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Evaluation of Plant Use with High Ecological Tolerance for Climate Change Resistant Landscape in Kilis Sample Parks

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Abstract

One of the most important ways to create climate-resilient landscapes in cities is the use of plants with high ecological tolerance in urban open-green spaces. The aim of this study is to evaluate the ecological tolerance factors (frost, salinity, wind, air pollution, and drought) of woody plants in sample city parks of Kilis city (Karataş Park, Fıstıklı Park, and Şehit Terzi Muzaffer Aydemir Park) and to determine if there is a significant difference between the parks in terms of these factors. Firstly, the general area uses, plant species and numbers, and the taxa/natural distribution areas of the plants in each park were determined, and these plants were evaluated according to the factors. Whether there is a significant difference between the ecological tolerance values of plant species in the parks was determined using the "Kruskal-Wallis H-Test for Independent Group". The study findings indicate that there are no significant differences at the $p \leq 0.05$ level in frost, wind, salinity, and air pollution tolerances between the parks; however, there is a significant difference in drought tolerance.

Keywords: *Urban open-green spaces, resilient landscapes, sustainability, ecological tolerance, Kilis.*

İklim Değişikliğine Dirençli Peyzajlar İçin Ekolojik Toleransı Yüksek Bitki Kullanımının Kilis Örnek Parklarında Değerlendirilmesi

Öz

Kentlerde iklim değişikliğine dirençli peyzajlar oluşturmanın en önemli yollarından birisi de kentsel açık-yeşil alan tasarımında kentin ve uygulama alanının ekolojik faktörlerine dayanıklı yani ekolojik toleransı yüksek bitkilerin kullanımıdır. Bu çalışmanın amacı Kilis kenti örnek kent parklarındaki (Karataş Parkı, Fıstıklı Park ve Şehit Terzi Muzaffer Aydemir Parkı) odunsu bitkilerin ekolojik tolerans faktörleri (don, tuzluluk, rüzgâr, hava kirliliği ve kuraklık) açısından değerlendirilmesi ve söz konusu bu faktörler çerçevesinde parklar arasında anlamlı bir farkın bulunup bulunmadığının tespit edilmesidir. Araştırmada öncelikle her bir parkın genel alan kullanımları, bitki türleri ve sayıları, bitkilerin taksonları/doğal yayılış alanları ortaya konulmuş ve söz konusu bitkiler ekolojik tolerans faktörlerine göre değerlendirilmiştir. Parklardaki bitki türlerinin ekolojik tolerans değerleri arasında anlamlı bir farkın olup olmadığı "Bağımsız Gruplar İçin Kruskal Wallis H-Testi" sonuçları ile tespit edilmiştir. Çalışma bulguları parklar arasında don, rüzgâr, tuzluluk ve hava kirliliği toleranslarında $p \leq 0.05$ düzeyinde anlamlı farklılıkların olmadığını; kuraklık toleransında ise farklılığın anlamlı olduğunu göstermektedir.

Anahtar kelimeler: *Kentsel açık-yeşil alanlar, dirençli peyzaj, sürdürülebilirlik, ekolojik tolerans, Kilis.*

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1. Introduction

Climate change is one of the most important environmental challenges facing the world today. It has been proven to be caused by an increase in the concentration of greenhouse gases in the atmosphere. According to the latest reference on this subject, the IPCC's 6th Assessment Report, the surface temperature is found to be 1.09°C higher in the 2011–2020 period compared to the 1900s, parallel to the increase in global greenhouse gases. The report predicts that even under a very low greenhouse gas emission scenario, the Earth's temperature will increase by 1.0°C to 1.8°C by 2100; under a moderate scenario, it will increase by 2.1°C to 3.5°C; and under a very high greenhouse gas emission scenario, it will increase by 3.3°C to 5.7°C (IPCC, 2021).

According to the greenhouse gas inventory data from the Turkish Statistical Institute (TSI) (2023), total greenhouse gas emissions in Türkiye in 2021 increased by 7.7% compared to the previous year, reaching 564.4 million tons (Mt) of CO_2 equivalent (eq.). Per capita total greenhouse gas emissions in the country were 4 tons of CO_2 eq. in 1990, 6.3 tons of CO_2 eq. in 2020, and 6.7 tons of CO_2 eq. in 2021. This increase in emissions has been confirmed to be parallel to the increase in temperature in the country, according to data from the Turkish State Meteorological Service (TSMS). The annual average temperature in the country, which was 12.9°C in 1970, rose to 14.5°C in 2022 (TSMS, 2023). The report *" Climate Projections and Climate Change with New Scenarios in Türkiye"* prepared by the TSMS includes predictions on climate change for Türkiye covering three different periods. According to the report, temperatures are expected to increase and rainfall is expected to decrease by seasons. The report suggests that by 2100, there will be an increase of 2°C to 4°C in winter and 5°C in other seasons in the country, with a 50% decrease in spring rainfall and a 70% decrease in summer rainfall (TSMS, 2015).

The assessments made regarding Turkey in the IPCC's 6th Assessment Report confirm these findings. The report emphasizes that scenarios and projections for climate change show geographical variations, highlighting that climate change will particularly affect North Africa, Italy, the Balkans, and Turkey more. It is predicted that the annual average temperature change in the Southeastern Anatolia region, which includes Kilis, the region where the study area is located, will exceed the global average temperature change (IPCC, 2021). When the meteorological drought map prepared based on the data for the last 24 months (January 2021-December 2022) is examined, it is noteworthy that the province is located in the severe drought region (TSMS, 2023).

It has been unequivocally proven that climate change is caused by human activities (IPCC, 2021). Today, the areas where human activities are most intense are cities. Terms such as "climate-resilient," "climate-resistant," and "resilient city" are commonly used in the literature on cities and climate change, regarding the increasingly important concept of resilience. In all these terms, the necessity for cities, urban systems, and urban dwellers to rapidly recover from climate-related shocks and stresses is emphasized (Leichenko, 2011). The IPCC defines resilience as *" 'the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change"* (IPCC, 2007).

At this point, the fundamental principle of creating resilient landscapes in cities is the accurate interpretation of the area's climatic data and the generation of solutions that minimize natural resource consumption. In recent years, ecological approaches have become increasingly important in ensuring the sustainability of open-green spaces in urban areas (Tel &.Erdoğan, 2021). Korkut et al., (2017) emphasized the significant role of ecological tolerance factors in designs for various types of areas such as urban parks, sports fields, and children's playgrounds to achieve sustainable development. They underscored the need to utilize climatic data such as precipitation, temperature, wind, and sunlight when designing to minimize natural resource consumption. At this point, the selection of appropriate plants is crucial in the areas. The term *'appropriate plant species'* refers to plants that not only serve aesthetic purposes but are also resilient to the environmental factors and ecological factors (frost, salt, temperature, air pollution, drought, wind, rainfall, etc.) of the urban area where they are applied. Choosing species with high ecological tolerance will result in the use of drought and heat-resistant, low-water-consuming plant species, which will partially contribute to alleviating the water problem arising from global climate change today. In recent years, it has been expressed by scientists that Turkey, which is among countries experiencing water scarcity, will turn into dry and semi-arid areas in the coming years, similar to other countries in the Mediterranean region. This situation particularly emerges as a problem in terms of the continuity of urban park designs that are important both naturally and aesthetically, highlighting the importance of preferring plant elements with high ecological tolerance in urban park facilities (Zencirkıran & Akdeniz, 2017).

The aim of this study is to evaluate the woody plants in three example urban parks (Karataş Park, Fıstıklı Park, and Şehit Terzi Muzaffer Aydemir Park) located in different regions of the city with high intensity of use and plant diversity, in terms of their ecological tolerance factors (frost, salinity, wind, air pollution, and drought), and to determine if there is a significant difference between the parks in terms of these factors.

For this purpose, firstly, the current structural and vegetative status of the parks were determined in the study. Within this scope, the general land uses of each park, the plant species and numbers, and the natural distribution areas of the plants were identified, and the identified plants were evaluated according to ecological tolerance factors. In the second part of the findings, the results of *"Cross-Tabulations"* conducted to evaluate the differences in frost, wind, salinity, air pollution, and drought tolerance between the parks, and the results of *"Independent Groups Kruskal Wallis H-Test"* applied to determine if there is a significant difference in the ecological tolerance values of the plant species used in the parks were evaluated to ensure the evaluation of the differences in tolerance between the parks. As a result of the study, recommendations were developed to increase the use of plants with high ecological tolerance in Kilis city parks.

2. Material and Method

The main materials of the study are Karataş Park (Park 1), Fıstıklı Park (Park 2), and Şehit Muzaffer Aydemir Park (Park 3). The reasons for selecting these parks are their characterization of the city, their locations in different regions of the city, their high intensity of use, and their high diversity/density of plant species. The relevant parks were identified through verbal interviews with the Kilis Municipality Parks and Gardens Directorate.

In order to determine the current status of the parks, AutoCAD 2016 software package was used for the arrangement of the structural and plant projects of the parks, and for determining their spatial distributions, based on satellite images from Google Earth. As access to the tender annexes of the relevant parks was not possible, site plans, structural landscape projects, and plant landscape projects of the parks were prepared using relevant programs. The species and quantities of plants in the parks were determined through field studies conducted with the assistance of a landscape architect. In identifying the plant species in the research area, the studies of Ürgenç, 1990; Pamay, 1992; Yaltırık, 1993a; Yaltırık, 1993b; Güngör et al., 2007; Mamıkoğlu, 2012 were utilized. The natural distribution areas and ecological tolerances (frost, drought, salinity, wind, and air pollution) of the identified species were determined using various sources (Wade & Midcap, 2007; Rayno, 2014; Bayramoğlu, 2016; Güvenç & Demiroğlu, 2016; Zincirkıran & Akdeniz, 2017; Sönmez & Zincirkıran, 2023). The SPSS 23 package program was used to interpret all the data statistically.

It would be appropriate to provide information about the general characteristics of Kilis province, where the study areas are located, as well as the general condition of the parks that constitute the material of the research. Located in the transition zone between the Mediterranean and Southeastern Anatolia regions, the climate of Kilis province is generally classified as Mediterranean. When the long-term average meteorological data of Kilis province is examined, it can be seen that the temperature and precipitation changes in the province are parallel to the trends in the world and Turkey. When the 40-year meteorological data of the province between 1980-2020 is examined, it is determined that the annual average temperature increased from 16.76°C to 18.70°C with an increase of approximately 2°C; while the annual average precipitation decreased from 54.47 mm to 48.23 mm. The long-term average monthly wind speed in the province is 2.2 m/s. The average number of frosty days per month from 1980 to the present is 12 days. While the highest number of frosty days was recorded as 55 days in 1992, there was no frost in any day of 2018 (TSMS, 2021). When the meteorological drought map prepared based on the data from the last 24 months (January 2021-December 2022) is examined, it is noteworthy that the province is located in the severe drought region (TSMS, 2023).

When the soil analysis results from soil profiles taken during afforestation studies in Kilis province are examined, it is observed that the soil structure of the province is generally clayey, slightly alkaline, free of salts (0.0–0.15 EC mS/cm), and highly calcareous (8.54% – 82.2%). The soil is generally poor in organic matter (0.52% - 3.39%) (Kilis Forestry Directorate, 2010).

Additionally, according to the results from one air quality monitoring station in Kilis province, measurements were conducted for five main pollutants causing air pollution. It was determined that the only pollutant for which the limit value was exceeded is Particulate Matter (PM10); the limit value for other pollutants was not exceeded (Rebuplic of Türkiye Ministry of Environment, Urbanization and Climate Change, 2019).

The most important material of the research consists of the selected sample parks in the city. The largest park evaluated in the research is Karataş Park. The park is located in the Aşiti neighborhood of the central district of Kilis city. Built in 1960 and revised twice in 2000 and 2017, the park has a total area of 68,753 m². The second-largest park evaluated in the research is Fıstıklı Park, located in the Mehmet Rıfat Kazancıoğlu neighborhood of the central district of Kilis city. Completed by the Kilis Municipality in 2016, the park has an area of 14,534 m². The third-largest park evaluated in the research is Şehit Terzi Muzaffer Aydemir Park. Completed by the Kilis Municipality in 2016, the park has an area of 2,960 m² and is located in the Atatürk neighborhood of the central district of Kilis city. (Figure 1-2).

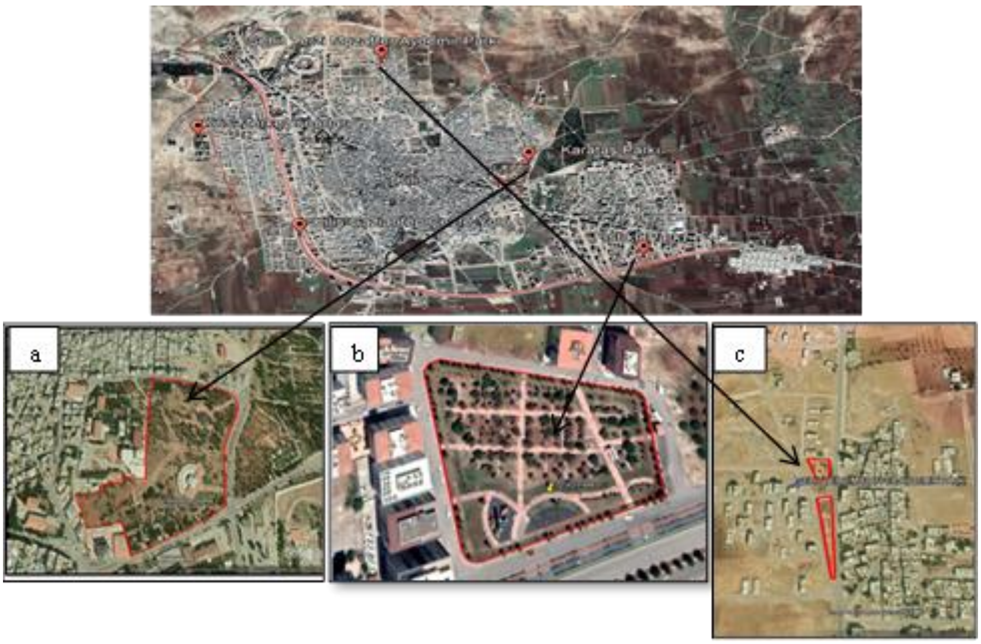

Figure 1. The locations of the parks (a) Karataş Park (P1); (b) Fıstıklı Park (P2) (c) Şehit Muzaffer Aydemir Park (P3) (Google Earth, 2021)

Figure 2. Some images from the parks (a) Karataş Park (P1) (b) Fıstıklı Park (P2) (c) Şehit Muzaffer Aydemir Park (P3) (taken by authors,2021).

The research was conducted in 4 stages;

In the first stage; the structural and plant projects of the 3 relevant parks, which constitute the basic material of the study, were digitized using the relevant drawing program (Autocad 2016). The species and quantities of plants in the parks were determined during field studies conducted by a landscape architect between May and September, as referenced in the materials section. These identified species were processed on the structural landscape projects of the areas using the relevant drawing program to create the plant projects of each park.

In the second stage; the ecological tolerances of the identified species (frost, drought, salinity, wind, air pollution, and drought) were determined using a 3-level rating (1: Low tolerance, 2: Moderate tolerance, 3: High tolerance) proposed by Zencirkıran & Seyitoğlu Akdeniz (2017), as well as the sources mentioned in the materials section. In this stage, ecological tolerance tables were created based on the species in each park, and the ecological tolerance status of the parks was evaluated in general through frequency analysis.

In the third stage; a data set containing all tolerance levels of the plant species used in the parks and all data related to the parks was created using the SPSS 23 package program. To find the average differences between variables (parks), the *"Frequency Distribution of Two or More Variables: Cross-Tabulation (Crosstab)"* method, which is one of the descriptive statistics methods, was used. The purpose of the crosstab is to provide the frequency and percentage distribution of participants in research according to two or more classificatory (categorical) variables. In screening and experimental studies, crosstab is used when it is desired to describe the personal characteristics of participants related to two classificatory variables. The crosstab allows the researcher to see and evaluate the percentages based on row and column margin totals and overall totals of the fissures formed according to at least two variables in the same table. In addition, crosstab provides the opportunity to generally examine opinions determined in any classification or ranking scale in terms of subgroups formed according to a classificatory variable (Büyüköztürk, 2012).

In the fourth stage; the percentages indicating the tolerance level of each park determined in the crosstab were entered into a new data set. The "Independent Groups Kruskal Wallis H-Test" was used on the new data set to determine if there was a significant difference between groups. The Kruskal Wallis test tests whether the mean ranks of two or more independent samples differ significantly from each other. In the analysis, the scores of k samples for a dependent variable are compared. This test requires observations to be independent of each other and at least ordinal scale for the dependent variable. Since the analysis does not require the assumptions of normal distribution and equality of variances in each subgroup (sample) created according to the group variable, it is an alternative to one-way analysis of variance. The statistical process is based on considering the groups' scores as a set and assigning rank values to the scores starting from the smallest score, and finding the sum of ranks. The Kruskal Wallis test is used to test the significance of the difference observed in the scores of groups in experimental studies with single-factor groups consisting of a small number of subjects. This procedure is recommended when the normality assumption of one-way ANOVA, which is a parametric test, is not met (Büyüköztürk, 2012).

3. Findings

The research findings were evaluated under two main headings: general findings related to the parks and findings related to the analysis results.

3.1. Findings Related to the Parks

Karataş Park (Park 1) has a total area of 68,753 m^2. This area includes 5,104 m^2 of grass area and 33,135 m^2 of soil area, totalling 38,239 m^2 of permeable area. The park consists of 30,514 m^2 of impermeable areas. The park features functional areas such as children's play area, fitness area, amphitheater, administrative building belonging to the Parks and Gardens Directorate, guard room, kiosk, toilets, ornamental pool, and a mini football field. The permeability rate of Karataş Park is 55.76% (Table 1, Figure 3).

In Karataş Park, there are 36 species of plants with a total of 2600 plants. Among these plants, 70 are trees; 187 are shrubs in the angiosperm taxon; 2058 trees and 385 shrubs are in the gymnosperm taxon. *Pinus brutia, Cupressus sempervirens*, and *Ligustrum japonica* are among the most commonly used species in the park. 15 species and 1672 plants are among the natural species found in our country, while 21 species and 928 plants consist of exotic species that do not have a natural distribution in the country. The naturalness percentage of Karataş Park is 64.3% (Table 2).

When the plants in Karataş Park are classified according to frost tolerance; it was determined that 930 plants (36%) have low frost tolerance; 79 plants (3%) have moderate frost tolerance; and 1591 plants (61%) have high frost tolerance. When the plants in the Park are classified according to wind tolerance; it was found that 1770 plants (68%) have low wind tolerance; 14 plants (1%) have moderate wind tolerance; and 816 plants (31%) have high wind tolerance. When the plants in the Park are classified according to salinity tolerance; it was determined that 504 plants (19%) have low salinity tolerance; 21 plants (1%) have moderate salinity tolerance; and 2075 plants (80%) have high salinity tolerance. When the plants in the Park are classified according to air pollution tolerance; it was found that 335 plants (13%) have low air pollution tolerance; 21 plants (1%) have moderate air pollution tolerance; and 2244 plants (86%) have high air pollution tolerance. When the tolerance of plants in the Park to drought is evaluated; it was determined that 101 plants (4%) have low drought tolerance; 272 plants (10%) have moderate drought tolerance; and 2227 plants (86%) have high drought tolerance (Table 3).

Fıstıklı Park (Park 2) has a total area of 14,534 m^2 of this area, 10,162 m^2 consists of permeable areas (lawn area, soil area, sand pit, and walking path); 4,372 m^2 consists of impermeable areas (children's play area, fitness area, concrete walkway, cafe). Outside the park, there are WC and guard room. The permeability rate of Fıstıklı Park is 69.9% (Table 1, Figure 3).

The number of plant species in Fıstıklı Park is 20, with a total of 545 plants. Of these, 152 are trees and 126 are shrubs in the angiosperm taxa, while 33 are trees and 234 are shrubs in the gymnosperm taxa. The species *Robinia pseudoacacia* "Umbraculifera," *Oenothera lindheimeri*, and *Nerium oleander* are among the most used species in the park. Of the total 217 plants belonging to 8 different species, are naturally distributed in Türkiye, while 328 plants from 12 species are exotic. The naturalness percentage of Fıstıklı Park is 39.81% (Table 2).

When evaluating the frost tolerance of the plants in Fıstıklı Park, it was determined that a total of 216 plants (40%) belonging to 10 different species have low tolerance to frost, while no plant species have medium tolerance to frost. Additionally, a total of 329 plants (60%) belonging to 10 different species have high tolerance to frost. Regarding wind tolerance, it was classified that 347 plants (64%) have low tolerance to wind, while no plants have medium tolerance to wind. Furthermore, 198 plants (36%) have high tolerance to wind. In terms of salinity tolerance, it was found that 273 plants

(50%) have low tolerance to salinity, while no plants have medium tolerance to salinity. Additionally, 272 plants (50%) have high tolerance to salinity. For air pollution tolerance, it was observed that 237 plants (43%) have low tolerance, while no plants have medium tolerance. However, 308 plants (57%) have high tolerance to air pollution. Regarding drought tolerance, it was found that 25 plants (4%) have low tolerance, 238 plants (44%) have medium tolerance, and 282 plants (52%) have high tolerance to drought (Table 3).

Şehit Muzaffer Aydemir Park (Park 3) has a total area of 2,960 m^2. This area consists of 1,136 m^2 of soil area and permeable area, and a total of 1,824 m^2 of impermeable area (children's play area, fitness area, and hard surface). The permeability rate of Şehit Terzi Muzaffer Aydemir Park is 37.7% (Table 1, Figure 3).

Table 1. Spatial uses of the parks

	Park 1	Park 2	Park 3
PERMEABLE AREA	**Area (m²)**	**Area (m²)**	**Area (m²)**
Grass field	5,104	4,636	-
Ground area	33,135	4,633	1,116
Sand Pool	-	36	
Walking path (Tile dust)	-	893	
Total Permeable Area	**38,239**	**10,162**	**1,116**
IMPERMEABLE AREA			
Children's playground-Fitness area (Rubber flooring on concrete)	2,042	347	218
Walking path (Fire brick, mortar flooring)	21,440	-	-
Walking path (Concrete)	-	2,385	-
Hard flooring (Keystone, mortared flooring)	2,012		-
Hard flooring (Tile, mortared flooring)	364	968	1,626
Parks and gardens directorate administrative building	164	-	-
Artificial turf (Carpet laying on concrete)	1,254	-	-
Amphitheater	2,856	-	-
WC	84	-	-
Buffet	74	-	-
Decorative pond	69	-	-
Guard room	155	-	-
Cafe	-	95	-
Fitness area (Rubber flooring on concrete)	-	257	-
Roofed bench-concrete floor	-	320	-
Total Impermeable Area	**30,514**	**4,372**	**1,844**
TOTAL AREA	**68,753**	**14,534**	**2,960**

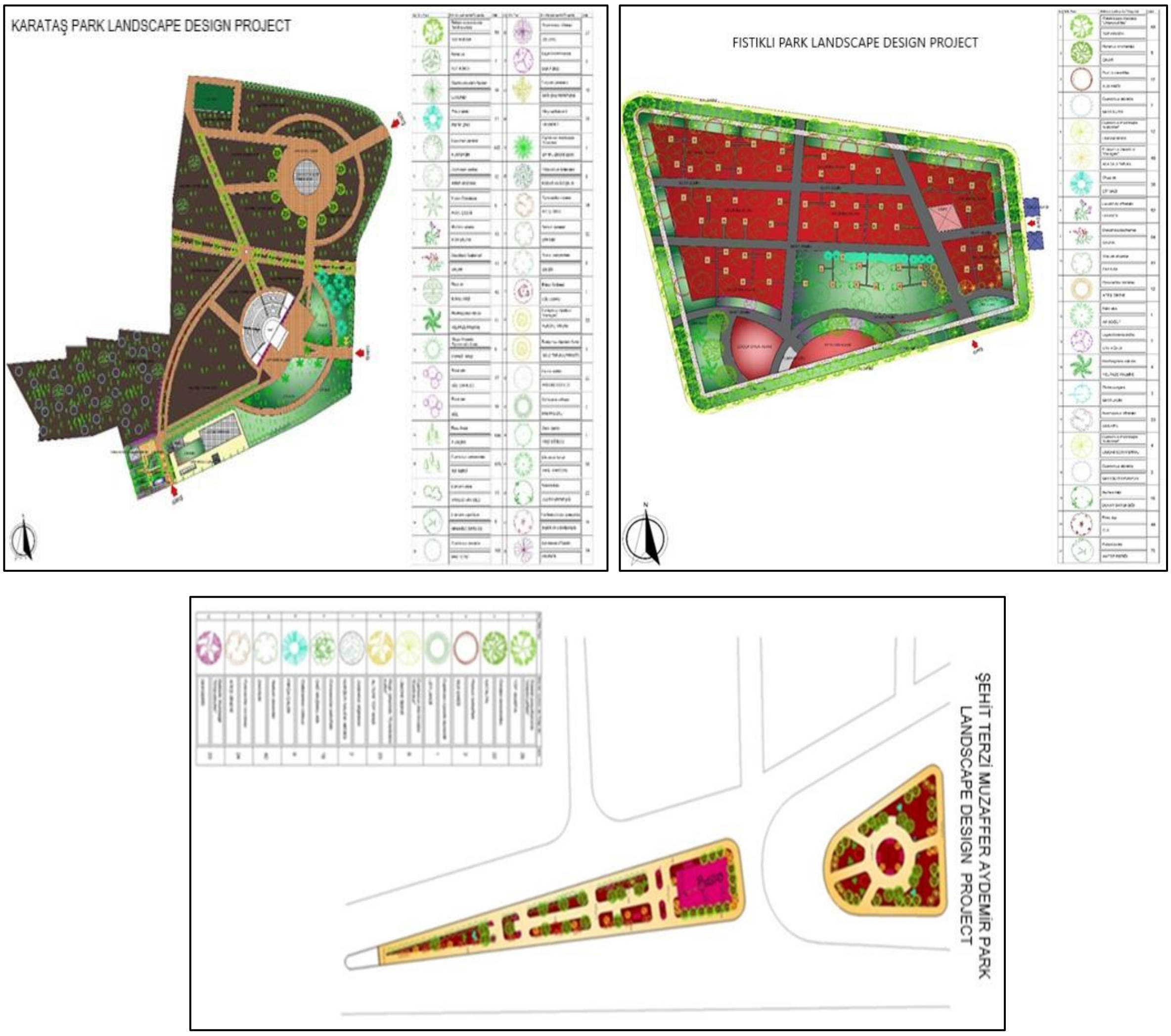

Figure 3. Landscape projects of the parks (drawn by the authors, 2021)

The park has a total of 12 plant species and 203 plants. *Nerium oleander, Robinia pseudoacacia* 'Umbraculifera', *Thuja orientalis* 'Pyramidata aurea', and *Berberis thunbergii* 'Atropupurea' are among the most commonly used species in the park. Of the total 203 plants in Şehit Terzi Muzaffer Aydemir Park, 71 are trees and 23 are shrubs of the angiosperm taxon, while 20 trees and 89 shrubs are of the gymnosperm taxon. There are 108 plants belonging to 5 species that are natural in Türkiye, and 95 plants belonging to 7 species that do not have a natural distribution in the country. The naturalness percentage of Şehit Terzi Muzaffer Aydemir Park is 53% (Table 2).

When classified according to frost tolerance, it was determined that 118 plants (58%) in the Park had low tolerance to frost, while no plant species had medium tolerance, and 85 plants (42%) had high tolerance to frost. 97 (48%) were slightly wind tolerant, 9 (4%) had medium wind tolerance, and 97 (48%) had high wind tolerance of the plants in the Park. When classified according to salinity tolerance, it was found that 95 plants (47%) had low tolerance to salinity, 9 plants (4%) had medium tolerance, and 99 plants (49%) had high tolerance to salinity (Table 3).

Table 2. Plant species in the parks and their natural distribution areas

Species name	Natural Distribution	Parks		
		Number of Plants		
		P1	P2	P3
Ampelopsis veitchii	North America	14		
Berberis thunbergii ''Atropupurea''	Japan			23
Buxus sempervirens	Spain, Portugal, France, Germany and Bulgaria	6		
Callistemon citrinus	Australia			9
Catalpa bignonioides	Western-North American, Exotic			22
Chrysanthemum japonense	Asia and Northeast Europe	28		
Cortaderia selloana	South America	2		
Cotoneaster salicifolia	Türkiye			18
Cupressocyparis leylandii	hybrid species	14	1	1
Cupressus arizonica	North America, Arizona, Mexico	163	9	
Cupressus macrocarpa ''Goldcrest''	Southwestern North America, California	2	16	8
Cupressus sempervirens	Anatolia, Aegean Islands, Iran, Italy	676		
Euonymus japonica	Japan, Korea and China	56	48	
Euryops pectinalus	South Africa	16		
Hedera helix	Central, Southern and Eastern Europe, Türkiye	22	16	
Jasminum sambac	Chinese	12		
Juniperus horizontalis	Central, Southern and Western Europe, Western Asia			2
Lagerstroemia indica	Eastern Asia, Philippines, China, Japan	3	7	
Laurus nobilis	Balkans, Mediterranean, Black Sea, Aegean , Marmara	22		
Lavandula officinialis	Mediterranean and Aegean		52	
Ligustrum japonicum	Europe-West Asia	465		
Lonicera caprifolium	Chinese	6		
Lonicera nitida	East Asia and China	23		
Malus floribunda	Europe, Asia and America	1		
Morus alba	China and Far East	7		
Nerium oleander	Southern Europe and the Mediterranean	52	61	42
Oenothera lindheimeri	Southern North America, Exotic	10	64	
Picea pungens	North America, Colorado, Exotic		3	
Pinus brutia	Türkiye	684		
Pinus pinea	Aegean, Mediterranean coast, Türkiye	21		
Pistacia vera	Türkiye		58	
Pittosporum tobira ''Nana''	Japan and China	8		
Platanus orientalis	Eastern Asia, Philippines, China, Japan		5	
Prunus cerasifera	West Asia and the Caucasus		17	3
Pyracantha coccinea ''Praecox''	Southern Europe, Mediterranean, Italy, Balkans	24	12	24
Robinia pseudoacacia ''Umbraculifera''	West-North America	58	66	28
Rosa meilland	Northern hemisphere	14	44	
Rosa rampicanti	Northern hemisphere	27		
Rosmarinus officinalis	Mediterranean and Aegean	27	23	
Salix alba	Türkiye, North Africa, Europe and Asia		3	
Salix caprea ''Pendula''	Europe, Asia and Northern Iran	1		
Thuja oriantalis ''Pyramidata aurea''	Turkestan, Iran, Türkiye	6		23
Thuja orientalis	North America	42	38	
Viburnum lucidum	Southern Europe and the Mediterranean	58		
Washingtonia robusto	Mexican	11	4	
Wisteria sinensis	Central, Southern and Eastern Europe and western Asia	13		
Yucca gloriosa	South of north america	6		

Among the plants in Şehit Terzi Muzaffer Aydemir Park, 36 plants (18%) were found to have low tolerance to air pollution, 9 plants (4%) have moderate tolerance, and 158 plants (78%) have high tolerance to air pollution. According to the findings regarding the drought tolerance of the plants in the park, while 1 plant (1%) has low drought tolerance and 31 plants (15%) have moderate drought tolerance, 171 plants (84%) have high drought tolerance (Table 3).

Table 3. Ecological tolerance levels of plant species in the parks

Species name	Parks			Ecological Tolerance Criteria and Degrees														
				Frost			Wind			Salinity			Pollution			Drought		
	P1	P2	P3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Ampelopsis veitchii	●					●		●		●					●			●
Berberis thunbergii ''Atropupurea''			●			●			●	●					●			●
Buxus sempervirens	●			●					●	●					●	●		
Callistemon citrinus			●	●				●			●			●				●
Catalpa bignonioides			●	●			●			●					●			●
Chrysanthemum japonense	●			●			●			●			●			●		
Cortaderia selloana	●		●					●		●			●					●
Cotoneaster salicifolia			●	●			●					●			●			●
Cupressocyparis leylandii	●	●	●			●		●				●			●			●
Cupressus arizonica	●	●				●	●			●			●					●
Cupressus macrocarpa ''Goldcrest''	●	●	●			●			●			●	●					●
Cupressus sempervirens	●					●	●					●			●			●
Euonymus japonica	●	●			●		●			●					●	●		
Euryops pectinalus	●			●			●			●			●					●
Hedera helix	●	●				●				●					●	●		
Jasminum sambac	●			●			●			●			●				●	
Juniperus horizontalis			●			●			●			●			●			●
Lagerstroemia indica	●	●		●			●			●			●					●
Laurus nobilis	●		●			●				●					●	●		
Lavandula officinialis		●				●			●	●					●			●
Ligustrum japonicum	●			●			●					●			●			●
Lonicera caprifolium	●					●	●					●			●		●	
Lonicera nitida	●					●	●					●			●		●	
Malus floribunda	●					●	●					●			●		●	
Morus alba	●					●			●			●			●		●	
Nerium oleander	●	●	●	●			●					●			●	●		●
Oenothera lindheimeri	●	●				●	●			●			●					●
Picea pungens		●	●			●	●			●					●	●		
Pinus brutia	●			●					●			●			●			●
Pinus pinea	●				●		●				●			●				●
Pistacia vera		●		●			●			●			●				●	
Pittosporum tobira ''Nana''	●			●			●					●			●	●		
Platanus orientalis		●				●	●			●			●			●		
Prunus cerasifera		●	●	●					●	●		●			●			●
Pyracantha coccinea ''Praecox''	●	●	●	●					●	●					●			●
Robinia pseudoacacia ''Umbraculifera''	●	●	●			●			●			●			●		●	
Rosa meilland	●	●				●	●					●			●		●	
Rosa rampicanti	●			●					●			●			●		●	
Rosmarinus officinalis	●	●		●			●					●	●					●
Salix alba		●				●			●	●			●			●		
Salix caprea ''Pendula''	●				●		●			●					●	●		
Thuja oriantalis ''Pyramidata aurea''	●		●			●			●			●			●			●
Thuja orientalis		●				●	●			●			●					●
Viburnum lucidum	●			●			●			●					●		●	
Washingtonia robusto	●	●		●			●			●			●				●	
Wisteria sinensis	●			●			●			●			●			●		
Yucca gloriosa	●			●			●					●	●			●		

1: Low tolerance *2: Moderate tolerance* *3: High tolarence*

3.2. Findings Regarding Analysis Results

The results of the "Cross-Tabulation (Crosstabs)" conducted to evaluate the differences in average:

Frost, wind, salinity, air pollution, and drought tolerance between the parks are provided in the following tables (Species-based only). When the cross-tabulation for frost tolerance is examined, it can be seen that Park 1, which has high frost tolerance, is at 50%, followed by Park 2 at 32.4% and Park 3 at 17.6%. According to the analysis results, the average of plant species with low frost tolerance used in all parks is 47.1%; the average of plant species with moderate frost tolerance is 2.9%; and the average of plant species with high frost tolerance is 50% (Table 4).

When the cross-tabulation is examined, it can be seen that Park 1, which has high wind tolerance, is at 40.9%, followed by Park 3 at 31.8% and Park 2 at 27.3%. Additionally, the average of plant species with low wind tolerance used in all parks is 61.8%; the average of plant species with moderate wind tolerance is 5.9%; and the average of plant species with high wind tolerance is 32.4% (Table 4).

When the relevant table is examined, it is determined that Park 1 has the highest salinity tolerance with a rate of 54.8%. According to the analysis, the salinity tolerance percentages of Park 2 and Park 3 are equal at 22.6%. Additionally, the average of plant species with low salinity tolerance used in all parks is 51.5%; the average of plant species with moderate salinity tolerance is 2.9%; and the average of plant species with high salinity tolerance is determined to be 45.6% (Table 4).

When the results of the Cross Table are examined, it can be seen that Park 1 has the highest air pollution tolerance with a rate of 55%; followed by Park 2 with a rate of 25%, and Park 3 with a rate of 20%. Additionally, the average of plant species with low air pollution tolerance used in all parks is 38.2%; the average of plant species with moderate air pollution tolerance is 2.9%; and the average of plant species with high air pollution tolerance is determined to be 58.8% (Table 4).

Lastly, when values related to drought tolerance are examined, it can be observed that Park 1 has thehighest drought tolerance with a rate of 47.2%; followed by Park 2 with a rate of 27.8%, and Park 3 with a rate of 25%. Additionally, the average of plant species with low drought tolerance used in allparks is 17.6%; the average of plant species with moderate tolerance is 29.4%; and the average of plant species with high drought tolerance is determined to be 52.9% (Table 4).

Table 4. The results of the cross-table analysis conducted on plant species in the parks

Parks	**Ecological tolerance percentages (%)**														
	Frost			**Wind**			**Salinity**			**Pollution**			**Drought**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
P1	53,1	100	50	61,9	25	40,9	51,4	50	54,8	50	50	55	75	50	47,2
P2	28,1	0	32,4	31	25	27,3	37,1	0	22,6	38,5	0	25	25	35	27,8
P3	18,8	0	17,6	7,1	50	31,8	11,4	50	22,6	11,5	50	20	0	15	25

Results of the Kruskal-Wallis H-test

The results of the "Kruskal-Wallis H-Test for Independent Groups," conducted on the dataset created by entering the percentages indicating the tolerance degrees of each park determined in the cross-tables into a new dataset, to determine if there is a significant difference in the ecological tolerance values of plant species used in the parks, are given in Table 5.

When considering the mean ranks of the groups in the analysis results, it is determined that Park 1 has the highest tolerance for all factors. The details are as follows:Park 1 is the park with the highest frost tolerance, followed by Park 2 and Park 3;

- Park 1 is the park with the highest wind tolerance, followed by Park 3 and Park 2;
- Park 1 is the park with the highest salinity tolerance, followed by Park 3 and Park 2;
- Park 1 is the park with the highest air pollution tolerance, followed by Park 3 and Park 2;
- Park 1 is the park with the highest drought tolerance, followed by Park 2 and Park 3 (Table 5).

The results of the Kruskal-Wallis H-test indicate that there are no significant differences at the $p \leq 0.05$ level in frost, wind, salinity, and air pollution tolerances among the parks; however, there is a significant difference in drought tolerance. According to this finding, it can be concluded that the tolerance levels of plants used in all parks are almost similar for frost, wind, salinity, and air pollution factors, but the drought tolerance levels of plants used in the parks are significantly different (Table 5).

Table 5. Comparison of the ecological tolerance groups of the parks, Kruskal-Wallis H-test results

Ecological tolerance	Park name	Mean	Degree of freedom (DF)	X^2	p
Frost tolerance	Park 1	8,00±	2	5,804	0,055
	Park 2	4,17±			
	Park 3	2,83±			
Wind tolerance	Park 1	6,17±	2	1,098	0,578
	Park 2	3,83±			
	Park 3	5,00±			
Salinity tolerance	Park 1	7,83±	2	5,040	0,080
	Park 2	3,17±			
	Park 3	4,00±			
Air pollution tolerance	Park 1	7,67±	2	4,506	0,105
	Park 2	3,33±			
	Park 3	4,00±			
Drought tolerance	park 1	8,00±	2	6,880	0,032*
	park 2	4,83±			
	park 3	2,17±			

*p<0.005

4. Discussion, Conclusion and Suggestions

The population growth and expansion towards rural areas in cities are increasing day by day. This situation has made cities the most important actor causing climate change. Cities are both the perpetrator and the victim of climate change and are also one of the most important areas of struggle against the effects of climate change (UN; 2014). In this struggle process, one of the most important focal points in cities is urban open green spaces. The sustainability of urban open and green spaces and the creation of landscapes resistant to climate change are crucial in urban designs, considering the environmental factors and ecological characteristics (salinity, temperature, drought, precipitation, etc.) of the city and the implementation area, using plants with high ecological tolerance, which are resistant to global climate change (Zencirkıran & Akdeniz, 2017; Yener, 2020; Güzel & Ulus, 2021; Sönmez & Zencirkıran, 2023), and especially for the city of Kilis located in the severe drought zone, is extremely important.

In this study, woody plants used in three sample urban parks located in the city center of Kilis were evaluated in terms of ecological tolerance factors. As a result of the evaluations of frost, wind, salinity, air pollution, and drought tolerances, it was determined that the tolerance factor with an average below 50% in the sample parks is wind when considering the total number of woody plants used; however, when considering only species, wind and salinity factors fall below the 50% average. It was found that 54.3% of woody plants used in the relevant parks and 50.7% of plant species have high frost tolerance; 38.3% of total plants and 37.8% of plant species have wind tolerance; 56.7% of total plants and 46.8% of plant species have salinity tolerance; 73.7% of total plants and 59.3% of plant species have air pollution tolerance; and 74% of total plants and 57.4% of plant species have good drought tolerance.

When the frost, wind, salinity, air pollution, and drought tolerances of the plants used in the relevant parks are evaluated separately, it is determined that 61% of the plants identified in Park 1 (Karataş Park) are highly tolerant to frost; 31% to wind; 80% to salinity; 86% to air pollution; and 86% to drought. In Park 2 (Fıstıklı Park), it is found that 60% of the plants are highly tolerant to frost; 36% to wind; 50% to salinity; 57% to air pollution; and 52% to drought. In Park 3 (Şehit Terzi Muzaffer Aydemir Parkı), it is determined that 42% of the plants are highly tolerant to frost; 48% to wind; 49% to salinity; 78% to air pollution; and 84% to drought. In this case, it is determined that Park 1 has the highest tolerance to frost, salinity, air pollution, and drought, while Park 3 has the highest tolerance to wind. Additionally, when considering the mean ranks of the groups in the Kruskal-Wallis H-Test analysis results, it will be seen that Park 1 has the highest average value in all ecological tolerance factors. Therefore, considering the construction years of the parks, it can be concluded that ecological tolerance factors were more considered in the selection of plants used in Park 1, which is the oldest park.

The study conducted evaluations and analyses taking into account both the total number of plants and the number of plant species in the parks. The study findings indicate that the ecological tolerances of the parks change when the plant species and the number of plants are evaluated separately, and that the same results are not reached. In Turkey, studies have been conducted by Sönmez & Zencirkıran (2023) in Ankara-Altınpark; Zencirkıran & Akdeniz (2017) in sample urban parks in Bursa; Yener (2020) in different coastal parks in Istanbul (Avcılar, Maltepe, Kartal, and Sarıyer); and Güzel & Ulus (2021) in 32 selected sample areas in Ordu, regarding the ecological tolerance assessments of plant species used. However, these studies did not analyze the plants in the parks based on the total number of plants. Therefore, this study differs from the other studies in this regard.

It has been determined that more than half of the plants and plant species used in the sample urban parks in Kilis have a high tolerance to frost. Although this rate is quite high, when the meteorological data specific to the city is examined, it will be seen that frost events do not pose an ecological risk in the province.

When the soil analysis results for Kilis province are examined, it is determined that the salinity level in the city center is low. However, salinity in soil occurs in two ways: natural and artificial. The natural formation occurs in arid-semiarid, flat or nearly flat basins where there is inadequate drainage in the soil, due to the transport of salts by precipitation, or due to the capillary rise of salts under extreme temperature conditions. Artificial formation, on the other hand, occurs due to irrigation or fertilization; in semi-arid and arid regions with insufficient rainfall, it is formed by the accumulation of fertilizers used in high concentrations in areas with intensive cultivation over many years (Sönmez & Sönmez, 2007). In our study, the average of plant species with high salinity tolerance in the sample parks of the city was determined to be 46.8%. Therefore, selecting plant species with high salinity tolerance in species selection is advantageous for a city like Kilis, which has low rainfall, high temperatures, and therefore high soil salinity due to artificial factors.

The average tolerance of plants used in the sample urban parks to air pollution is 59.3%. This finding is particularly important for parks and green spaces surrounded by potential areas with high air pollution (such as roads with heavy traffic and densely populated residential areas), considering that the only pollutant exceeding the limit in Kilis province based on measurements is Particulate Matter (PM10).

According to the results of the "Kruskal-Wallis H-Test for Independent Groups" conducted to determine if there is a significant difference in the ecological tolerance values of plant species used in the parks, except for drought tolerance, there were no significant differences at the $p \leq 0.05$ level in frost, wind, air pollution, and salinity tolerances among the parks. It was determined that the tolerance levels of plants used in all parks, except for drought tolerance, are almost similar.

When the average temperature and precipitation values of the city of Kilis are evaluated over the years, it is determined that temperatures have risen and the precipitation rate has decreased. Therefore, it would be appropriate to state that the most important tolerance factor in terms of ecological tolerance in the city is tolerance to drought. It has been determined that 57.4% of the plant species used in example parks have a high tolerance to drought. When evaluated based on the total number of plants used, it can be seen that drought tolerance is at good levels in all 3 parks; with a plant ratio of 74% having high drought tolerance. It has been found that in the two city parks established after Karataş Park, more than 50% of the preferred plant species have low water consumption. This indicates that water scarcity, caused by the climate change and drought problems resulting from the increasing global warming issues, is taken into account in the city parks established in recent years.

The selection of plant species from natural species in urban areas is an important factor for utilizing the dominant ecological tolerance factors of the region positively and increasing the ecological quality of the region in terms of the sustainability of green areas. In this study, the naturalness values of plants used in parks have also been determined. The rate of use of natural species in parks was determined to be 64.30% in Park 1, 39.81% in Park 2, and 53.00% in Park 3. Therefore, the naturalness average of all parks is 52.37%. Maaşoğlu & Demiroğlu (2022) evaluated 10 parks completed in Kilis city between 2015-2019 in terms of xerophilic landscape design principles. The average rate of use of natural plants in all parks in the relevant study was determined to be 25.20%. The average naturalness value of the plants used in the sample 3 parks is higher than this rate.

The use of native plants in parks is also important in reducing water consumption and increasing the drought tolerance of parks. The parallelism between the rate of use of natural plants in parks identified in the study and the rate of tolerance to drought confirms this information. In his study, Bayramoğlu (2016) found a low rate of use of natural species in the example of Karadeniz Technical University campus, whereas in the study of Karaca & Kuşvuran (2012), it was stated that, as in the example of Çankırı city parks in terms of aesthetics and functionality, it is necessary to prefer natural species that can replace these species or species with lower water consumption instead of species with high water consumption.

Various researchers have emphasized the importance of native plant species in reflecting the identity and culture of the cities we live in and ensuring the continuity of these species, as well as their important role in preventing drought (Ertop, 2009; Tülek & Barış, 2011; Baykan & Birişçi, 2013). Similarly, in the study by Çetin & Mansuroğlu (2018), it is emphasized that selections should be made for the use of natural plants in xerophilic landscape applications under Mediterranean conditions. Furthermore, the study examined a limited number of plant nurseries and found that exotic species, which are aesthetically appealing, are predominant. Therefore, it is also emphasized that it is important for local producers to reduce this cost and turn to local plants for sustainability.

Studies conducted by scientists and ecology experts in different regions of the world demonstrate the positive environmental effects of using native plants in parks and urban areas. These studies emphasize that in landscape designs, native-local plants, being adapted to local climate and soil conditions, require less maintenance and therefore incur lower costs (such as water, fertilizer, insecticides, mowing, etc.). They are also more resilient to extreme climate conditions and create natural habitats for regional wildlife, thereby promoting biological diversity (Meurk & Swaffield, 2007; Mingguo & Guocang, 2007; EPA, 2010; Hanula & Horn, 2011; Ignatieva & Ahrné, 2013).

Based on scientific studies and research, the sustainable design of urban parks and urban green spaces depends on the selection of plant species with high likelihood of resilience within the range of ecological tolerance limits, including low water consumption, tolerance to drought, frost, air pollution, salinity, and wind. Additionally, the use of native plant species found in the specific flora of the region is of great importance. Therefore, in newly established parks, this factor must be taken into consideration, and more emphasis should be placed on design plants that are suitable for ecological tolerance.

It is the responsibility of municipalities to plan and manage all open green spaces open to the use of everyone living within the municipal boundaries. The design, implementation, maintenance, and repair of urban open green spaces and the plants in these areas, managed by the Parks and Gardens Directorate, are technical issues that must be handled professionally. Therefore, it is crucial for the technical staff and personnel working in relevant units within the municipality to have the necessary qualifications and quantity. This is an important condition for the sustainability of green spaces. In landscaping works in open green spaces, principles should be established in collaboration with academics in relevant departments of universities to ensure that urban parks are landscaped in accordance with ecological tolerance factors. Informative meetings and seminars should be organized, and educational publications should be prepared.

The study was conducted in three different regions of Kilis city; Karataş Park (Park 1), Fıstıklı Park (Park 2), and Şehit Muzaffer Aydemir Parkı (Park 3), which have high usage intensity and plant diversity. The study is important in providing guidance for sustainable plant use in the design of parks in Kilis city, which is located in a severely drought-prone zone according to the 2022 drought data, and facing today's cities combating global climate change. The limiting factors of the research are the absence of the final versions of the structural and plant projects of the parks in a computer environment and the difficulty of plant identification studies in a hot-dry climate region. Therefore, this research was limited to the 3 parks that characterize the city. The method of this research is applicable by using different statistical methods that may vary depending on the diversity of plant species, to all parks of the city and/or different green infrastructure components of the city (medians, promenades, etc.). In this sense, the study has the potential to be developed further.

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