</i> (Ehrh.) Pers.	7
<i>Spiraea japonica</i> ‘Little princess’	border hedges
<i>Taxus baccata</i> ‘Fastigiata’ (f)	9
<i>Thuja occidentalis</i> ‘Brabant’	30
<i>Thuja occidentalis</i> ‘Globosa’	border hedges
<i>Thuja occidentalis</i> ‘Rheingold’	border hedges
<i>Thuja occidentalis</i> ‘Smaragd’	41
<i>Tilia cordata</i> Mill.	24
<i>Tilia platyphyllos</i> Scop.	4
<i>Tilia tomentosa</i> Moench	12
<i>Ulmus glabra</i> ‘Exoniensis’	8
<i>Ulmus glabra</i> ‘Pendula’	15
<i>Ulmus minor</i> Mill.	1
<i>Wisteria sinensis</i> (Sims) Sweet	27 (pergolas)
<b>Total:</b>	<b>1,318</b>

<sup>7</sup> RHS accepted name: <https://www.rhs.org.uk/Plants/46527/Santolina-rosmarinifolia-subsp-rosmarinifolia/Details> (RHS, 2019b)



### Analysis of the urban dendroflora

After the field research and the determination of the woody plants in the Park, 82 taxa were identified, represented in 1,318 individuals. Most represented tree species is the hybrid *Platanus* × *hispanica* Mill. ex Münchh. (Figure 4) with 103 individuals (7.81 % of the overall urban dendroflora). Most frequent tree including infraspecific taxa is *Fraxinus excelsior* L. including *F. e.* ‘Globosa’ (Figure 5), *F. e.* ‘Jaspidea’, and *F. e.* ‘Pendula’ with a total number of 146 individuals (11.08 %).

Concerning other growth form, the mini shrubs and small tree roses of hybrid *Rosa Floribunda* Group (Figures 2 and 6) outnumber all ornamental woody species with 225 bushes (17.07 %).

Climbers are represented with 3 taxa (3.66 % of identified taxa) in pergolas with 27 vines of *Wisteria sinensis* (Sims) Sweet and 18 of *Parthenocissus quinquefolia* (L.) Planch. (Figure 7), and wire cage topiary (*Hedera helix* L.).

Likewise, 87 individuals (6.60 %) of 10 species (12.19 %) occur as line trees (Figure 5), solitary trees or in small groups as remnants of the greening in the past: *Platanus* × *hispanica* with 45 trees, *Morus alba* L. with 13 (Figure 4), *Juglans regia* L. (with 8), *Celtis australis* L. (3), *Aesculus hippocastanum* L. (1), *Gleditsia triacanthos* L. (1), *Pinus nigra* J.F.Arnold (1), and *Ulmus minor* Mill. (1), including 3 species used as a green core of a small sacral architecture: *Cupressus sempervirens* var. *horizontalis* (Mill.) Loudon (with 10 trees), *Platycladus orientalis* (L.) Franco (3), and *Pinus nigra* (1). It is interesting to note that the citizens of the immediate surroundings planted the white mulberry ‘grove’ near the wooden gazebo for chess play (Figure 4).



**Figure 7.** Square with *Wisteria sinensis* and *Parthenocissus quinquefolia* on pergolas, border hedges of *Thuja occidentalis* ‘Globosa’, and *Prunus cerasifera* ‘Nigra’ as focal point, 2018.

**Slika 7.** Trg s *Wisteria sinensis* i *Parthenocissus quinquefolia* na pergoli, bordura od *Thuja occidentalis* ‘Globosa’ i *Prunus cerasifera* ‘Nigra’ kao fokusne točke, 2018 g.

## Discussion

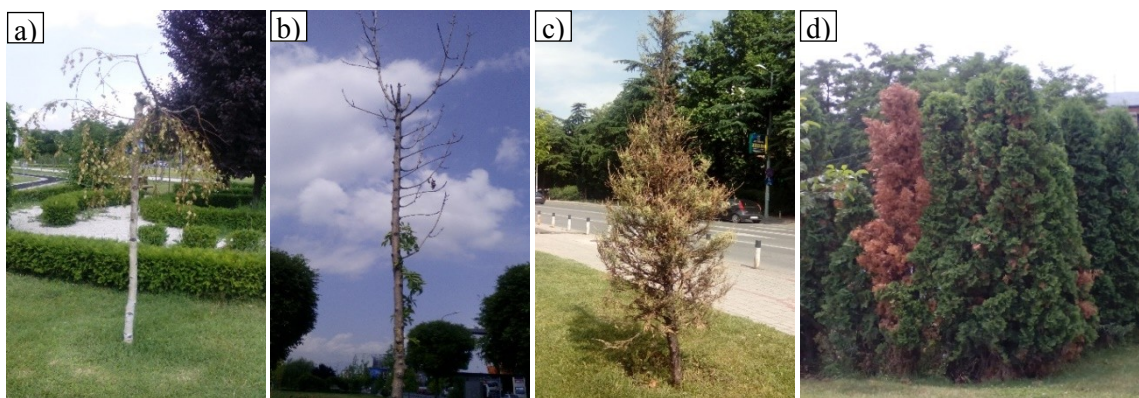
Although it has been a short period of investigation since the urban dendroflora was established to date, there are still some phenomena that can be discussed, of course, based on the abovementioned.

Public green spaces fulfil important aesthetic, social and environmental functions in urban areas (Hadji Pecova et al., 2015). Environmental ecosystem services provided by urban forests (including individual trees and shrubs, parks and forests) can be evaluated in three main categories: regulation of air, water, soil and climate, provisioning of habitat quality, and provisioning of other goods and services (Roeland et al., 2019). The Macedonia Park has various contents that are offered to the citizens. The synergy between the green and grassy areas, areas for active (Figure 2) and passive recreation (Figure 4), children's playgrounds and pet-friendly areas makes this urban environment a highly correlated socio-ecological green city core at this moment. The number of individuals (1,318) and (ornamental) woody taxa (82) used for landscaping (Table 1) are satisfying taking into account the total area of the Park (5 ha), and overall suitable for the location and the purpose they are planted for. As a justification, compared are some examples on this matter in the region, due to lack of existing data on domicile parks: the dendroflora of the Bihać City Park is represented in 80 taxa with 663 woody plants on an area of 3.1 ha (Delić et al., 2018), the park surrounding the Faculty of Forestry and the Faculty of Agriculture of the University of Zagreb with 112 woody taxa on 5.7 ha (Salantić, 1992), the park Univerzitetški Grad in the city of Banja Luka with 88 woody taxa and 1,553 specimens on 21 ha (Stupar, 2009).

Certain individual trees and small groups from the greening in the past have been left untouched, even incorporated or as much as it can in the newly established Park. It is important to emphasize the cooperation of the citizens and the responsible authorities for the improvement of the white mulberry trees and their promotion to allée (Figure 4).

Particularly interesting composition of the Park are the 4 round squares with pergolas and benches under the climbers' colourful 'canopy' of *Wisteria sinensis* and *Parthenocissus quinquefolia*, gravel paths with border hedges of *Thuja occidentalis* 'Globosa' and *Buxus* spp., and *Prunus cerasifera* 'Nigra' as a focal point in the center (Figure 7). Likewise, main aspects and functions of the plant design in parks and gardens (Sandeva et al., 2013) in urban environment are carefully met (Despot et al., 2013).

Unfortunately, like the other city green areas, in the Macedonia Park occasionally are noticeable certain issues that disturb the beautiful scenery and pleasant ambience. Such phenomena that can be remedied by humans should not be allowed to stand for long periods, since they interrupt the impression of the green space.



a) *Betula pendula* 'Youngii', b) *Fraxinus excelsior* 'Jaspidea', c) *Juniperus scopulorum* 'Skyrocket',  
d) *Thuja occidentalis* 'Smaragd'.

**Figure 8.** Withering of individuals, 2018.

**Slika 8.** Sušenje stabala, 2018 g.



**Figure 9.** Small alpine-like garden, 2018.

**Slika 9.** Mali (alpski) vrt, 2018 g.

Regarding the ecology of the recent species in the Park, for *Betula pendula* Roth species it is especially important to pay attention to the humidity, as the silver birch is sensitive to high temperatures and dry air (Džekov, 1988). This is very important for proper growth and development, and even for the survival of these trees, as birch is a light- and humidity-demanding species and thrives on full sun (Džekov, 1988). Several trees, during the data processing, were already withering (Figure 8, a). In addition, withering has been observed in some exemplars of ash, 'Jaspidea' in particular (Figure 8, b), and *Thuja* spp. (Figure 8, d).

Serious problem may be the presence of coal debris in the underground left over from the period when the narrow-gauge train was operating. It is for sure that the coal is a physical obstacle when planting various woody species in the Park.



In one section of the Park, the line of woody ornamentals along the Mitropolit Teodosij Gologanov Blvd. incite issues regarding the purpose of use and morphoecology of the species. *Magnolia kobus* × *stellata* is a shrub/small tree, and *Juniperus scopulorum* ‘Skyrocket’ is a narrowly columnar evergreen conifer shrub concerning the height, with an ultimate spread of 0.5 – 1 metres (RHS, 2019c). Therefore, using these two species one after another (alternately) as part of an avenue in this case, whose primary purpose is to prevent insulation during the summer along south-facing aspect for pedestrians and traffic is rather a pointless discussion. Moreover, the distance between the individuals is inadequate (too distant) for their habit and it is unlikely to create tree-lined avenue. In addition, many Rocky Mountain juniper ‘Skyrocket’ individuals are already withered (Figure 8, c).



a) *Salix alba* ‘Tristis’, b) *Quercus rubra*.

**Figure 10.** a) Trunk support with poles after windstorm, and b) bent tree caused by wind, 2018.

**Slika 10.** a) Učvršćivanje stabla drvenim kolcima i b) iskrivljeno stablo zbog vjetrova, 2018 g.

Attention should be paid to *Tilia* spp. as they develop a strong root system, similar as *Platanus* spp., but with root suckers (Džekov, 1988), which can uplift the soil media and could damage paved surfaces - paths and pavements in an urban environment, in particular where they are too close to this type of infrastructure (certain sections in the Park). Occasionally, during the dry summer season, summer leaf fall or leaf drying is observed. In addition, the appearance of honeydew secretion from leaf insects is often manifested, similar to that of *Catalpa bignonioides* Walter (including ‘Nana’). For this species, however, it is specific that its sharp, long, thin legume-like capsule fruit (Džekov, 1988; Idžojtić, 2013) can be dangerous for passersby when falling from the canopy.

Within the small garden (Figure 9), certain species are not suitable for the purpose of intended alpine-like space, are planted too close or cannot be maintained properly, or they are not characterized by prostrate/dwarf growth (RHS, 2002), for example these evergreen species: *Chamaecyparis lawsoniana* ‘Alumii’, *Cupressus* × *leylandii* A.B.Jacks. & Dallim., *Pinus nigra* J.F. Arnold. In addition, *Salix alba* ‘Tristis’ with its pendulous canopy completely covers or overshadows some of the light-demanding species (Figure 9).

As a relatively new raised green area on an open space, in the Park occasionally occur strong air flows, which may cause crown/trunk breaks or windthrows if they are not protected by physical support until the root system becomes sufficiently branched (RHS, 2002) to carry the load on the overhead part. In this regard, care should also be taken of the crown-root ratio of species with larger canopy like white willow ‘Tristis’ (Figure 10, a) and crown-trunk ratio as of *Sorbus aucuparia* L. and *Quercus rubra* L. (Figure 10, b), no matter of the fact that the first two are wind resistant species (RHS, 2002).

*Robinia pseudoacacia* L. (Figure 11, a) and *Koelreuteria paniculata* Laxm. (Figure 11, b), as species that can behave invasive in the Republic of North Macedonia (Simovski and Nikolov, 2019; Simovski et al., 2012; Trajanovski et al., 2018) are needed to be monitored for possible expansive territorial impact on other plants in the Park and the surrounding environment.

Eventually, it can be noted that only a small portion of the existing dendroflora in the investigated area, probably due to planting time, inadequate microclimate or quality of plant material, physiological weaken, and some species (may) decline. Thus, not only does the specimens lose its decorative value, but also it is necessary to constantly allocate resources for their proper care and maintenance (e.g. the Chusan palms lined trees of the past urban dendroflora) or to replace them again with the same species. Therefore, significant attention should be paid to the (future) proper selection of plants with suitable morphoecological characteristics with seasonal dynamics, and on adequate micro-locations (Simovski, 2011a,b,c,d).



**Figure 11.** Individual of a) *Robinia pseudoacacia* and lined trees of b) *Koelreuteria paniculata*, 2018.

**Slika 11.** Pojedinačno stablo a) *Robinia pseudoacacia* i drvo red s b) *Koelreuteria paniculata*, 2018 g.

Taking into consideration all of the above, it should be point out that the Macedonia Park consecutively is gaining its projected physiognomy, successional emphasizing aesthetic, environmental and social features of the ornamental woody plants.



## Conclusion

After field and laboratory observation during the period 2012-2019, an inventory with analysis of the existing urban dendroflora of the Macedonia Park in the city of Skopje is made: 82 taxa were identified, represented in 1,318 individuals. Beside the common use of trees and shrubs as typical park species, certain species are planted as lined trees, some small shrubs as border hedges, climbers for pergolas, form wire cage topiary, and for small alpine-like garden. Furthermore, there are species used as memorial trees of small sacral architecture in a previously established landscape design. The most represented tree species is the hybrid *Platanus* × *hispanica* Mill. ex Münchh. with 103 individuals, which is 7.81 % of the total urban dendroflora. The most frequent tree including infraspecific taxa is *Fraxinus excelsior* L. (including *F. e.* ‘Globosa’, *F. e.* ‘Jaspidea’, and *F. e.* ‘Pendula’) with a total number of 146 individuals (11.08 %). Concerning other growth forms, the mini and tree roses of hybrid *Rosa Floribunda* Group outnumber all ornamental woody species with 225 bushes (17.07 %). Climbers are represented with 3 taxa (3.66 % of identified taxa) in pergolas and wire cage topiary. Likewise, 87 individuals (6.60 %) of 10 species (12.19 %) occur as remnants of the previous greening of which 3 species are used as a green core of a small sacral architecture. After observation of morphological and ecological features of the woody species and their current state in this environment, the urban dendroflora is properly selected and used for greening, although certain species are withering or unsuitably used for avenue and in small alpine-like garden.

These results are the first published investigation for the woody plants of the Park. As such, they are a base for further scientific research concerning the urban dendroflora represented in the Park over time. The observed occurrence and the abundance of the species gives valuable up-to-date information for input in the Green Cadastre of the City of Skopje, and the morphoecological phenomena noted in the Park can practically guide the legal authorities (Parks and Greenery, the City of Skopje, and the Municipality of Karposh) to improve and properly maintain the existing woody ornamentals. In addition, the data may help elaborate future development plans for the Park.

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