DOI:10.54614/forestist.2022.21038
Forestist 2022: 72(3): 266-274

ISTANBUL UNIVERSITY
CERRAHPAŞA

Original Article

Comparing Urban Parks' Woody Plant Diversity in Seven Different Locations of Turkey

Hüseyin Öğçe[1], Elif Şatıroğlu[2], Fatih Bekiryazıcı[2], Deryanur Dinçer[2]

[1]Department of Landscape Architecture, İstanbul Technical University, Faculty of Architecture, İstanbul, Turkey
[2]Department of Landscape Architecture, Recep Tayyip Erdoğan University, Engineering and Architecture Faculty, Rize, Turkey

ABSTRACT

Plant diversity is critical to regulating the urban ecosystem and offers myriad positive benefits in a logical and well-planned structure. This article aims to demonstrate the woody plant diversity of the selected urban parks and their importance for the urban ecosystem. As a material, seven urban parks were selected from different locations in Turkey, located in Aydın, Istanbul, Kayseri, Samsun, Rize, Trabzon, and Van. In methodology, we recorded the plants' families and species and calculated the diversity and dissimilarity values of the selected urban parks through Shannon (α) and Whittaker (β) indexes on the Paleontological Statistics and Biodiversity Component Calculation Software programs. The results showed that 71 plant species belonging to 32 families were recorded, and the most dominant families were Pinaceae and Rosaceae. As a result of planting design styles, the non-native woody plant species were higher than the native ones. Moreover, the alpha diversity of seven parks was 0.4099 (Park I), 1.931 (Park II), 1.936 (Park III), 2.564 (Park IV), 2.622 (Park V), 2.124 (Park VI), and 1.881 (VII) values. On the other hand, the beta results showed that the highest similarity value (1 − dissimilarity) was 0.28 between Parks IV and V. In conclusion, there were huge differences among the selected parks concerning plant biodiversity because of limited native plants usage.

Keywords: Shannon, Turkey, urban ecosystem, urban parks, Whittaker, woody plant diversity

Introduction

Biological diversity, which means the living organism variety in an ecosystem (Sjerp de Vries & Snep, 2019), is a common heritage and an essential part of the ecology, and it can determine the health, resilience, and efficiency of an ecosystem (Öztürk et al., 1998). Nowadays, many studies show that biological diversity is under the threat of climate change (Alizadeh & Hitchmough, 2020).

Turkey is located in three bio-geographical regions: Anatolia, Mediterranean, Black Sea and their transition zones. As the country is a bridge between two continents, its climate and geographical features change at short intervals (Ergüner et al., 2019). Turkey is comparable to a miniature continent because of its biological diversity (flora and fauna) and is one of the countries with the richest biodiversity in Europe and the Middle East and ranks ninth in biological diversity on the European continent. It has a rich flora that includes more than 11,000 plant species and 33% of plant species are endemic (approximately 3700) in Turkey itself. The country's territory consists of forests, mountains, steppes, wetlands, coastal and marine ecosystems, and various forms and combinations of these systems (IUCN, 2021). All environmental types are critical to an ecosystem and its cycle.

As an ecosystem, urban areas include biodiversity inside (Çoban et al., 2020; Güler, 2020). Urban biodiversity is defined as species, habitats, and ecosystem services. An urban area consists of diverse kinds of elements, including physical, social, and psychological notions. Undoubtedly, each element or element groups influence the other in case of any alteration in an environment. Climate change poses significant challenges to human health and biodiversity (Dunn, 2017) because of the increasing population, releasing fossil fuel-based gases and improper solutions. Also, rapid urbanization causes dramatic challenges in urban and peri-urban areas. These issues are highly significant as ecosystem services are primarily provided by biodiversity (Jochum et al., 2020).

Urban ecology plays an essential role in determining the elements' interaction (Swan et al., 2016). Unfortunately, it is a relatively neglected topic compared with other urban studies. However, increasing climate change

Cite this article as:
Öğçe, H., Şatıroğlu, E., Bekiryazıcı, F., & Dinçer, D. (2022). Comparing urban Parks' woody plant diversity in seven different locations of Turkey. *Forestist*, 72(3), 266-274.

Corresponding Author:
Hüseyin Öğçe
e-mail:
ogce20@itu.edu.tr

Received: August 17, 2021
Accepted: October 25, 2021
Available Online Date: April 12, 2022

awareness triggered an improvement in this field (Baruch et al., 2020). Whether in urban or rural patterns, green tissue reduces negative human energy and indirectly contributes to human health. Road trees and green links help adaptation to climate change, namely high-temperature control, insufficient air quality, and effective water management (Czortek & Pielech, 2020). As such, nature-based solutions can reduce these effects. Increasing awareness of biodiversity creates potentials to maximize public health's synergy, helps adaptation to climate change, and aids nature conservation. The most critical element of this synergy is green spaces which are open space clinics. Urban forest also contributes to communities' cultural and spiritual values (Stas et al., 2020).

From a different perspective, plants (CAM, C3, and C4) play an essential role in the carbon sequestration process (Choudhury et al., 2020; Gogoi et al., 2021). The rate of C_4 plants that play an influential role in carbon fixation is approximately 3% within the plant realm, and they account for 25% of terrestrial photosynthesis (Kadereit & Freitag, 2011; Rudov et al., 2020). However, this activity is infrequent in trees (Young et al., 2020), as most trees use different photosynthesis processes. Nonetheless, it does not mean that trees are unimportant to reduce the CO_2 level in the atmosphere. When trees grow, they stock C (carbon) elements into their trunk and the other parts (Pilania et al., 2014).

In contrast, the green texture may not always provide positive benefits if unplanned arrangements are made in these areas. For example, using high pollen-containing plant species in combination with low air quality can harm public health (Damialis et al., 2019). In addition, urban areas suffer from decreasing biodiversity because of improper urbanization (Keten et al., 2020). It is estimated that by 2050 the human population will be 10 billion. The concept of nature is often considered as green infrastructure systems in cities. However, cities and their people cannot be considered in isolation from everything else (Lindley et al., 2019).

To preserve the urban biological diversity, parks and green spaces must be considered in detail. The green spaces within the urban environment facilitate the physical activities of communities. Moreover, there are direct relations between green space and mental well-being (Dadvand et al., 2019). People who visit the urban green areas experience psychological restoration (Meyer-Grandbastien et al., 2020). These areas also offer space for recreational activities of the people and they serve as resting places (Talal & Santelmann, 2020). Biological diversity reflects people's culture in the environment. Furthermore, cultural diversity with a firm place attachment helps to protect the natural areas (riparian, urban forest, etc.) and the biodiversity in urban and suburban areas (Grant, 2012).

Analyzing biodiversity inside cities requires high-level experience and hard work (Nilon et al., 2017). There are two advanced applications: iNaturalist and iBird, facilitating the implementation of this process (Li et al., 2019). Numerous methods and indexes were developed in biological diversity studies (Solon, 1996). Shannon-Wiener, Simpson (1-D), Brillouin, and Margalef for alpha diversity and Whittaker, Routledge, Harrison 2, and Williams for beta dissimilarity are preferred for calculations (Gülsoy & Özkan, 2008).

This study aims (1) to examine the woody plant species and the numbers in the selected urban parks considering the native or non-native species to Turkey through Shannon (α) and Whittaker (β) indices and (2) to compare their plant diversity (trees, shrubs, and perennials) to recommend appropriate species in planting design projects.

Material and Methods

The Research Areas

The parks are located in Aydın, İstanbul, Kayseri, Rize, Samsun, Trabzon, and Van of Turkey (Figure 1). These are Park I (Aydın Söke Square Park), Park II (İstanbul Silivri Kale Park), Park III (Kayseri Erkilet Cemal Bozkurt

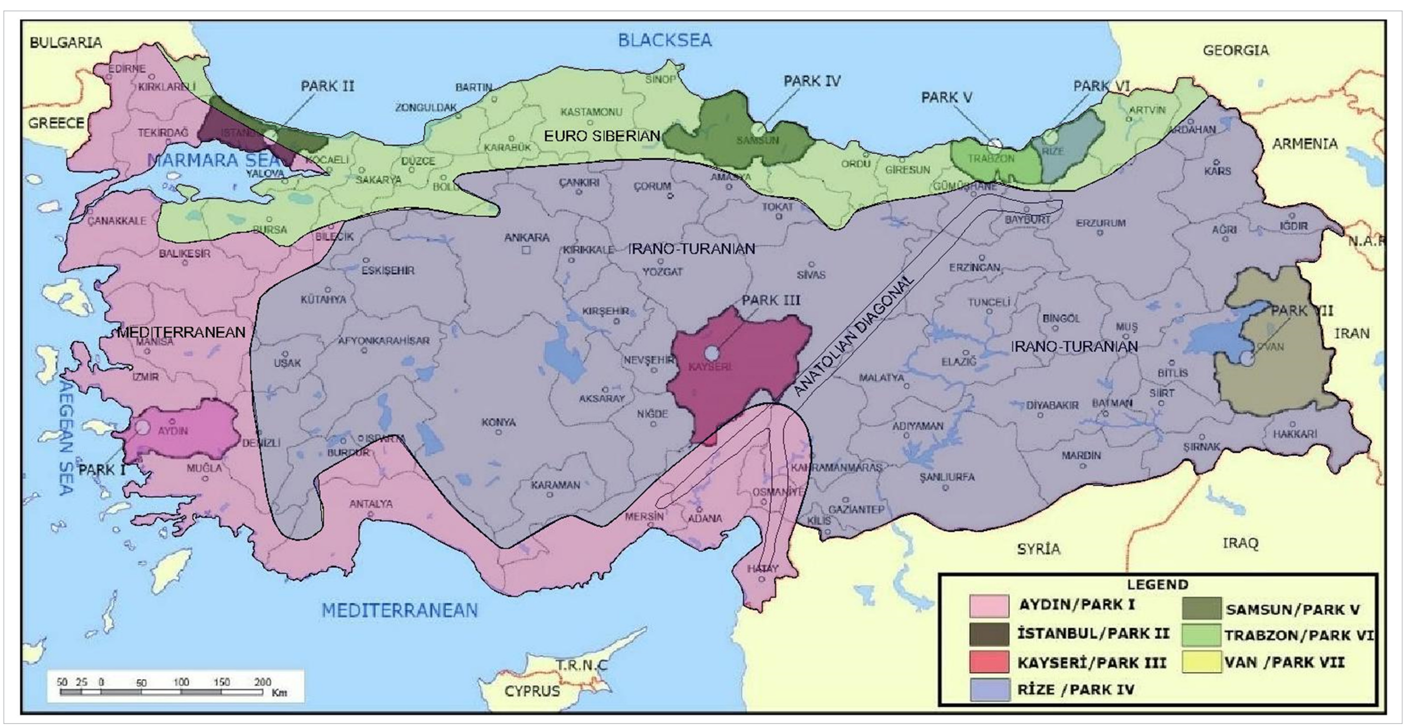

Figure 1.
Location of Parks With Turkey's Phytogeographical Regions (Original, 2021).

Table 1.
Locational and Spatial Information of the Parks

	Parks	m^2	North Coordinate	East Coordinate
Park I	Aydın Söke Square Park	3948	37° 45' 17"	27° 24' 27"
Park II	İstanbul Silivri Kale Park	8044	41° 04' 09"	28° 14' 53"
Park III	Kayseri Erkilet Cemal Bozkurt Park	21,072	38° 48' 30"	35° 27' 00"
Park IV	Rize Doğu Park	11,000	41° 03' 12"	40° 36' 52"
Park V	Samsun Millet Garden	4291	41° 16' 12"	36° 21' 21"
Park VI	Trabzon Pelitli Park	6633	40° 59' 27"	39° 47' 40"
Park VII	Van Kocaeli Park	20,000	38° 25' 33"	43° 17' 46"

Park), Park IV (Rize Doğu Park), Park V (Samsun Millet Garden (The northern part of the park was used as a sample area.)), Park VI (Trabzon Pelitli Park), and Park VII (Van Kocaeli Park). The most important common feature of the parks is that they are urban parks. The coordinates of the parks were shown in Table 1. Satellite images and general photographs of the parks are shown in Figure 2.

Data Collection

The research covers 7 different urban parks' woody plant diversity (determined as suitable study areas for selected criteria) obtained from the 15 final assignments of the PEM 427 coded "Survey and Measurement Knowledge" class. This study was carried out with the distance education outputs of the course during the COVID-19 pandemic. First, students were asked to detect the woody plant species and numbers of a city park in their location concerning the selected criteria. Those criteria were as follows: (1) the parks should be located in urban areas, (2) the parks should be preferable parks for recreation, (3) the parks should be under stewardship by the municipalities, etc. Then, the detected species were checked in the online course, and necessary corrections were made concerning the selected criteria.

Data Calculation with Alpha and Beta Indices

First, plant inventories in the parks were tabulated according to species, family, and number (frequency) (Table 2). Next, these data were comparatively calculated using the Paleontological Statistics and Biodiversity Component Calculation Software (Özkan et al., 2020) programs. Then, the outputs were analyzed in the concept of current urban parks' woody plant diversity. As a measurement method, Shannon (α) and Whittaker (β) indices were chosen to evaluate the plants' diversity. The formulas of indices are presented as follows:

Shannon: $H' = -\sum(pi\ .lnpi)$ (Shannon, 1948),

Whittaker: $\beta w = (S\text{-}\alpha)\text{-}1$ (Whittaker, 1972).

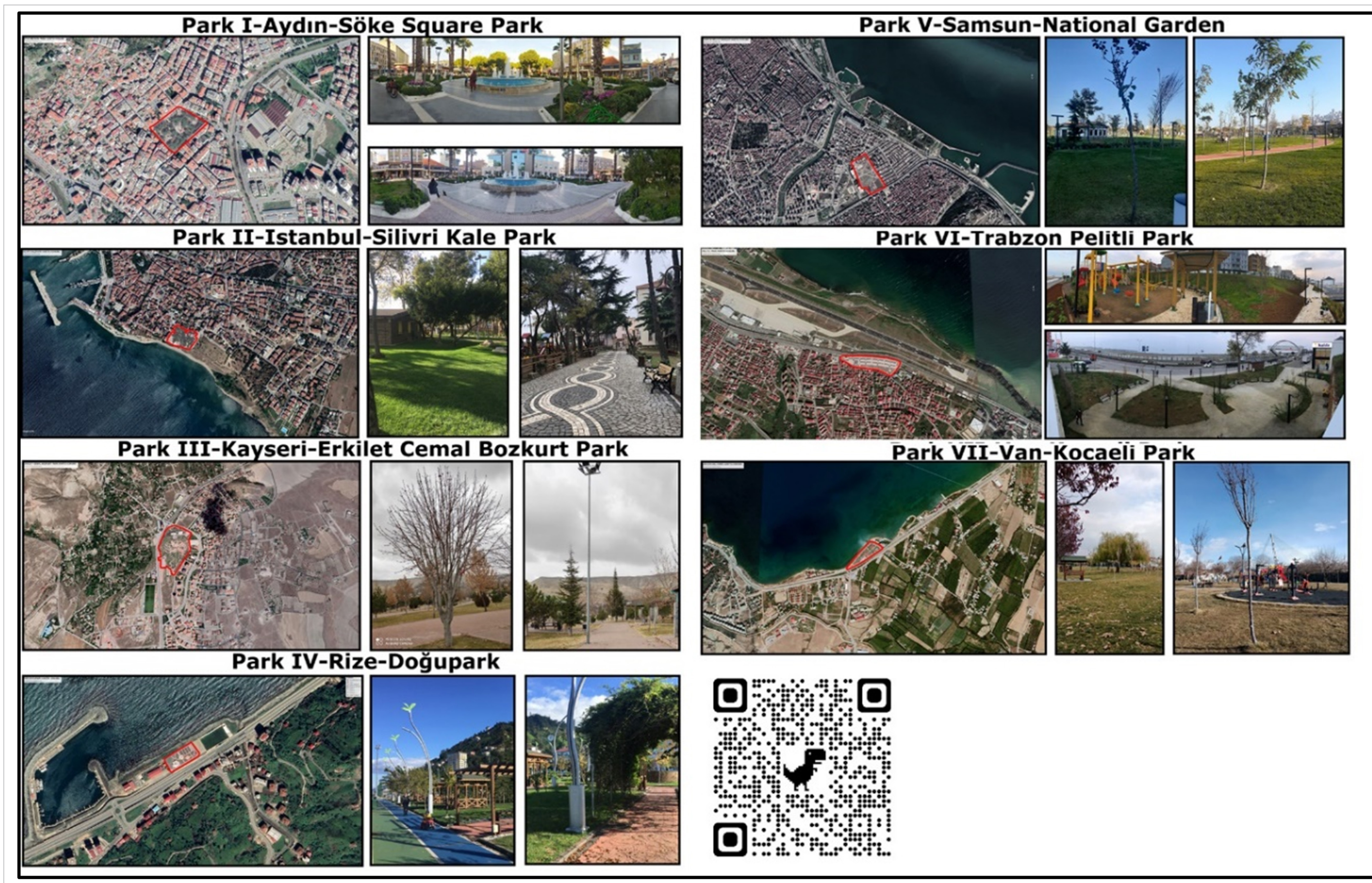

Figure 2.
Parks' Photographs (Original, 2021).

Table 2.
Species Abundance Values

			Park I	Park II	Park III	Park IV	Park V	Park VI	Park VII
Family	Species					Values			
Sapindaceae	*Acer campestre* L.	N					19		
Sapindaceae	*Acer palmatum* Thunb.	E				9	11		
Sapindaceae	*Acer negundo* L.	N				40	26	24	
Sapindaceae	*Acer platanoides* L.	N					12		
Sapindaceae	*Aesculus hippocastanum* L.	E			54				6
Fabaceae	*Albizia julibrissin* Durazz	E					5	39	
Berberidaceae	*Berberis thunbergii* DC.	E					120		
Betulaceae	*Betula alba* L.	N							16
Pinaceae	*Cedrus atlantica* Endl.	E					10	17	
Pinaceae	*Cedrus libani* A. Rich.	N			24				
Pinaceae	*Cedrus deodora* Roxb.	E		125			2		5
Fabaceae	*Cercis siliquastrum* L.	N					5		
Rutaceae	*Citrus chinensis* L.	E				7			
Rutaceae	*Citrus reticulata* L.	E				8			
Rosaceae	*Chaenomeles japonica* Thunb.	E						2112	
Cornaceae	*Cornus alba* L.	E						3770	
Cupressaceae	*Cupressus arizonica* Greene.	E						48	
Cupressaceae	*Cupressus macrocarpa* A. Cunn.	E				12			
Cupressaceae	*Cupressocyparis leylandii* A.B. Jacks & Dallim.	E					130	51	
Cycadaceae	*Cycas revoluta* Thunb.	E	7						
Rosaceae	*Crataegus monogyna* Jacq.	N					12		
Elaeagnaceae	*Elaeagnus angustifolia* L.	N							2
Asteraceae	*Euryops pectinatus* L.	E	8				33		
Celastraceae	*Euonymus japonica* Thunb.	E		33			263	1348	17
Fagaceae	*Fagus sylvatica* L.	E					6		
Oleaceae	*Fraxinus excelsior* L.	N		3	54	21		14	
Oleaceae	*Forsythia x intermedia*	E						2753	
Malvaceae	*Hibiscus syriacus* L.	E					15		
Hydrangeaceae	*Hydrangea macrophylla* Thunb.	E		35		2			
Ginkgoaceae	*Ginkgo biloba* L.	E					9		
Cupressaceae	*Juniperus virginiana* L.	E			47				
Pinaceae	*Larix decidua* Mill.	E					9		
Rosaceae	*Laurocerasus officinalis* Roamer.	N				5			
Lythraceae	*Lagerstroemia indica* L.	E				3	3		
Lamiaceae	*Lavandula angustifolia* Mill.	N					15		
Oleaceae	*Ligustrum japonica* Thunb.	E				10	31		
Lauraceae	*Laurus nobilis* L.	N				3			
Caprifoliaceae	*Lonicera sp.*	N						2465	
Berberidaceae	*Mahonia japonica* DC.	E						3318	
Magnoliaceae	*Magnolia grandiflora* L.	E				2	4		
Moraceae	*Morus alba* L.	E				12			
Rosaceae	*Malus perpetu*	E				16			

(*Continued*)

Table 2.
Species Abundance Values (Continued)

			Park I	Park II	Park III	Park IV	Park V	Park VI	Park VII
Family	Species		Values						
Rosaceae	*Malus floribunda* Siebold.	E						24	
Apocynaceae	*Nerium oleander* L.	N		3			20		
Onagraceae	*Oenothera indheimeri* Engelm & A.Gray.	E					57		
Oleaceae	*Olea europaea* L.	N				1			
Asphodelaceae	*Phormium tenax* J.R. Forst & G. Forst	E		6					
Rosaceae	*Photinia* x *fraseri* Dress.	E				13	3	2465	
Rosaceae	*Photinia serrulata* Kalkman.	E				13	67		
Proteales	*Platanus orientalis* L.	N							16
Pinaceae	*Picea abies* H. Karst.	E						24	
Pinaceae	*Picea pungens* Engelmn.	E			11				
Pinaceae	*Pinus radiata* D. Don.	E			44				
Pinaceae	*Pinus sylvestris* L.	N						19	
Pinaceae	*Pinus pinea* L.	N	31	43	8				
Pittosporaceae	*Pittosporum tobira* Thunb.	E	676	3				5185	
Rosaceae	*Prunus cerasifera* Ehrh.	E						34	
Rosaceae	*Prunus serrulata* Lindl.	E				50			14
Fabaceae	*Robinia pseudoacacia* L.	E			38		24		34
Rosaceae	*Rosa Sp.*	N		120				320	
Lamiaceae	*Rosmarinus officinalis* L.	N		105					
Fagaceae	*Quercus robur* L.	N					3		
Adoxaceae	*Sambucus racemosa* L.	E					35		
Salicaceae	*Salix babylonica* L.	E							1
Salicaceae	*Salix matsudana*	E				1			
Cupressaceae	*Thuja occidentalis* L.	E	3						
Malvaceae	*Tilia tomentosa* Moench.	N					113		
Pinaceae	*Tsuga sieboldii* Carr.	E		3					
Adoxaceae	*Viburnum tinus* L.	E		36					
Arecaceae	*Washingtonia robusta* H. Wendl.	E	15						
Fabaceae	*Wisteria sinensis* DC.	E				32			
	Total		740	515	280	260	1062	24,030	111

Note: N = native to Turkey (21); E = exotic (non-native) to Turkey (50).

where pi is the proportion of individuals in its species, *S* is the total number of species, and *α* is the average species richness of the samples.

Interpretation of the Results

First, the quantitative characteristics of woody plant species in the parks were presented. Next, the evergreen/broadleaf features of plants were addressed. Allergic reactions that can occur due to the pollen properties of plants are known. For this reason, the presence of allergic plants in Turkey was briefly evaluated. Then, the family distributions of woody plants and their native or non-native status to Turkey were examined. Finally, interpretations of the parks' alpha diversity and beta dissimilarity were made and discussed with the literature.

Results and Discussion

General Evaluation

In the light of species' frequency analysis (Table 2), 32 families and 71 different species have been detected in the parks. Parks I, II, III, IV, V, VI, and VII have total element values of 740, 515, 280, 260, 1062, 24,030, and 111, respectively. Woody plant species native to Turkey were 29.58% (21), and non-natives were 70.42% (50). When the native species were examined, the highest native species was detected in Park V and the lowest was in Park I. Native species percentage of the parks in the total abundance was as follows: Park I was 3.33%, Park II was 16.67%, Park III was 10%, Park IV was 16.66%, Park V was 26.67%, Park VI was 16.67%, and Park VII was 10% (Table 2).

The plants' features, including deciduous, evergreen, flowers, etc., are important for creating a sustainable ecosystem all year round. When the sample areas are examined, Parks I, II, III, IV, V, VI, VII, and VII have evergreen plants ratios of 100%, 76.1%, 47.8%, 29.2%, 53%, 51.8%, and 20.7%, respectively. Another issue is the plant species whose pollen may pose a threat. In this context, some types can cause pollen allergy (specifically in Turkey): *Alnus glutinosa*, *Betula verrucosa*, *Corylus avellana*, *Cupressus sempervirens*, *Olea europaea*, and *Platanus orientalis* (Damialis et al., 2019). The excessive integration of such plants into the plantation design can threaten public health during pollen periods. In our case, the rate of plants with pollen threat is quite low, which is eligible (Table 2).

On the other hand, appropriate pollination is another issue to protect and maintain environmental health. For example, *Tilia* species are significant in maintaining this cycle and contribute significantly to pollination ecosystem service in green areas during flowering periods (Daniels et al., 2020). The *Tilia* species are seen only in Park V among the sample areas. Additionally, *Pinus sp.*, *Eucalyptus sp.*, and *Leucaena sp.* demonstrate high carbon sequestration performance (Saifuddin et al., 2020; Silveira et al., 2020). Turkey is rich in *Pinus* species. When the native ones are examined, it is seen that they are used insufficiently in the parks (Table 2).

According to the plant family distributions, the most preferred ones are Pinaceae (three are native and seven are non-native), Rosaceae (three are native and seven are non-native), Cupressaceae (five are non-native), and Sapindaceae (three are native and two are non-native) (Figure 3). In Turkey, the Pinaceea, Sapindaceae, and Rosaceae families, in particular, have a vibrant flora. Some critical species are (Pinaceae) *Pinus sylvestris* L., *Pinus nigra* subsp. *pallasiana*, *Pinus brutia*, *Pinus pinea* L., *Pinus halepensis* Mill., *Picea orientalis* L., *Abies nordmanniana*, *A. cilicica* subsp. *cilicica*, *Cedrus libani*; (Sapindaceae) *Acer campestre* L., *A. cappadocicum*, *A. hyrcanum*, *A. heldreichii*, *A. monspessulanum*, *A. negundo*, *A. platanoides*, *A. pseudoplatanus*, *A. sempervirens* L., *A. tataricum* L.; (Rosaceae) *Amygdalus communis* L., *Sorbus domestica* L., *Cotoneaster melanocarpus* Lodd., *Crataegus orientalis* Pall., *Laurocerasus officinalis* Roamer., *Malus sylvestris* Mill., *Prunus avium* L., *Potentilla anatolica* Browicz., *Pyrus communis* L., *Rosa canina* L., and *Spiraea crenata* L. (Davis & Hedge, 1975; Güner, 2012).

Evaluation of Alpha (α) Diversity

Alpha diversity is the method that measures the biological diversity of the sample area itself. According to Shannon analysis (α), the parks had the following values: 0.4099 (Aydın Söke Square Park), 1.931 (İstanbul Silivri Castle Park), 1.936 (Kayseri Erkilet Cemal Bozkurt Park), 2.564 (Rize Doğu Park), 2.622 (Samsun Millet Garden), 2.124 (Trabzon Pelitli Park), and 1.881 (Van Kocaeli Park) (Figure 4). Park IV and V are overlapped with the studies of Koricho et al. (2020) and Muthulingam and Thangavel (2012). Furthermore, all parks achieved lower values than those of the study of Li et al. (2020). These comparisons are important for future studies. When the diversity of native and non-native (exotic) species is examined, the parks have native diversity values of 0 (Park I), 1.119 (Park II), 0.8693 (Park III), 1.065 (Park IV), 1.551 (Park V), 0.471 (Park VI), and 0.8761 (Park VII), respectively, and non-native diversity values are 0.2463 (Park I), 1.472 (Park II), 1.518 (Park III), 2.147 (Park IV), 2.2384 (Park V), 1.934 (Park VI), and 1.437 (Park VII), respectively.

The Mediterranean climate is appropriate to include myriad diversity of woody plants (Cowling et al., 1996), and Turkey's Mediterranean region has the highest plant diversity compared to other regions. In this richness, the lack of native plants' usage is a significant key point to consider. As for non-native species' assessment, non-native woody plants are higher than native species' diversity. This finding put forward an unsuitable condition for the climate-adaptive urban green space approach (Acar et al., 2007).

The native species evaluation of this study highlighted that although Park I is located in the Aegean region of Turkey, namely Mediterranean climate does not have adequate native plant usage. Aydın province includes a number of woody plant species to use in planting design such as *Capparis ovata* Willd., *C. libani* A. Rich., *Cercis siliquastrum* L., *C. sempervirens* L., *Ficus carica* L., *Hedera helix* L., *Laurus nobilis* L., *Liquidamber orientalis* Mill., *Myrtus communis* L., *Nerium oleander* L., *Olea europea* L., *Pinus brutia* Ten., *P. orientalis* L., *Populus tremula* L., *Salix alba* L., *Sambucus nigra* L., and *Tamarix parviflora* DC. (Deniz & Sirin, 2010). However, only *P. pinea* was detected in Park I. In addition, *Pinus brutia* is a suitable tree for birds (Asik & Kara, 2021). Using *P. brutia* in planting design can improve the habitat quality of Park I. Similar findings of lack of native plants were valid for Park II, and the results support the study of Yener and Ayaşlıgil (2016).

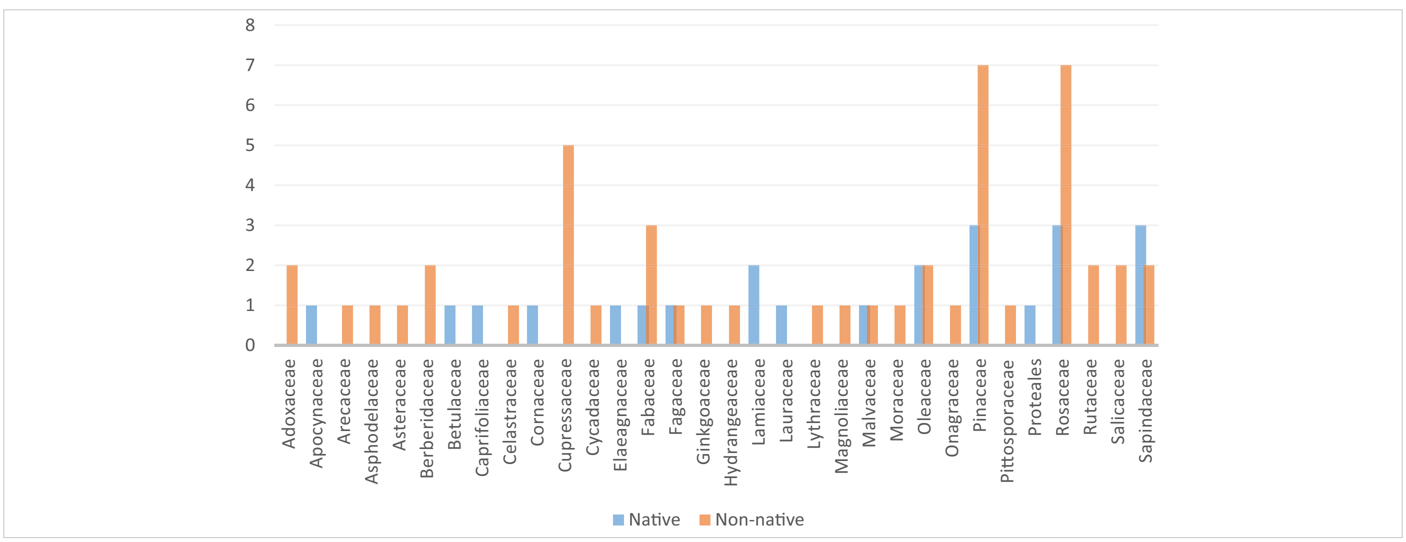

Figure 3.
Plant Families in the Parks.

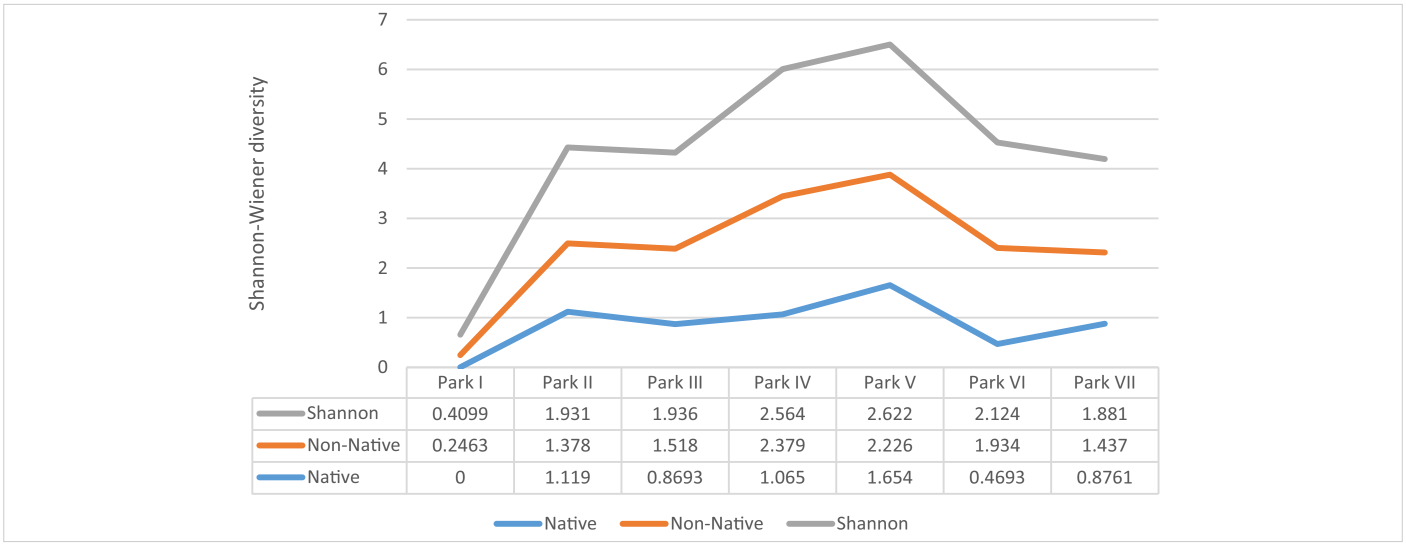

Figure 4.
Shannon–Wiener Diversity Values.

Parks IV, V, and VI are located in Rize, Samsun, and Trabzon province, respectively. The findings of these parks demonstrate the lack of native plant usage in their planting design. The result is matched with that of the study of Tarakcı-Eren and Var (2016) for Park VI. Some native species are *C. sempervirens* L., *C. libani* A. Rich, *P. pinea* L., *Picea orientalis* L., *N. oleander* L., *A. glutinosa* L., *Alnus orientalis* Decne., *Betula pubescens* Ehrh., *Buxus sempervirens* L., *Viburnum opulus* L., *Spartium junceum* L., *Fagus orientalis* Lipsky, *L. nobilis* L., *Ceratonia siliqua* L., *L. officinalis* Roemer, *Rosmarinus officinalis* L., *Crateagus monogyna* Jacq., *Ficus carica* L., *Fraxinus excelsior* L., *Philadelphus coronarius* L., and *Tilia rubra* DC.

Parks III and VII are located in Kayseri and Van provinces, respectively, thus, they are included in the Irano-Turan phytogeographical region (Avcı, 1993). As shown in Table 2, these parks' plant diversity mostly consists of plant species non-native to Turkey. To recommend suitable plant species, the following species can be considered to use in planting design: *Acer negundo* L., *Betula pubescens* Ehrh., *Cotinus coggygria* Scop., *Crateagus orientalis* M.Bieb., *Elaeagnus angustifolia* L., *F. excelsior* L., *Juglans regia* L., *Morus alba* L., *P. sylvestris* L., and *Viburnum opulus* L. (Askan & Yılmaz, 2016).

Evaluation of Beta (β) Dissimilarity

Table 3 shows that the plant species diversity of the parks varies greatly. Although Parks IV, V, and VI are in the same climatic zone, their similarity rates are low due to low native species usage. When the Whittaker (β) dissimilarity analysis is examined, the parks' highest dissimilarity rates are Park I versus Park IV and VII because the same species are not integrated into the plantation design in areas. The lowest dissimilarity rate, namely the highest similarity rate, was found between Park IV and Park V (Table 3). If the use of native species is increased, species differences between parks are likely to decrease. Moreover, this is crucial to minimize plants' maintenance because native species can naturally adapt to the area's climate and soil conditions (Guo et al., 2018; He & He, 2020).

Conclusions and Recommendations

Bio-diversity studies have importance in ecology, and, undoubtedly, raising awareness about climate change-related topics increases the volume. This issue is crucial to mitigate the adverse effects and to put forward new natural-based solutions. These kinds of researches can adequately improve the quality of ecology. As such, biodiversity studies is a crucial aspect (as a tool) to investigate urban ecology.

Today, the essential tasks of landscape architects are to reduce carbon dioxide in the atmosphere and to build a climate-adapted urban ecosystem. In performing these tasks, designers use many nature-based solutions. Some of these are to select suitable native plant species with a high adaptation to climate change and to improve ecosystems' quality. We highly recommend that plants should be native species as far as

Table 3.
Whittaker Beta Dissimilarity Values

	Park I	Park II	Park III	Park IV	Park V	Park VI	Park VII
Park I	0	0.77778	0.85714	1	0.94286	0.92	1
Park II	0.77778	0	0.8	0.875	0.85366	0.74194	0.80952
Park III	0.85714	0.8	0	0.92857	0.94595	0.92593	0.76471
Park IV	1	0.875	0.92857	0	0.71429	0.84615	0.93103
Park V	0.94286	0.85366	0.94595	0.71429	0	0.75	0.84211
Park VI	0.92	0.74194	0.92593	0.84615	0.75	0	0.92857
Park VII	1	0.80952	0.76471	0.93103	0.84211	0.92857	0

possible in a plantation design. According to this criterion, none of the selected parks contains native species at the desired rate.

Overall, there is a considerable difference between the seven selected parks. Samsun Millet Garden (Park V) had the highest woody plant diversity (2.622), and Aydın Söke Square Park (Park I) had the lowest woody plant diversity (0.4099). We recommend researchers make similar studies to compare species diversity. In the beta dissimilarity analysis, there is a high difference between parks because of the lack of usage of native species. Native species must be preferred in the parks' plantation design, with similar climate conditions to reduce the beta dissimilarity and maintenance costs. To examine the beta results in detail, the native species' inventory in nurseries and designers' approaches to planting design should be examined by different studies.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – H.O., E.Ş., F.B., D.D.; Design – H.O., E.Ş., F.B., D.D.; Supervision – E.Ş., D.D.; Materials – E.Ş., F.B.; Data Collection and/or Processing – H.O., E.Ş.; Analysis and/or Interpretation – H.O.; Literature Search – H.O., D.D.; Writing Manuscript – H.O., F.B.; Critical Review –E.Ş., D.D.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

References

- Acar, C., Acar, H., & Eroğlu, E. (2007). Evaluation of ornamental plant resources to urban biodiversity and cultural changing: A case study of residential landscapes in Trabzon city (Turkey). *Building and Environment*, *42*(1), 218–229. [CrossRef]
- Alizadeh, B., & Hitchmough, J. D. (2020). Designing sustainable urban landscape and meeting the challenge of climate change: A study of plant species adaptation and fitness under different climate change scenarios in public landscape of UK. *Landscape Research*, *45*(2), 228–246. [CrossRef]
- Asik, Y., & Kara, B. (2021). Variation in avian diversity in relation to plant species in urban parks of Aydin, Turkey. *Applied Ecology and Environmental Research*, *19*(3), 2013–2035. [CrossRef]
- Askan, G., & Yılmaz, H. (2016). Erzincan Kenti açık-yeşil Alanlarında Kullanılan Bitkisel Materyalin Belirlenmesi. *Erzincan Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *9*(1), 2016. [CrossRef]
- Avcı, M. (1993). Türkiye'nin flora bölgeleri ve Anadolu diagonali ne coğrafi bir yaklaşım. *Türk Coğrafya Dergisi*, *28*, 225–248.
- Baruch, Z., Liddicoat, C., Cando-dumancela, C., Laws, M., Weinstein, P., Young, J., & Breed, M. F. (2020). Increased plant species richness associates with greater soil bacterial diversity in urban green spaces. *Environmental Research*, 110425. [CrossRef]
- Choudhury, M. A. M., Marcheggiani, E., Despini, F., Costanzini, S., Rossi, P., Galli, A., & Teggi, S. (2020). Urban tree species identification and carbon stock mapping for urban green planning and management. *Forests*, *11*(11), 1226. [CrossRef]
- Çoban, S., Doğanay, Y. Ş., & Bayraktar, S. (2020). Woody plant composition and diversity of urban green spaces in Istanbul, Turkey. *Plant Biosystems*, *155*(1), 83–91. [CrossRef]
- Cowling, R. M., Rundel, P. W., Lamont, B. B., Kalin Arroyo, M. K., & Arianoutsou, M. (1996). Plant diversity in Mediterranean-climate regions. *Trends in Ecology and Evolution*, *11*(9), 362–366. [CrossRef]
- Czortek, P., & Pielech, R. (2020). Surrounding landscape influences functional diversity of plant species in urban parks. *Urban Forestry and Urban Greening*, *47*, 126525. [CrossRef]
- Dadvand, P., Gascon, M., & Markevych, I. (2019). Green spaces and child health and development. In *Biodiversity and health in the face of climate change* (pp. 121–132). Springer Nature.
- Damialis, A., Traidl-Hoffmann, C., & Treudler, R. (2019). Climate change and pollen allergies. In *Biodiversity and health in the face of climate change* (1st ed, pp. 47–66). Springer Nature.
- Daniels, B., Jedamski, J., Ottermanns, R., & Ross-Nickoll, M. (2020). A "plan bee" for cities: Pollinator diversity and plant-pollinator interactions in urban green spaces. *PLoS ONE*, *15*(7), e0235492. [CrossRef]
- Davis, P. H., & Hedge, I. C. (1975). The Flora of Turkey: Past, present and future. *Candollea*, *30*, 331–351.
- de Vries, S., & Snep, R. (2019). Biodiversity in the context of 'biodiversity – mental health' research. In *Biodiversity and health in the face of climate change* (1st ed, pp. 159–174). Springer Nature.
- Deniz, B., & Sirin, U. (2010). A study of ecological integrity based on native plants in Kusadasi (Turkey) urban area and surrounding natural environment. *Scientific Research and Essays*, *5*(14), 1820–1828.
- Dunn, C. P. (2017). Biological and cultural diversity in the context of botanic garden conservation strategies. *Plant Diversity*, *39*(6), 396–401. [CrossRef]
- Ergüner, Y., Kumar, J., Hoffman, F. M., Dalfes, H. N., & Hargrove, W. W. (2019). Mapping ecoregions under climate change: A case study from the biological 'crossroads' of three continents, Turkey. *Landscape Ecology*, *34*(1), 35–50. [CrossRef]
- Gogoi, A., Ahirwal, J., & Sahoo, U. K. (2021). Plant biodiversity and carbon sequestration potential of the planted forest in Brahmaputra flood plains. *Journal of Environmental Management*, *280*, 111671. [CrossRef]
- Grant, C. (2012). Analogies and links between cultural and biological diversity. *Journal of Cultural Heritage Management and Sustainable Development*, *2*(2), 153–163. [CrossRef]
- Güler, B. (2020). Plant species diversity and vegetation in urban grasslands depending on disturbance levels. *Biologia*, *75*(9), 1231–1240. [CrossRef]
- Gülsoy, S., & Özkan, K. (2008). Importance of biodiversity from the ecological standpoint and some diversity indexes. *Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi*, *1*, 168–178.
- Güner, A. (2012). *Türkiye Bitkileri listesi (1st ed). ANG Vakfı.* kitabına ait ISBN no: 978-605-60425-7-7, İl: İstanbul pp. 1290.
- Guo, Q. F., Fei, S. L., Shen, Z. H., Iannone, B. V., Knott, J., & Chown, S. L. (2018). A global analysis of elevational distribution of non-native versus native plants. *Journal of Biogeography*, *45*(4), 793–803. [CrossRef]
- He, Z. S., & He, W. M. (2020). Asymmetric climate warming does not benefit plant invaders more than natives. *Science of the Total Environment*, *742*, 140624. [CrossRef]
- IUCN. (2021). Turkey. Retrieved from https://www.iucn.org/regions/europe. Access Date: 24.06.2021.
- Jochum, M., Fischer, M., Isbell, F., Roscher, C., van der Plas, F., Boch, S., Boenisch, G., Buchmann, N., Catford, J. A., Cavender-Bares, J., Ebeling, A., Eisenhauer, N., Gleixner, G., Hölzel, N., Kattge, J., Klaus, V. H., Kleinebecker, T., Lange, M., Le Provost, G., Meyer, S., … Manning, P. (2020). The results of biodiversity–ecosystem functioning experiments are realistic. *Nature Ecology and Evolution*, *4*(11), 1485–1494. [CrossRef]
- Kadereit, G., & Freitag, H. (2011). Molecular phylogeny of Camphorosmeae (Camphorosmoideae, Chenopodiaceae): Implications for biogeography, evolution of C4-photosynthesis and taxonomy. *Taxon*, *60*(1), 51–78. [CrossRef]
- Keten, A., Eroglu, E., Kaya, S., & Anderson, J. T. (2020). Bird diversity along a riparian corridor in a moderate urban landscape. *Ecological Indicators*, *118*, 106751. [CrossRef]
- Koricho, H. H., Shumi, G., Gebreyesus, T., Song, S., & Fufa, F. (2021). Woody plant species diversity and composition in and around Debre Libanos church forests of North Shoa Zone of Oromiya, Ethiopia. *Journal of Forestry Research*, *32*(5), 1929–1939. [CrossRef]
- Li, E., Parker, S. S., Pauly, G. B., Randall, J. M., Brown, B. V., & Cohen, B. S. (2019). An urban biodiversity assessment framework that combines an urban habitat classification scheme and citizen science data. *Frontiers in Ecology and Evolution*, *7*, 277. [CrossRef]
- Li, X., Jia, B., Zhang, W., Ma, J., & Liu, X. (2020). Woody plant diversity spatial patterns and the effects of urbanization in Beijing, China. *Urban Forestry and Urban Greening*, *56*, 126873. [CrossRef]
- Lindley, S. J., Cook, P. A., Dennis, M., & Gilchrist, A. (2019). Biodiversity, physical health and climate change: A synthesis of recent evidence. In *Biodiversity and health in the face of climate change* (1st ed, pp. 17–46). Springer Nature.
- Meyer-Grandbastien, A., Burel, F., Hellier, E., & Bergerot, B. (2020). A step towards understanding the relationship between species diversity and psychological restoration of visitors in urban green spaces using landscape heterogeneity. *Landscape and Urban Planning*, *195*, 103728. [CrossRef]
- Muthulingam, U., & Thangavel, S. (2012). Density, diversity and richness of woody plants in urban green spaces: A case study in Chennai metropolitan city. *Urban Forestry and Urban Greening*, *11*(4), 450–459. [CrossRef]
- Nilon, C. H., Aronson, M. F. J., Cilliers, S. S., Dobbs, C., Frazee, L. J., Goddard, M. A., O'Neill, K. M. O., Roberts, D., Stander, E. K., Werner, P., Winter, M., & Yocom, K. P. (2017). Planning for the future of urban biodiversity: A global review of city-scale initiatives. *BioScience*, *67*(4), 332–342. [CrossRef]

- Özkan, K., Küçüksille, E. U., Mert, A., Gülsoy, S., Süel, H., & Başar, M. (2020). Biyolojik Çeşitlilik Bileşenleri (BİÇEB) hesaplama yazılımı. *Turkish Journal of Forestry*, *21*, 344–348.
- Öztürk, M., Yücel, E., Yargı, C., Çelik, A., & Aksoy, A. (1998). Plant diversity in the Turkish Black Sea region and strategies for its conservation. In *Conservation of tile biological diversity as a prerequisite for sustainable development in tile Black Sea Region* (pp. 155–173). Kluwer Academic Publishers.
- Pilania, P. K., Gujar, R. V., & Panchal, N. S. (2014). Carbon sequestration by different tree species in tropical dry deciduous forest of Panchmahal District (Gujarat) in India. *Environment Conservation Journal*, *15*(3), 101–107. [CrossRef]
- Rudov, A., Mashkour, M., Djamali, M., & Akhani, H. (2020). A review of C4 plants in southwest Asia: An ecological, geographical and taxonomical analysis of a region with high diversity of C4 eudicots. *Frontiers in Plant Science*, *11*, 546518. [CrossRef]
- Saifuddin, M., Osman, N., & Khandakera, M. M. (2020). Carbon sink and biochemical potentially of two legume tree species. *Journal of Tropical Forest Science*, *32*(3), 217–226. [CrossRef]
- Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, *27*(3), 379–423. [CrossRef]
- Silveira, C. S., Oliveira, L. De, & Talamini, E. (2020). Which species perform best in carbon sequestration and storage in planted forests? A review of the potential of Pinus and Eucalyptus. *International Forestry Review*, *22*(4), 544–557. [CrossRef]
- Solon, J. (1996). The biological diversity of vegetational landscapes: Problems with evaluation. In A. Breymeyer, et al. (Eds.), *Biodiversity conservation in transboundary protected areas* (pp. 15–24). National Academy Press. [CrossRef]
- Stas, M., Aerts, R., Hendrickx, M., Dendoncker, N., Dujardin, S., Linard, C., Nawrot, T., Van Nieuwenhuyse, A., Aerts, J., Van Orshoven, J., & Somers, B. (2020). An evaluation of species distribution models to estimate tree diversity at genus level in a heterogeneous urban-rural landscape. *Landscape and Urban Planning*, *198*, 103770. [CrossRef]
- Swan, C. M., Johnson, A., & Nowak, D. J. (2017). Differential organization of taxonomic and functional diversity in an urban woody plant metacommunity. *Applied Vegetation Science*, *20*(1), 7–17. [CrossRef]
- Talal, M. L., & Santelmann, M. V. (2020). Vegetation management for urban park visitors: A mixed methods approach in Portland, Oregon. *Ecological Applications*, *30*(4), e02079. [CrossRef]
- Tarakcı-Eren, E., & Var, M. (2016). Parkların bitkisel tasarımında kullanılan taksonlar: Trabzon kent merkezi örneği. *Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi*, *17*(2), 200–213. [CrossRef]
- Whittaker, R. H. (1972). Evolution and measurement of species diversity. *Taxon*, *21*(2–3), 213–251. [CrossRef]
- Yener, Ş. D., & Ayaşlıgil, Y. (2016). İstanbul Marmara kıyılarının odunsu bitki varlığı açısından değerlendirilmesi. *Journal of the Faculty of Forestry Istanbul University*, *66*(1), 1–15. [CrossRef]