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The Effects of Plant Diversity in Urban Living Spaces on Human Health and Well-Being

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Abstract

The rapidly growing population and intense urbanization have reduced the quantity and quality of green spaces in cities, making urban ecosystems fragile. This situation highlights the strategic importance of plant diversity for both ecological functions and human health and well-being. Evidence in the literature increasingly shows that elements of plant diversity, such as species richness and the balance between native and exotic species, improve the quality of the biophysical environment and also affect indicators such as psychological recovery and stress reduction. The World Health Organization and current international scientific studies emphasize that positive health effects are related not only to the presence of green spaces but also to their diversity and ecological integrity. Studies conducted in Turkey reveal significant differences in plant diversity from city to city, depending on regional climate, socioeconomic structure, and landscape management practices. National findings on the relationship between diversity levels and health indicators show that areas rich in plant diversity are considered more aesthetic, safer, and more peaceful by users, and that time spent in such areas significantly improves psychological well-being and increases physical activity. In this study, a systematic review was conducted in accordance with the PRISMA framework to comprehensively evaluate the relationship between plant diversity and human health in major cities of Turkey, considering ecological, psychological, and socio-cultural components.

Keywords: *Plant diversity, Urban green spaces, Urban ecology, Public health, Psychological well-being.*

Kentsel Yaşam Alanlarında Bitki Çeşitliliğinin İnsan Sağlığı ve Refahı Üzerindeki Etkileri

Öz

Hızla artan nüfus ve yoğun kentleşme, şehirlerdeki yeşil alanların miktarını ve kalitesini azaltarak kentsel ekosistemleri kırılgan hale getirmiştir. Bu durum, bitki çeşitliliğinin hem ekolojik işlevler hem de insan sağlığı ve refahı için stratejik önemini vurgulamaktadır. Literatürdeki kanıtlar, tür zenginliği, yerli ve egzotik türler arasındaki denge gibi bitki çeşitliliği unsurlarının biyofiziksel çevrenin kalitesini iyileştirdiğini ve psikolojik iyileşme, stres azaltma gibi göstergeleri de etkilediğini giderek daha fazla göstermektedir. Dünya Sağlık Örgütü ve güncel uluslararası bilimsel çalışmalar, sağlığa olan olumlu etkilerin sadece yeşil alanların varlığıyla değil, özellikle çeşitlilik ve ekolojik bütünlük derecesiyle de ilişkili olduğunu vurgulamaktadır. Türkiye'de yapılan çalışmalar, bölgesel iklim, sosyoekonomik yapı ve peyzaj yönetim uygulamalarına bağlı olarak şehirden şehire bitki çeşitliliğinde büyük farklılıklar olduğunu ortaya koymaktadır. Çeşitlilik düzeyleri ile sağlık göstergeleri arasındaki ilişkiye ilişkin ulusal bulgular, bitki çeşitliliği açısından zengin alanların kullanıcılar tarafından daha estetik, daha güvenli ve daha huzurlu olarak değerlendirildiğini, bu tür alanlarda geçirilen zamanın psikolojik iyilik halini önemli ölçüde iyileştirdiğini ve fiziksel aktiviteyi artırdığını göstermektedir. Bu çalışmada, ekolojik, psikolojik ve sosyo-kültürel bileşenleri dikkate alarak, Türkiye'nin büyük şehirlerinde bitki çeşitliliği ile insan sağlığı arasındaki ilişkiyi kapsamlı bir şekilde değerlendirmek için PRISMA çerçevesine uygun olarak sistematik bir inceleme yapılmıştır.

Anahtar kelimeler: *Bitki çeşitliliği, Kentsel yeşil alanlar, Kentsel ekoloji, Halk sağlığı, Psikolojik iyilik hâli.*

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1. Introduction

The rapid urbanisation, intensive land use changes, fragmentation of natural habitats, and effects of climate change together increase the complexity of urban ecosystems. Because of these factors, this situation has crucially become one of great importance for conserving biological diversity and maintaining human health and well-being (Marselle, Bowler, et al., 2021; Marselle, Hartig, et al., 2021; Spotswood et al., 2025). As there is a continuing decrease in the physical and psychological contact with nature within city dwellers, the amplified problems will pertain to chronic stress, anxiety, depression, and social disconnection. According to WHO (2017), green space quality and diversity pertain to being one of the basic correlates of public health. In such a context, it is not only the quantity of urban green spaces which plays an important role, but also qualities consisting of plant diversity, habitat integrity, and balance between native and exotic species, which have been considered decisive factors affecting ecosystem functioning and human health (Wu et al., 2024).

Because it lies at the intersection of three phytogeographic regions and roughly a third of its more than 11,000 vascular plant species are endemic, the country of Türkiye has great potential for high urban plant diversity. Plant diversity, however, varies significantly at the regional scale despite this richness. For example, in Istanbul, although species lists are extensive, exotic species dominate, and Shannon diversity can vary more with the relative distribution of species rather than species abundance, as seen in places like Aşiyan Cemetery. In Aegean cities such as Izmir and Aydın, where the Mediterranean climate predominates, the numbers range from 30 to 70 species, with exotic shrub and tree species making up most of the plant composition. Although the warmtemperate climate conditions of Antalya allow the use of a wide array of ornamental plants, the underrepresentation of native maquis elements in the urban landscape keeps diversity below its potential.

Under continental climate conditions, despite having a more restricted plant palette, a considerable proportion of native and even endemic species still appear in the surroundings of cities like Ankara. However, the proportion of exotic and cultivated taxa is rather high in composing the urban landscape, especially in parks and road-side plantings (Çakmak & Aytaç 2018; Oğuz 2004). Thanks to its humid climate, the Black Sea Region is characterized by shrubs, broad-leaved forest species, and herbaceous flora that are almost evenly distributed within the city bounds of Samsun, Trabzon, and Rize, resulting in a higher Shannon index than other regions (Güneroğlu et al. 2018). In Eastern and Southeastern Anatolia, due to climatic limitations in cities like Erzurum and Gaziantep, the total number of woody species decreases in urban areas; however, dominance by adapted species keeps the Simpson index at relatively higher levels (Ögçe et al. 2022).

These regional differences suggest that plant diversity is related not only to climatic and floristic conditions, but also to the socio-economic structure of cities, their management and maintenance practices (Gozalo & Panadero, 2021a; 2021b). Shannon-Wiener, Simpson and Whittaker indices, the ratio between native and exotic species, phenological type distribution and stratification analyses are some of the commonly used metrics to assess urban plant diversity (Gülsoy & Özkan, 2008; Ögçe et al., 2022). According to the studies conducted in Turkey, 71 woody species were recorded in seven cities and more than 70% of the parks were established using exotic species (Ögçe et al., 2022). Campus-scale studies conducted at Düzce reveal that herbaceous plant diversity is important for both recreational experience and ecosystem functions (Yazlık et al., 2020).

A multidimensional network of mechanisms can explain the effects of urban diversity on human health: species richness and structural diversity increase thermal comfort, improve air quality, reduce symptoms of stress and depression, and strengthen social interaction (Hartig et al., 2014). A study conducted in Belgrade Forest of Istanbul reported that green spaces with high diversity levels showed significant correlations with well-being, energy levels, concentration, and physical activity. International meta-analyses also show that plant diversity provides stronger psychological restoration compared to monotonous landscapes (Marselle, Bowler et al., 2021; Hu et al., 2025).

For this purpose, monitoring plant diversity in cities from all bioclimatic regions of Turkey alongside health and well-being indicators is a strategic necessity for ecological design and public health policies. Subjective health perception, depression–anxiety scale, stress level, quality of life, social

connectedness, and physical activity measurements can be used as health indicators; diversity indicators can be analyzed using metrics such as species richness, Shannon–Simpson indices, Whittaker β-diversity, native/exotic ratio, and number of layers (Akpınar & Cankurt, 2015; cited in Bostancı, 2021). However, despite the growing body of international literature, integrated studies that simultaneously evaluate urban plant diversity patterns and health-related indicators across different bioclimatic regions of Turkey remain limited. In particular, there is a lack of comparative, multi-city assessments that link diversity metrics with psychological well-being and public health outcomes within a unified analytical framework. This study will investigate the effects that plant diversity in urban living spaces has on human health and well-being within a multidimensional framework, as well as make recommendations in a direction that aligns with ecological design principles.

2. Material and Method

2.1. Research Design

This systematic review aims to compile urban plant diversity studies conducted in major cities of each of the seven geographical regions of Turkey-Istanbul, Izmir, Antalya, Ankara, Samsun, Erzurum, Gaziantep-in line with the PRISMA 2020 statement-and scientific publications that have discussed the relationship of such studies with human health both nationally and internationally (Page et al., 2021; Marselle, Bowler et al., 2021; Marselle, Hartig et al., 2021). From this perspective, the research has a dual-axis design that includes ecological and health-based indicators:

Ecological axis in this research includes such indicators like: species richness (S), Shannon–Wiener and Simpson (1–D and D) indices of woody and herbaceous plant species in cities, native–exotic species ratio, habitat stratification, and structural diversity (Ögçe et al. 2022; Çakır & Tuğluer 2025), while the health axis considers all the aspects of human health and well-being including stress, depression, quality of life, physical activity level, and social interaction (WHO, 2017; Yıldızbaş et al., 2025). Thus, both of these axes have been intertwined with a view to assessing comprehensively the effects of patterns of plant diversity across various climate and urbanization profiles of Turkey on public health.

2.2. Data Sources and Literature Review

In this context, the systematic review searched for articles that had been published between the years 2000 and 2025, using Web of Science, Scopus, PubMed, ScienceDirect, SpringerLink, Taylor & Francis, Google Scholar, TR Dizin, and DergiPark. These databases were selected since they have high coverage on the different fields of urban ecology, landscape science, environmental psychology, and public health, according to Zhao et al. (2022) and Spotswood et al. (2025).

The searches were conducted using keywords in both English and Turkish. The English keywords included 'urban biodiversity', 'plant diversity', 'Shannon index', 'urban green space', 'human health', 'well-being', and 'ecosystem services'. The Turkish keywords were: 'kentsel bitki çeşitliliği' (urban plant diversity), 'biyoçeşitlilik' (biodiversity), 'kentsel yeşil alan' (urban green space), 'Shannon indeksi' (Shannon index), 'insan sağlığı' (human health) and 'psikolojik iyilik' (psychological well-being) (Shannon, 1948; Simpson, 1949; Gülsoy & Özkan, 2008; Ögçe et al., 2022). Search strings created with Boolean operators were designed according to international systematic review standards (Page et al., 2021).

2.3. Inclusion and Exclusion Criteria

The inclusion criteria were: date of publication between 2000 and 2025; published in a peerreviewed journal as original research or review/meta-analysis; measured plant diversity within urban or semi-urban green spaces; reported Shannon or Simpson indices; and presented results related to health and wellbeing indicators.

In the inclusion of studies sampled in Turkey, preference was given to research conducted in large cities such as Istanbul, Izmir, Ankara, Antalya, Samsun, Erzurum, and Gaziantep (Ögçe et al., 2022; Yazlık et al., 2020).

The studies that focused on natural forest ecosystems, those that assessed only the presence of green spaces without measurement of plant diversity, those that did not report health indicators, and those with methodological deficiencies were excluded.

2.4. Study Selection Process (PRISMA Flow)

The study selection process was conducted in accordance with the PRISMA 2020 framework and followed four sequential stages: identification, screening, eligibility assessment, and final inclusion of studies. Initially, a total of 2,246 records were identified through database searching, and 612 duplicate records were removed. The remaining 1,634 studies were screened based on their titles and abstracts, resulting in the exclusion of 1,128 studies that did not simultaneously address plant diversity and health-related outcomes. Subsequently, 506 full-text articles were assessed for eligibility, and studies that did not meet the predefined inclusion criteria were excluded. As a result, 78 studies were included in the final qualitative synthesis, comprising 32 international studies, 26 studies from Europe and the United States, and 20 field-based studies conducted in Turkey (Page et al., 2021; Ögçe et al., 2022; Çakır & Tuğluer, 2025).

2.5. Data Extraction Process

A data extraction form was applied to each study in a systematic manner. The metric for plant diversity included species richness, Shannon–Wiener (H’), Simpson (1–D), the ratio of native-exotic species, stratification level, deciduous–evergreen balance, and seasonal tissue diversity (Güneroğlu et al., 2018; Ögçe et al., 2022).

Human health indicators such as psychological stress, depression, and anxiety scales (PSS, DASS, WHO-5), quality of life (WHOQOL), physical activity level, and social interaction scores were assessed in various studies (Yıldızbaş et al., 2025; Hu et al., 2025).

Sample area type, climate class, population density and land-use pattern were some of the significant information that was coded regarding urban and regional information (Söğüt, 2000; Niray, 2021).

2.6. Data Analysis and Synthesis Approach

A quantitative meta-analysis was not undertaken, due to methodological diversity among the studies; instead, a three-stage narrative synthesis method was applied. In the first stage, the studies had thematically been divided into categories such as "plant diversity-psychological health," "plant diversity-physical health," and "plant diversity-social well-being" (Marselle, Bowler et al., 2021; Spotswood et al., 2025).

In the second step, plant diversity values in the seven regions' largest cities were compared, and it was confirmed that the H’ values of the coastal cities were significantly higher than in inland and arid regions (Ögçe et al., 2022; Çakır & Tuğluer, 2025).

At the final stage, studies were assessed on the level of evidence concerning the sample size, the quality of the method applied, and the verifiability of the health indicators.

2.7. Ethical Considerations

This study is based on scientific literature published in journals and does not need any ethical committee approval. Sources used within this paper are cited by academic rules, with the full list presented in the references section.

3. Findings and Discussion

Table 1 synthesizes the main results derived from the reviewed literature by summarizing regional plant diversity patterns, associated ecological characteristics, and their implications for human health and well-being in major Turkish cities. The findings highlight a pronounced spatial gradient in plant diversity, strong contrasts between coastal and inland settlements, and consistent links between biodiversity levels and psychological, physical, and environmental health indicators.

Table 1. Summary of major findings on plant diversity patterns and health outcomes in large Turkish cities.

Theme	Regional Pattern	Key Findings	Health Implications	Main References
Plant diversity gradient	Coastal > Inland > Eastern regions	Higher Shannon index values in coastal cities; limited species richness in Ankara and Erzurum	Weakened ecosystem services in inland regions	Ögçe et al., 2022; Güneroğlu et al., 2018
Native–exotic species balance	Exotic species > native species in metropolitan areas	60–70% of park vegetation is dominated by exotic species	Increased allergen load and habitat degradation	Hatipoğlu & Ekren, 2022; Ögçe et al., 2022
Habitat stratification	Black Sea and Mediterranean > inland regions	Multilayered vegetation structure is stronger in coastal cities	Enhanced restorative environment perception	Yazlık et al., 2020; Hartig et al., 2014
Psychological health	Higher diversity = improved well-being	Reduced cortisol levels and increased attention	Lower risk of depression and stress	Hu et al., 2025; Yıldızbaş et al., 2025
Physical activity	Activity increases with increasing diversity	Higher park usage rates	Reduced obesity and non-communicable disease (NCD) risk	Akpınar & Cankurt, 2015; Marselle, Bowler et al., 2021
Ecosystem services	Broadleaf species dominant in coastal regions	Heat mitigation and particulate matter (PM) removal	Improved thermal comfort	WHO, 2017; Kabisch et al., 2017
Overall conclusion	Coastal cities are more advantageous	Plant diversity should be a primary planning criterion	Direct contribution to public health	Wu et al., 2024; Spotswood et al., 2025

3.1. Plant Diversity Patterns in the Major Cities of Türkiye

Based on literature findings from major cities representing Turkey's seven geographical regions, plant diversity follows a distinct spatial gradient across regions. Table 2 summarises the main findings regarding spatial patterns of plant diversity and their associations with physical, psychological and social health outcomes in major urban centres across Turkey. The temperate climate conditions in coastal cities (Istanbul, Izmir, Antalya, Samsun) increase habitat heterogeneity, which facilitates high distribution, especially for broad-leaved species, thus contributing to Shannon diversity values that range between 2.3 and 3.2 (Ögçe et al., 2022; Kuşak et al., 2022). Contrarily, in the cities of Central Anatolia and Eastern Anatolia (Ankara, Erzurum), where the dominant climate is continental, the species richness is more limited; the number of woody taxa is decreasing, but the Simpson index is relatively balanced due to the relative dominance of selected coniferous species (Güneroğlu et al., 2018). This situation shows that evaluating plant diversity may not be based only on the number of species but also on structural balances based on the relative abundance of species (Wu et al., 2024).

Table 2. Summary of main findings on plant diversity patterns and health outcomes in major Turkish cities (Ögçe et al., 2022; Kuşak et al., 2022)

Region	City	Climate	Diversity Level	Dominant Structure	Health Impacts
Marmara	İstanbul	Transitional	Medium	Exotic-dominated	Moderate
Aegean	İzmir	Mediterranean	Medium–High	Mixed shrubs & trees	High
Mediterranean	Antalya	Warm–humid	Medium–High	Ornamentals	High
Black Sea	Samsun	Humid	High	Native broadleaf trees	Very High
Central Anatolia	Ankara	Continental	Low–Medium	Conifers	Limited
Eastern Anatolia	Erzurum	Cold continental	Low	Sparse woody taxa	Low
Southeastern Anatolia	Gaziantep	Hot–dry	Low–Medium	Xerophytic species	Moderate

3.2. Native–Exotic Species Balance and Ecological Consequences

It is indicated that exotic species usage is very high, especially in big metropolitan areas (Istanbul, Izmir, Antalya), and that 60–70% of parks have a composition dominated by exotic species (Ögçe et al., 2022). Even though exotic species have several advantages, like enhancing landscape aesthetics and fast adaptation, they are reported to carry ecological and public health risks by weakening pollination networks, reducing interaction with native fauna, and increasing allergen load (Hatipoğlu & Ekren,

2022). On the other hand, higher proportions of native taxa, as seen in Black Sea cities, result in positive outcomes with regard to both air quality regulation and the continuity of ecosystem functions (Güneroğlu et al., 2018). These findings point to a need within Turkey for a hybrid approach in urban plant diversity planning that preserves the native species (Marselle, Bowler et al., 2021).

3.3. Habitat Stratification and Landscape Integrity

Habitat stratification, being the balance between tree-shrub-herbaceous layers, is one of the most important components influencing ecosystem services and differs substantially in the cities studied in Turkey.

It has been reported that shrub and herbaceous layers are stronger in Black Sea and Mediterranean cities, while stratification is weak and monocultural landscape patterns are dominant in Central and Eastern Anatolia (Ögçe et al., 2022; Yazlık et al., 2020). The structural diversity is considered one of the basic spatial elements which enhance psychological well-being, especially because of its impact on visual complexity and restorative experience (Hartig et al., 2014).

3.4. The Relationship Between Plant Diversity and Psychological Health

Findings from Turkish and international literature suggest that areas with high plant diversity can substantially reduce stress, improve mood and promote mental restoration. In clinical studies, even short visits to green spaces with high plant diversity have been found to reduce cortisol levels and improve mood (Hu et al., 2025). In the Belgrade Forest of Istanbul, a study revealed statistically significant improvements in energy, attention, physical activeness and overall well-being for the subjects exposed to high plant diversity (Yıldızbaş et al., 2025). The studies confirm that plant diversity plays a decisive role not only in physical health but also in cognitive and emotional health (Spotswood et al., 2025).

3.5 Plant Diversity, Physical Activity, and Social Health

Increasing the diversity of green spaces raises the motivation of individuals to use open spaces and thus provides higher physical activity levels for them. As revealed by the studies conducted in Turkey, parks with diverse plant species are perceived as more attractive, safe, and comfortable by users; visit times are also longer in areas with high species diversity (Akpınar & Cankurt, 2015; Yazlık et al., 2020). As stated by the international meta-analyses, not only does high landscape diversity increase the frequencies of walking and recreational uses but it also has positive effects on social interaction, community cohesion, and spatial belonging (Marselle, Bowler et al., 2021; Marselle, Hartig et al., 2021). These results support the indirect effects of ecological diversity on social health.

3.6 Ecosystem Services and Their Impact on Public Health

Plant diversity has a direct impact on public health through ecosystem services of air quality regulation, PM2.5 retention capacity, shading, heat island effect, and water cycle regulation, particularly in urban ecosystems. As diversity increases, the diversification of functional characteristics shows that there is a marked increase in heat reduction capacity and urban cooling efficiency (WHO, 2017). It has also been indicated that findings such as high diversity of leafy species, especially in Samsun, Istanbul, and Antalya in Turkish cities, are a positive aspect in which one can consider the heat island effect (Ögçe et al., 2022). Another reason that plant diversity is a critical variable for public health policies is the multi-layered impact on ecosystem services.

Indeed, when all the findings are considered in combination, it is obvious that there is a big variation in the urban plant diversity of Turkey, depending on geographical conditions, climatic features, planning perspective, and socio-economic characteristics. This is manifested in Tables 1 and 2. Therefore, plant diversity affects human health and well-being directly and indirectly. While higher plant diversity in coastal cities contributes to more positive psychological and social health outcomes, lower diversity in inland areas is related to the weakening of ecosystem services and higher health risks (Marselle, Bowler et al., 2021; Marselle, Hartig et al., 2021; Ögce et al., 2022). This situation urgently requires an approach to plant diversity systematically in urban planning in Turkey.

When compared with international research results, the overall trends in Turkey show a high degree of similarity with regard to results relating to urban areas in Europe, North America and East Asia, in terms of the correlation between high plant diversity and ecosystem services, and high PS (Hartig et al., 2014; Marselle, Bowler et al., 2021; Wu et al., 2024).

However, there is a fundamental difference in terms of the level of diversity loss and its underlying causes. While international papers tend to highlight urban densification and land-use intensity as major limiting factors, it is clear that management patterns, the large-scale use of exotic species, and the lack of integration of native flora into urban planning have a more decisive influence on diversity in the Turkish context.

Furthermore, compared to cities in Western Europe, where native species are increasingly prioritised through biodiversity-focused plans, Turkish cities exhibit greater dominance of exotic taxa for ornamental purposes. This may partially explain the lower resilience reported in certain regions (Marselle, Hartig et al., 2021; WHO, 2017).

4. Conclusion and Suggestions

This study demonstrates that plant diversity in major cities across different geographical regions of Turkey is a key determinant of both ecological quality and human health and well-being. The limited use of native species in urban green spaces, together with the dominance of exotic species, not only weakens ecosystem resilience but also poses public health risks in terms of allergen load, maintenance costs, and species continuity. Therefore, urban landscape planning should prioritise the use of native and ecologically compatible species, selecting them not solely based on aesthetic criteria but also on ecological performance and health-related considerations.

In this context, it is recommended that municipalities and local authorities integrate native species quotas and ecological suitability criteria into urban planting guidelines, tender specifications, and landscape design standards. In addition, the regular monitoring of plant diversity using indices such as Shannon–Wiener and Simpson, together with species richness, provides an objective and traceable tool for evaluating the quality of urban green infrastructure. Integrating these diversity metrics into municipal green space management and reporting systems would enable evidence-based monitoring of urban ecosystems over time.

Moreover, the planning of multilayered landscapes with tree–shrub–grass stratification enhances health-related ecosystem services, including thermal comfort, aesthetic perception, and psychological restoration. For future research, combining plant diversity indicators with validated health assessment tools (e.g. WHO-5, DASS, PSS) and developing region-specific landscape policies aligned with climate sensitivity should be considered priority actions to support sustainable urban health strategies.

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The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Disclosure Information

The article was written by a single author. There is no conflict of interest.

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