DENDROBIOLOGY

2024, vol. 91, 100–112

https://doi.org/10.12657/denbio.091.008

*Betül Tülek*, Derya Sarı, Pelin Şahin Körmeçli*

# Ecosystem services provided by urban woody plants in the context of spatial relations: Çankırı case area

*Received: 8 January 2024; Accepted: 28 March 2024*

**Abstract:** Ecosystem services (ES), which are defined as the benefits provided by humans from ecosystems, provide recreation opportunities for urban people with green areas in the cities, while supporting biodiversity on the other hand. This research seeks to answer the following 3 questions: (1) Can the contribution of plants used in urban parks to urban ES be measured? (2) Are the location and characteristics of the areas where plants are placed in urban parks a factor in providing ES? (3) Which ES stands out in the network of relationships established by the ES provided by plants in urban green spaces? Within the scope of these questions, ES provided by woody plants in Çankırı urban park, which is an essential green area for Çankırı/Türkiye, were examined. In the light of the examinations on-site, the presence of 49 woody plant taxa was determined. The contribution of plant taxa to the ecosystem has been assessed within the framework of 13 sub-parameters related to provisioning, supporting, regulating and cultural services. Hot spot analysis and hierarchical cluster analysis methods were used to determine the ES and spatial distribution of taxa within the park. Subsequently, a centrality analysis was carried out in the Graph Commons program using the network mapping method to determine the importance of ES provided by plants. As a result of the study, it was revealed that the woody plants used in Çankırı urban park contribute highly to the urban ecosystem in terms of pollination, erosion control, recreation and education, soil and air quality improvement and habitat provision. However, the spatial distribution of taxa was not balanced. Therefore, a balanced spatial distribution of woody plant taxa, which make a valuable contribution to ES, in urban green spaces is an issue that should be considered in urban ES planning.

**Keywords:** ecosystem services, hotspot analysis, Graph Commons, urban ecosystems, woody plants, Çankırı

**Addresses:** B. Tülek, P. Şahin Körmeçli, Çankırı Karatekin University, Faculty of Forestry, Department of Landscape Architecture, Çankırı, e-mail: betultulek@karatekin.edu.tr
D. Sarı, Artvin Çoruh University, Faculty of Art and Design, Department of Landscape Architecture, Artvin, e-mail: deryasari@artvin.edu.tr
* corresponding author

## Introduction

ES is defined in the Millennium Ecosystem Assessment (MEA, 2005) report as the benefits that people derive from ecosystems. In the report, ES are classified and evaluated in 4 main function groups and 30 categories, namely resource provisioning, regulating, cultural and supporting services. Provisioning and cultural services are services that people benefit from directly, while regulating and supporting services are services that people benefit from indirectly (MEA, 2005). Cultural Ecosystem Services (CES) are defined in the MEA (2005) report as the non-material benefits that people derive from ecosystems through spiritual and cognitive development, recreation and aesthetic experiences (Sarukhán & Whyte, 2005).

The benefits of trees in the ecosystem can be divided into different classes. In terms of sustainable development, these benefits can be divided into three main groups for people, ecological balance and the economy (Laille et al., 2013). The benefits provided by the use of plants in urban green areas can also be divided into three groups: environmental, social and economic (Torbay, 2013). Plants provide many valuable ES such as improving air quality, increasing cultural and aesthetic value, biodiversity potential, carbon sequestration, energy saving and microclimate regulation, improving human health, noise reduction and storm water management.

Urban areas are social-ecological systems characterized by complex networks of interacting components (Bennett, 2016; Chelleri et al., 2015; Kremer et al., 2015; McPhearson et al., 2014; Meerow et al., 2016; Schewenius et al., 2014).

Urban parks can play an important role with contributing to human well-being in the cities. They can supply urban air with comfortable thermal effect and reduce urban heat island effect. In the literature, urban parks are called as park cool islands (Spronken-Smith & Oke, 1998; Kabisch et al., 2017). In this context, the selection of suitable tree species contributes to habitat species in urban parks, reducing the effect of urban heat, and adding aesthetic value, on the other hand it is important for the achievement of high temperature efficiency (Emilson & Sang, 2017; Rahman et al., 2015).

Strengths and weaknesses should be taken into account before urban parks planning (Fracini et al., 2022). Plants species in urban parks can provide benefit to closer inhabitants, or larger scales, for example some specific ornamental plants spread in an urban area can benefit the entire city with pollution removal, air cleaning, enhancing biodiversity, reducing noise, improving community health etc. (Evans et al., 2022). There are 5 different benefits can be defined for plants in urban parks (Çetinkaya & Uzun, 2014; Gómez-Baggethun et al., 2013; Laille et al., 2013; Roy et al., 2012; Sarı et al., 2020; Torbay, 2013):

– Social benefits: Recreational and educational opportunities, contributing to the improvement of environmental quality, physical and mental health of the community, being of historical and symbolic importance, contributing to the urban identity.
– Aesthetic benefits: Creating aesthetic value with vegetation in different colors, textures, forms and density, the potential to monitor seasonal changes, creating a sense of space, contributing to the increase of visual quality.
– Climatic and physical benefits: Microclimate creation, dust retention and air pollution reduction, noise control, erosion control, wind control.
– Biological benefits: Creating habitat for species in the urban environment, attracting butterflies-birds-bees, improving soil.
– Economic benefits: Creating opportunities for tourism, contributing to the increase in the value of the surrounding land, having economic value, medical-aromatic value, edible property, other uses.

The concept of urban ES was first used by Bolund and Hunhammar in 1999. Urban ES are defined as the value and benefits provided by the inner ecosystems in a city to the inhabitants of the city (Demiroğlu & Karadağ, 2015). Urban ES depends on the quantity, quality and diversity of the green infrastructure that produces them (Calderón-Contreras & Quiroz-Rosas, 2017). All plants in urban areas are part of the urban flora, and this flora is supported by urban park systems (Kim, 2016), which are an important part of urban green infrastructure. The benefits of ES depend on the urban areas and the distribution of green areas. In order to benefit from ES in urban areas and especially urban parks, the distribution of plant species use must be planned correctly (Yu et al., 2023).

Woody plants play important roles in terms of the ES they provide in urban areas. Unfortunately, the majority of the plants used in today's urban parks consist of exotic ornamental plants. There are very few studies that demonstrate and spatially describe these species' adaptations to local conditions, sustainability and support for the ES they provide and urban green infrastructure (Sarı et al., 2020). Urban parks improve the quality of life, improve biodiversity in cities and contribute to the ecosystem. Within the scope of this study, it was aimed to examine the ES provided by urban trees in Çankırı's largest urban park and to reveal their spatial distribution and the most benefits and services provided. The contributions of plant species to the ecosystem were evaluated in 13 different criteria including food, biological raw material, decorative resources, biochemical and medicinal products, air quality regulation, erosion control, pollination, recreation and education, inspirational value, soil improvement, sense of place, cultural heritage value, providing habitat.

## Material and Methods

### Study area

Çankırı urban park, which constitutes the research area, is within the borders of Çankırı Province, Central District. According to flora of Türkiye, the area is located in the Iranian-Turanian phytogeographic region (Davis 1965-1988). Çankırı provincial center is surrounded by mountains on all four sides and consists of settlement centers built on these mountains, on the slopes and in the valleys between the mountains. The height above sea level is 730 m. Çankırı generally has a climate typical of Central Anatolia. While winters are cool and summers are mild in the central, Ilgaz and Yapraklı districts, winters are cold and summers are cool in Çerkeş district (Pekin Timur, 2012).

Çankırı urban park is located in Esentepe Neighborhood, on the edge of Acıçay Stream and especially the vegetation of Acıçay Stream riparian zone is observed in the area. *Elaeagnus angustifolia, Tamarix smyrnensis, Salix alba, Salix amplexicaulis, Populus* spp. form the tree and shrub layer of the riparian zone and plant species resistant to moist and saline soils are distributed in these regions (Dölarslan & Göl, 2008). Many large and small mammal species live in the area. The main ones are *Martes foina, Vulpes vulpes, Lepus europaeus, Meles meles, Sus scrofa, Lutra lutra, Erinaceus concolor* and *Canis lupus*. In terms of aquatic

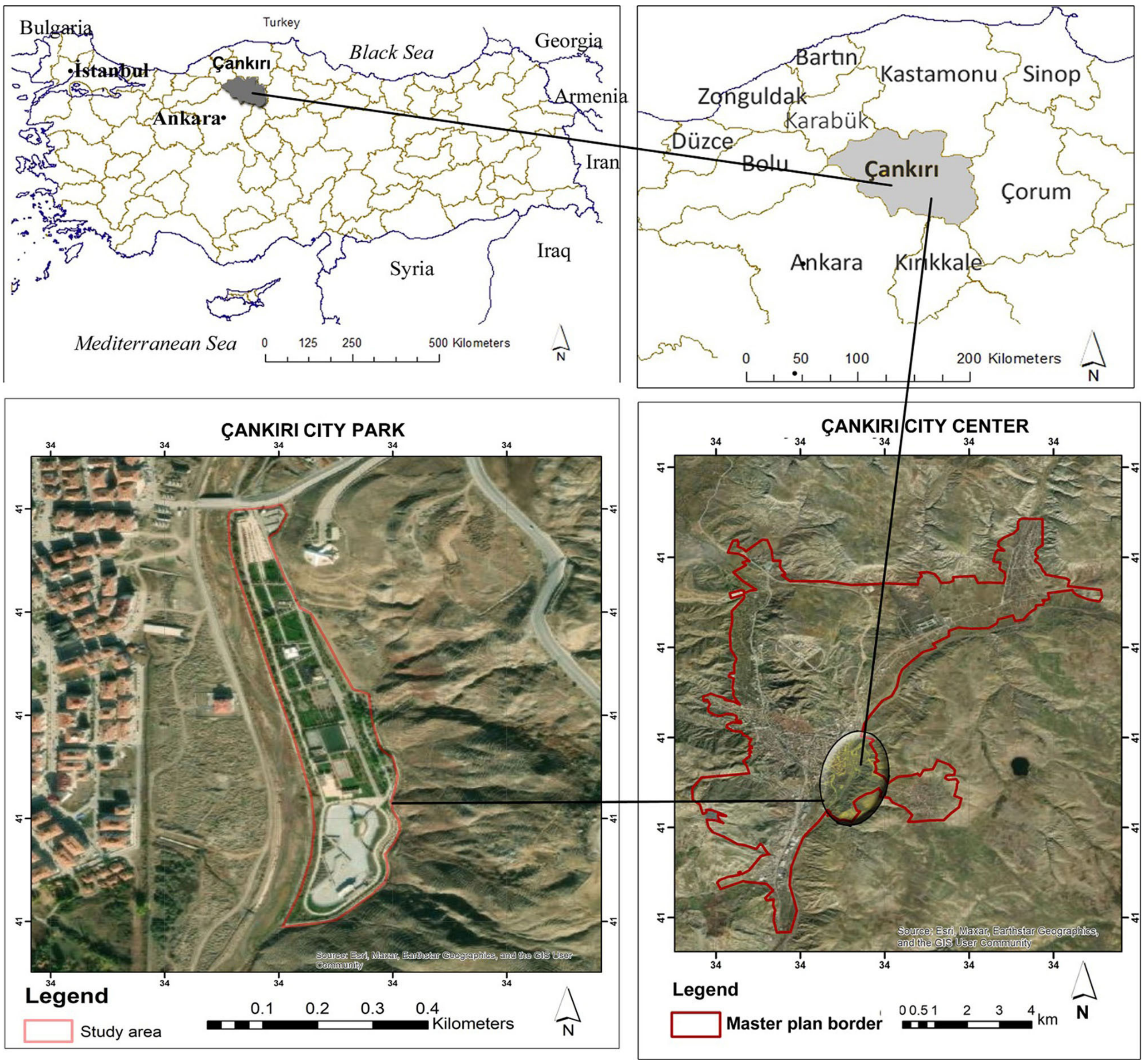


Fig. 1. Location of case study area


Fig. 2. Current state of the study case (Original, 2023)

life, bird species such as *Ciconia ciconia, Ciconia nigra, Ardea cinerea, Egretta garzetta* are frequently seen in the area (Ediş et al., 2022).

Çankırı urban park is the largest park in the city center. The park has a total area of 114.830 m², with a total green area of 63.199 m², a solid surface of 27.446 m², a pond area of 12.055 m² and other usage areas. The park has a sports complex consisting of 1 artificial turf field, 1 basketball court, 2 table tennis courts, 2 mini golf courses, 1 tennis court, 1 sports center, 3 kiosks, 1 cafeteria, 1 restaurant, 1 open-air prayer place, a children's traffic training park, an amphitheater, benches and many picnic tables. The park, which is located between the main basins of Kızılırmak River and Western Black Sea in terms of Çankırı urban ecosystem, was chosen as the study area because it is in an important position in terms of urban ecosystem. The location of the study area is given in Fig. 1.

Acıçay Stream, located to the west of the park, provides an important ecological landscape value to the region. The park is in a state of development with its water assets, green areas and circulation system. The area is located on a topographically flat terrain and it is seen that the height differences increase in the east direction. Images of the current situation of the study area are given in Fig. 2.

The park, located in the form of a natural valley formation, is located near the riparian zone. Riparian zones are important landscape elements due to their spatial location in basins (Martí et al., 2000). Acıçay Stream, which flows through the center of Çankırı province and flows into Kızılırmak River, passes right next to the park. The riverbanks and nearby vegetation are potential areas that contribute to the urban ecosystem by providing services such as soil improvement and water quality enhancement.

## Method

In the first phase of the research, local and foreign articles, books and reports on ES, urban ecosystems, urban green spaces and plant use, as well as data obtained from the internet were analyzed. In the second phase of the research, woody plant taxa were identified and their spatial distributions were recorded by conducting on-site fieldwork in Çankırı urban park in the spring and summer seasons of 2022-2023.

In phase 3 of the research, the park area was divided into 9 spaces according to the type of utilization square, parking area, around the pond, green spaces, picnic area, around the river, playground area, sports area and main path. General characteristics of the plants (class, family, growth form, status) were entered into the data tables. Within the scope of the study, the ES provided by each woody taxon was evaluated according to 13 ES categories (food, biological raw material, decorative resources, biochemical and medicinal products, air quality regulation, erosion control, pollination, recreation and education, inspirational value, sense of place, cultural heritage value, soil improvement, providing habitat) under 4 headings: Provisioning, regulating, supporting and cultural services (Gómez-Baggethun et al., 2013; MEA, 2005; TEEB, 2010). Various literature sources and plant database websites were used for identification studies and plant species characteristics (Akkemik, 2018; Davis, 1965-1988; Johannsmeier, 2016; PFAF, 2023; WFO, 2023).

In Phase 4 of the research, numerical data on plant taxa were transferred to Excel tables and mapped in ArcMAP 10.3 with the help of point location data of plants in the park area and the site plan obtained from Çankırı Municipality. *Cluster Analysis of Incident Points* was applied based on the research of Dvarskas (2018) to determine the point densities of plants in mapping. *Ward's method* was used in the analysis with PAST 4.03 data analysis software (Hammer et al., 2001). In the dendogram created, 2 main groups emerged. Accordingly, the taxa providing the most ES were clustered in group 1. At this phase, evaluations were made regarding the benefits provided by the woody taxa in the park areas. It was evaluated in which regions the ES provided by the taxa used in the park area are concentrated according to the spatial use of the park.

In the 5th and final phase of the research, ES provided by the plants were evaluated using the network

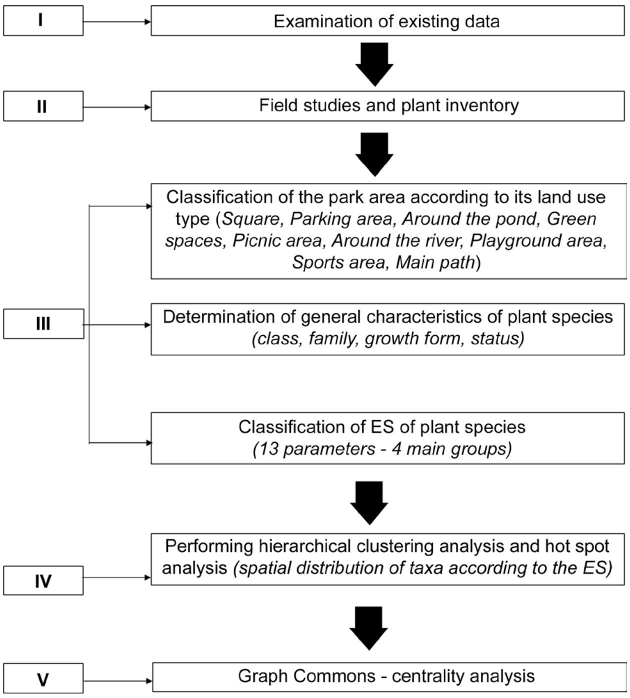


Fig. 3. Flowchart of the method

mapping method. Contributions of each plant to ES were assigned and *centrality analysis* was performed in Graph Commons program. For cluster and centrality analyses, the contribution of plant taxa to the ecosystem is organized through 13 sub-parameter frameworks related to provisioning, regulating, cultural and supporting services. First, each plant used in the area was entered as point data, and then these 13 ES parameters provided by the woody plants were entered as another point data. In the program, the network map was obtained by creating connections by associating ES and plants as point data with each other according to their contributions. To find the importance of ES, the centrality degree algorithm (number of connections) value was examined. A high value means that the contribution order provided is high. By evaluating all the data obtained, the highest value ES provided by all plants in the park were extracted (Fig. 3).

## Results

The plant taxa identified in the research area are listed in Table 1. In this context, there are 49 taxa belonging to 21 families, 10 of which are native and 39 of which are exotic plants. In terms of species diversity, broad-leaved trees and shrubs have the highest diversity and conifers have the lowest diversity. Hierarchical clustering analysis was performed by taking into account the ES provided by the woody plants identified in the park area. *Hierarchical clustering analysis* was performed based on the ES provided by the woody taxa identified in the park area and their presence status (1/0). According to the map and dendogram, taxa are found in 9 spaces in the park in the first group and the number of taxa found in the area is 24. These are: *Acer negundo, Aesculus hippocastanum, Quercus robur, Salix babylonica, Tilia tomentosa, Catalpa bignonioides, Cupressocyparis leylandii, Eleagnus angustifolia, Fraxinus excelsior, Juglans regia, Platanus orientalis, Populus alba, Prunus avium, Prunus ceracifera* 'Pissardii Nigra', *Acer platanoides, Cedrus libani, Elaeagnus pungens, Morus alba, Prunus serrulata* 'Kanzan', *Robinia pseudoacacia, Aesculus carnea, Malus floribunda, Picea pungens* 'Glauca', *Picea pungens* (Fig. 4).

Regarding the species distribution in the area in general, it can be said that the species are mostly seen in green spaces, around the pond, square and playground areas (Fig. 5). As part of the research, the taxa studied in the first group were concentrated in red areas on the distribution map made with hot spot cluster analysis, and these areas were formed by the square, parking area and green area areas, followed by picnic areas. It is possible to say that the red area has more plant diversity and thus is the region that provides the most ES.

When a general evaluation is made, it can be said that the woody plants in the park provide Provisioning Services in terms of food (49%), biological raw materials (55%), decorative resources (20%) and medical products (59%), Regulating Services in terms of climate and air quality regulation (78%), erosion prevention (86%) and pollination (84%), Supporting Services in terms of soil formation (69%) and providing habitat (59%), and Cultural Services in terms of recreation (76%), inspiration value (12%), sense of place (31%) and cultural heritage value (6%) (Fig. 6).

If the ES provided by the taxa concentrated in red area and analyzed in the first group with the dendogram are mentioned separately, it can be said that the species forming the first group have important contributions to the area in terms of providing Food (*Acer negundo, Aesculus hippocastanum, Eleagnus pungens, Eleagnus angustifolia, Fraxinus excelsior, Juglans regia, Malus floribunda, Morus alba, Picea pungens, Prunus ceracifera, Prunus avium, Prunus serrulata, Quercus robur, Robinia pseudoacacia, Tilia tomentosa*), Biological raw material (*Acer negundo, Acer platanoides, Aesculus hippocastanum,Catalpa bignonoides, Cedrus libani, Cuppressus arizonica, Eleagnus angustifolia, Fraxinus excelsior, Juglans regia, Morus alba, Picea pungens, Platanus orientalis, Populus alba, Prunus avium, Quercus robur, Robinia pseudoacacia, Salix babylonic, Tilia tomentosa*). While almost all of the taxa forming this group contribute to the aesthetic value of the park within CES; only *Cedrus libani* and *Platanus orientalis* have cultural heritage value.

Table 1. Plant taxa list determined in Çankırı urban park

| Plant taxa | Abbreviation | Status | Family | Presence in spaces (%) | Number of ES provided |
|---|---|---|---|---|---|
| Conifers | | | | | |
| *Cedrus libani* A. Rich. | Cede | Exotic | Pinaceae | 11 | 8 |
| *Cuppressus arizonica* Greene | Cuar | Exotic | Cupressaceae | 11 | 7 |
| x*Cuppressociparis leylandii* (A.B.Jacks. & Dallim.) Farjon | Cule | Exotic | Cupressaceae | 44 | 3 |
| *Picea pungens* Engelm. | Pipu | Exotic | Pinaceae | 56 | 6 |
| *Picea pungens* Engelm. 'Glauca' | Pipug | Exotic | Pinaceae | 11 | 7 |
| *Pinus nigra* Arnold subsp. pallasiana (Lamb.) Holmboe | Pini | Native | Pinaceae | 11 | 7 |
| *Platycladus orientalis* (L.) Franco | Plaor | Exotic | Cupressaceae | 67 | 6 |
| Deciduous | | | | | |
| *Acer negundo* L. | Acne | Exotic | Sapindaceae | 33 | 10 |
| *Acer platanoides* L. | Acpl | Exotic | Sapindaceae | 22 | 8 |
| *Aesculus carnea* Hayne. | Aeca | Exotic | Sapindaceae | 33 | 6 |
| *Aesculus hipocastanum* L. | Aehi | Native | Sapindaceae | 11 | 10 |
| *Catalpa bignonioides* Walt. | Cabi | Exotic | Bignoniaceae | 22 | 9 |
| *Eleagnus angustifolia* L. | Elan | Native | Elaeagnaceae | 44 | 8 |
| *Fraxinus excelsior* L. | Frex | Native | Oleaceae | 44 | 9 |
| *Juglans regia* L. | Jure | Native | Juglandaceae | 11 | 9 |
| *Malus floribunda* Siebold. ex Van Houtte. | Mafl | Exotic | Rosaceae | 11 | 6 |
| *Morus alba* L. | Moal | Native | Moraceae | 22 | 9 |
| *Morus alba* L. 'Pendula' | Moalp | Exotic | Moraceae | 22 | 6 |
| *Platanus orientalis* L. | Plor | Exotic | Platanaceae | 56 | 9 |
| *Populus alba* L. | Poal | Native | Salicaceae | 22 | 9 |
| *Prunus avium* L. | Prav | Native | Rosaceae | 11 | 9 |
| *Prunus ceracifera* Rehd. 'Pissardii Nigra' | Prce | Exotic | Rosaceae | 56 | 9 |
| *Prunus serrulata* Lindl. 'Kanzan' | Prse | Exotic | Rosaceae | 33 | 8 |
| *Quercus robur* L. | Quro | Exotic | Fagaceae | 22 | 10 |
| *Robinia pseudoacacia* L. | Rops | Exotic | Leguminosae | 44 | 8 |
| *Salix alba* L. | Saal | Exotic | Salicaceae | 22 | 7 |
| *Salix babylonica* L. | Saba | Exotic | Salicaceae | 11 | 10 |
| *Tilia tomentosa* Moench | Tito | Exotic | Tiliaceae | 11 | 10 |
| Shrubs | | | | | |
| *Berberis thunbergii* 'Atropurpurea' L. | Beth | Exotic | Berberidaceae | 78 | 8 |
| *Chaenomeles japonica* (Thunb.) Lindl. & Spach | Chja | Exotic | Rosaceae | 11 | 5 |
| *Elaeagnus pungens* Thunb. | Elpu | Native | Elaeagnaceae | 44 | 8 |
| *Euonymus japonica* L. | Euja | Exotic | Celastraceae | 22 | 4 |
| *Forsyhtia x intermedia* Zabel | Foin | Exotic | Oleaceae | 33 | 5 |
| *Gaura lindheimeri* Engelm. & A. Gray | Gali | Exotic | Onagraceae | 11 | 4 |
| *Juniperus sabina* L. | Jusa | Exotic | Cupressaceae | 44 | 4 |
| *Juniperus oxycedrus* L. | Juox | Exotic | Cupressaceae | 44 | 5 |
| *Pyracantha coccinea* Roemer | Pyco | Exotic | Rosaceae | 78 | 6 |
| *Rosa sp.* L. | Rosp | Cultivar | Rosaceae | 33 | 6 |
| *Senecio cineraria* DC | Seci | Exotic | Leguminosae | 11 | 4 |
| *Syringa vulgaris* L. | Syvu | Exotic | Oleaceae | 56 | 5 |
| *Weigela florida* (Bunge) A. DC. | Wefl | Exotic | Caprifoliaceae | 22 | 4 |
| *Tamarix smyrnensis* Bunge | Tasm | Native | Tamaricaceae | 11 | 6 |
| *Vibirnum opulus* L. | Viop | Exotic | Caprifoliaceae | 11 | 6 |
| Climbing and groundcover plants | | | | | |
| *Hedera helix* L. | Hehe | Exotic | Araliaceae | 22 | 6 |
| *Lavandula angustifolia* L. | Laan | Exotic | Lamiaceae | 22 | 7 |
| *Jasminum nudiflorum* Lindl. | Janu | Exotic | Oleaceae | 11 | 3 |
| *Juniperus horizantalis* Moench | Juho | Exotic | Cupressaceae | 22 | 4 |
| *Lonicera japonica* Thunb. | Loja | Exotic | Cupressaceae | 11 | 5 |
| *Parthenocissus quinquefolia* L. Planch | Paqu | Exotic | Vitaceae | 22 | 6 |

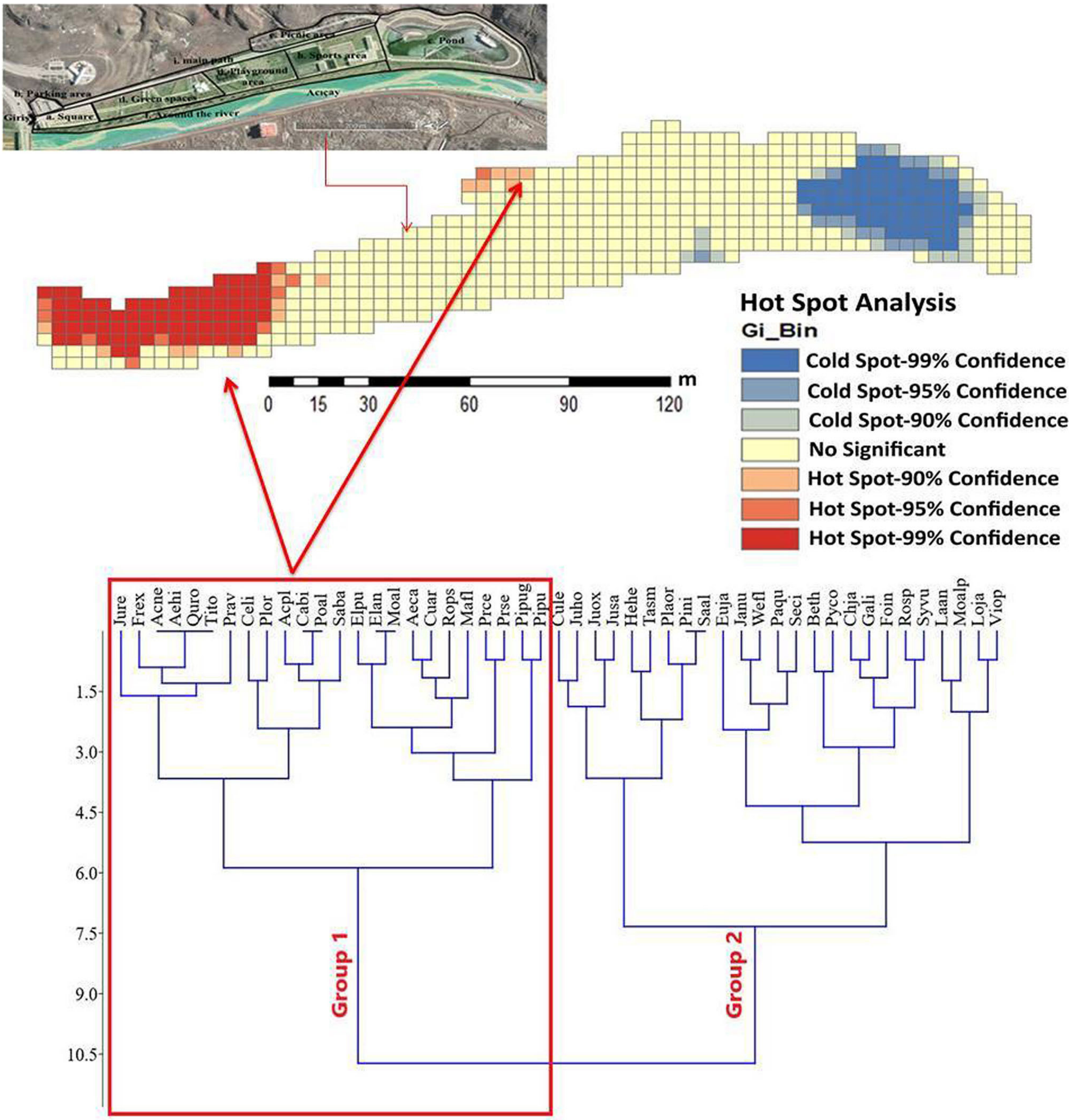


Fig. 4. Dendrogram and map of hierarchical and hot spot cluster analysis

The taxa that provide opportunities for recreational and educational activities that provide social benefits for the people of the city in the park area are as follows: *Acer negundo, Aesculus hippocastanum, Quercus robur, Salix babylonica, Tilia tomentosa, Catalpa bignonioides, Eleagnus angustifolia, Fraxinus excelsior, Juglans regia, Platanus orientalis, Populus alba, Prunus avium, Prunus ceracifera* 'Pissardii Nigra', *Acer platanoides, Cedrus libani, Elaeagnus pungens, Morus alba, Prunus serrulata* 'Kanzan', *Robinia pseudoacacia, Aesculus carnea, Malus floribunda, Picea pungens* 'Glauca', *Picea pungens*.

It was observed that all taxa in this group contribute to almost all of the supporting ES as an element of biological benefit, while *Acer negundo, Aesculus hippocastanum, Quercus robur, Salix babylonica, Tilia tomentosa, Catalpa bignonioides, Eleagnus angustifolia, Fraxinus excelsior, Platanus orientalis, Populus alba, Prunus avium, Prunus ceracifera, Acer platanoides, Cedrus libani, Elaeagnus pungens, Morus alba, Prunus serrulata, Robinia pseudoacacia, Aesculus carnea, Malus floribunda, Picea pungens* 'Glauca', *Picea pungens* species contribute to soil development. 24 taxa contribute to habitat provision as well.

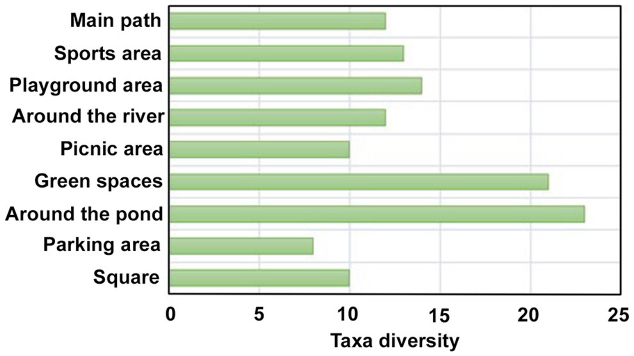


Fig. 5. Distribution of taxa diversity by the spaces in the park area

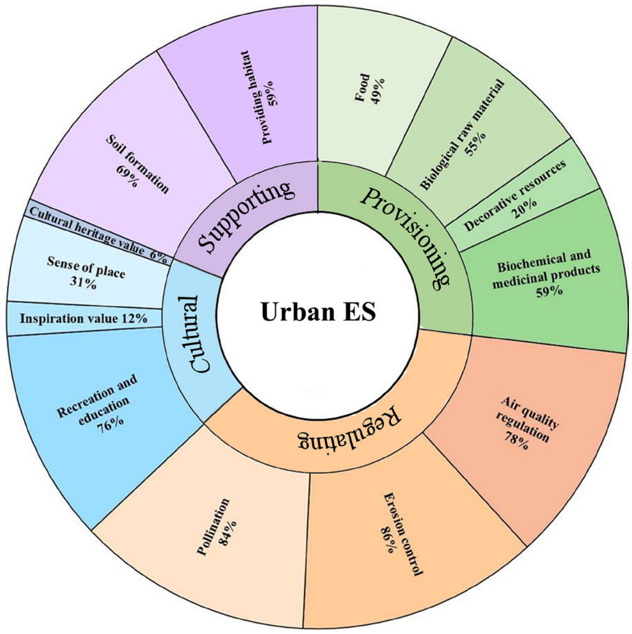


Fig. 6. ES rates provided by plant taxa in *Çankırı* urban park

In terms of climatic benefits, it can be stated that the identified species have effects such as regulating air quality, reducing air pollution, and creating dust and noise barriers. In the literature, it is noted that especially broad-leaved and coniferous trees contribute more in terms of air quality regulation services (Bolund & Hunhammar, 1999). In this context, *Acer negundo, Aesculus hippocastanum, Quercus robur, Salix babylonica, Tilia tomentosa, Catalpa bignonioides, Eleagnus angustifolia, Fraxinus excelsior, Juglans regia, Populus alba, Prunus ceracifera* 'Pissardii Nigra', *Acer platanoides, Cedrus libani, Elaeagnus pungens, Morus alba, Prunus serrulata* 'Kanzan', *Robinia pseudoacacia, Aesculus carnea,* species are determinant. A network map was created to find out which of the ES provided by all plants contributes more. The centrality analysis of ES in the park is given in Fig. 7.

The *centrality degree* value has been considered to highlight the importance of ES provided by plants in the park area. With 41 centrality degree scores, the most important services in the park were pollination and erosion control. Landscape plants used to ensure

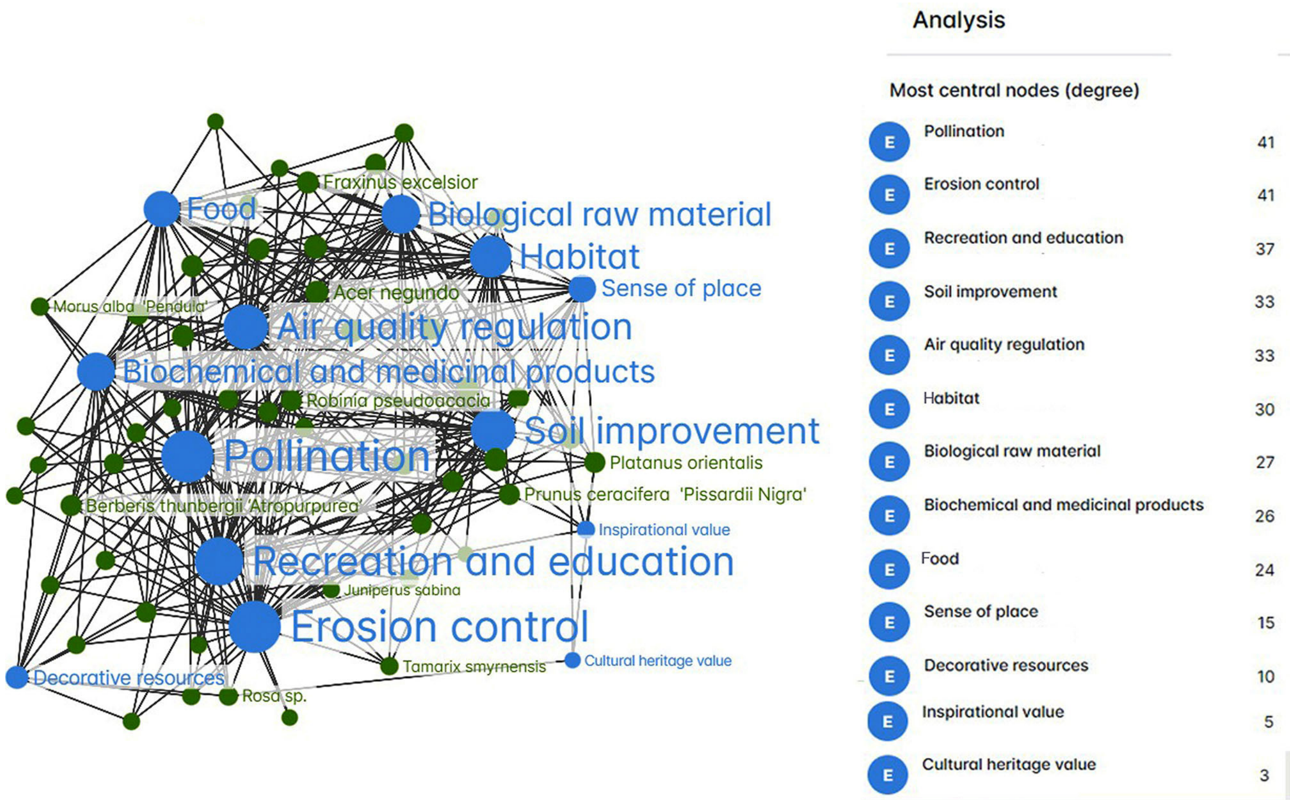


Fig. 7. Centrality analysis of ES in the park

the continuity of pollination in urban areas are very important. Some studies have shown that the variety and abundance of woody plants has a positive effect on pollination function (Pardee & Philpott, 2014; Somme et al., 2016). In this context, urban parks, as man-made green spaces, constitute a source for many pollinators. The ES provided by plants were found to be in the form of recreation and education, soil improvement, air quality, habitat, biological raw material, biochemical and medicinal products, food, sense of place, decorative resources, inspirational value, cultural heritage in order from increasing to decreasing degrees of centrality.

## Discussions

In this study, which addressed Çankırı urban park, which constitutes the largest park area in Çankırı green space system, was examined, it was determined that the tree species used in the urban park provide many social, aesthetic, climatic, ecological and economic benefits to the urban ecosystem by provisioning, regulating, supporting and cultural services.

When we look at the spatial distribution of the plant species used in the park area, it is seen that there is no balanced distribution, and the plant diversity is mostly met from the square, green space, parking area and a little picnic area, which causes the ES provided from the area to be limited. It should be taken care of the balanced distribution of plants that provide high levels of ES in the park across the area. The benefits of tree species in urban parks are described as improving environmental quality, contributing to the physical and mental health of urban people, creating aesthetic values with plant compositions, improving visual quality, creating micro-conditioning, dust retention, reducing air pollution, controlling noise and creating habitats for species within urban environments (Sarı et al., 2020).

In this study, it was revealed that the woody plants used in Çankırı urban park contribute highly to the ecosystem in terms of pollination, erosion control, recreation and education, soil and air quality improvement and habitat provision. Indeed, riparian areas provide ES such as preventing erosion and providing habitat with their vegetation. The ecosystem contributions provided by the park located next to the river were found to support the results obtained in the research. The fact that the city park is located near the Riparian zone reveals that the area is open to the development of vegetation. An ecological buffer should be created by increasing the use of *Tamarix smyrnensis* and *Elaeagnus angustifolia* species in the river vegetation in the park. Plant species belonging to the natural vegetation of the city should be included in the park. The low resistance of plant species due to the salty soil structure of the area is one of the features that negatively affect vegetation. In this respect, it is very important to ensure a balance in plant distribution by considering ES characteristics in plant design applications to be made in city parks.

In the inventory study conducted in the park area, 39 species were found to be exotic origin. This situation shows that aesthetic purposes are prioritized especially in plant selection. Çorbacı et al. (2022) stated in his research that the abundance of exotic plants poses great risks for the sustainability of natural ecosystems. On the other hand, the use of natural species will contribute to urban identity (Karaşah & Sarı, 2018) and urban ES.

Wang et al. (2011) stated in their research that exotic plant species can cause invasiveness and habitat loss of native species and this can cause economic losses or some health problems on humans. Babaç (2004) stated that the plant species in Çankırı province are *Acer hyracanum* Fisch Et. Mey. subsp. *hyracanum* Fisch Et. Mey., *Amygdalus orientalis* Miler, *Amygdalus x balansae* Boiss., *Crataegus x bornmuelleri* Zabel, *Elaeagnus angustifolia* L., *Pistacia atlantica* Desf., *Pyrus communis* L. subsp. *communis* L., *Tamarix smyrnensis* Bunge, *Ulmus minor* Miller subsp. *minor* Miller. These plant species should be included in the planting design of the park. It is possible to say that the trees used in the park are also a source of various raw materials (such as wood, fiber, organic products), but since they are used in urban areas mostly for their aesthetic properties, it is not possible to evaluate them with their raw material properties.

Many of the exotic ornamental plants used in urban areas can also create habitats for other creatures. They provide shelters, feeding and breeding areas for organisms living in these environments, thanks to many micro-habitat structures such as leafy and coniferous tree species, pebbles, shell pockets, cracks and crevices, resin and tree own waters, found in the bodies of some tree and bush species (Bütler et al., 2013). Some species can only survive in certain microhabitat environments. For this reason, the more microhabitat structures many woody plants and especially trees have, the greater the diversity of living things they contain. However, as trees age, the microhabitat structures on them increase and thus provide ES to more living things (Güzel, 2023; Sarı & Karaşah, 2023). In this context, the taxa in *Çankırı* urban park will contribute more to the ecosystem as potential habitat trees for the coming years.

Urban green spaces are important areas in cities that contribute to mitigating the effects of climate change, cleaning the air and reducing the effects of thermal radiation. Air pollution can result in polluted soils (Davidson et al., 2006), surface waters (Le Pape et al., 2012) and groundwater (Gallo et al., 2012) in urban areas. There is a need to include more ES in urban management plans and to create guidelines for planning urban green infrastructure systems such as urban parks and street trees. Scholz et al. (2018) reported that the most important ES provided by street trees in Duisburg (Germany) are primarily the removal of 16% of city emissions of particulate matter and the reduction of 58% of thermal radiation. In the literature, it has been noted that especially broadleaved and coniferous trees contribute more in terms of air quality regulating services (Bolund & Hunhammar, 1999). However, it is known that plants provide soil stabilization mostly through their root structures (Arkun et al., 2014). When the individual characteristics of woody plants in Çankırı urban park are analyzed based on literature, it can be said that they provide high ES in terms of regulating services. In the continuation of this study, it will be possible to conduct field studies on the services provided by woody plants in the park area against the urban heat island effect with carbon and particle emission measurements.

Excessive use of invasive and allergenic plant species in urban parks negatively affects urban ES. Sarı et al. (2020) found that species such as *Populus nigra* and *Robinia pseudoacacia* were used in the park, while *Ailanthus altissima* (invasive, poisonous and allergenic) was found to be present in the area although it was not planted. This deteriorates the aesthetics of the urban landscape, damages the natural ecosystem and increases maintenance costs. Similarly, Cariñanos et al. (2020) tried to analyze the effect that air pollutants have on pollen emissions of *Platanus x hispanica* Mill. ex Münchh tree (London-plane tree) in urban environment. Invasive, poisonous and allergenic species damage ES as they negatively affect the balance of the natural ecosystem and the spread of native species, and the use of plants with allergenic properties may also pose a threat to public health. As well as, Roman et al. (2021) examine the central role of human perception in the interpretation of ecosystem services and disservices, as well as species selection and local conservation concerns. In particular, they discuss the stereotype that 'everyone likes trees'.

Both in studies conducted in Europe (Kiss et al., 2015) and in Türkiye, databases of plant inventories of cities are not at a sufficient level. For this reason, it will be necessary to carry out plant inventories of cities and transfer them to digital media by mapping and digitalizing them in order to benefit more from ES in cities. Another study, Bilgili et al. (2012) concluded that digitizing the road trees in Çankırı city center and evaluating the plant material within the scope of the manageability of green areas based on geographical information systems provides important information to local managers in the management of plant material. As a matter of fact, this study concluded that plant use evaluation should be developed using different technological methods in addition to GIS.

## Conclusion

ES provide many benefits to humans from natural systems. In order to benefit from these services, it is important to develop vegetation in green areas that support biodiversity. There are many ES provided by plants. CES that provide aesthetic value and provisioning services that provide food or pharmaceutical raw materials can be given as examples to these services.

Woody plants provide a wide range of ES. Therefore, it is important to consider the qualities of these taxa in planning healthy and sustainable environments and to evaluate them in planting design strategies. Especially in urban areas, it is necessary to know which ES plant species provide in order to create planting designs that are resistant to the effects of global climate change and to make the right plant choices in designs that support green infrastructures.

It has been observed that the plant species used in Çankırı urban park are mostly composed of exotic species. In order to provide more and more effective ES from woody plants in urban parks, more natural species should be used. It should also be kept in mind that urban parks located near the riparian zone will make important contributions to the development of natural vegetation in the area, support urban ES and urban identity. Although pollination, erosion control and recreational services may be the most important services in park areas near the riparian zones, a balance in species distribution should be ensured in order to provide all ES effectively from urban parks. In this sense, the issue of ES should be taken into account at the landscape design stage of urban parks, and the selection and distribution of woody species should be realized accordingly.

However, the inclusion of potential disservices (eg. pollen allergenicity, toxicity) in future urban park planting design projects are extremely important in depends of Ecosystem Disservices. It is thought that the findings obtained in this study will guide future studies to follow the temporal change and development of ES provided by urban plants.

## References

Akkemik Ü (2018) Turkey's natural-exotic trees and shrubs I ve II. Publications of the General Directorate of Forestry, Ankara.

Arkun A, Ergen M & Çakır F (2014) The investigation of slope stabilization with plant roots by fi-

nite element analysis. Turkish Journal of Forestry 15: 77–83.
Babaç MT (2004) Possibility of an information system on plants of South-West Asia with particular reference to the Turkish plants data service (TÜBİVES). Turkish Journal of Botany 28: 119–127. http://194.27.225.161/yasin/tubives/index.php?sayfa=210&name=18.
Bennett EM (2016) Research frontiers in ecosystem service science. Ecosystems 20: 31–37. doi:10.1007/s10021-016-0049-0.
Bilgili BC, Çorbacı ÖL & Gökyer E (2012) Çankırı kent içi yol ağaçlarının değerlendirilmesi üzerine bir araştırma. Tekirdağ Ziraat Fakültesi Dergisi 9: 98–107.
Bolund P & Hunhammar S (1999) Ecosystem services in urban areas. Ecological Economics 29: 293–301. doi:10.1016/S0921-8009(99)00013-0.
Bütler R, Lachat T, Larrieu L & Paillet Y (2013) Habitat trees: key elements for forest biodiversity: Integrative approaches as an opportunity for the conservation of forest biodiversity(ed. by D Kraus & F Krumm) Freiburg, Germany, pp. 84–91.
Calderón-Contreras R & Quiroz-Rosas LE (2017) Analysing scale, quality and diversity of green infrastructure and the provision of Urban Ecosystem Services: A case from Mexico City. Ecosystem Services 23: 127–137. doi:10.1016/j.ecoser.2016.12.004.
Cariñanos P, Ruiz-Peñuela S, Valle AM, & de la Guardia CD (2020) Assessing pollination disservices of urban street-trees: The case of London-plane tree (*Platanus* x *hispanica* Mill. ex Münchh). Science of the Total Environment 737: 139722. doi:10.1016/j.scitotenv.2020.139722.
Chelleri L, Schuetze T & Salvati L (2015) Integrating resilience with urban sustainability in neglected neighborhoods: challenges and opportunities of transitioning to decentralized water management in Mexico City. Habitat International 48: 122–130. doi:10.1016/j.habitatint.2015.03.016.
Çetinkaya G & Uzun O (2014) Landscape planning. Birsen Yayınevi, İstanbul.
Çorbacı ÖL, Ekren E & Atasoy M (2022) Rize kentsel açık yeşil alanlarındaki istilacı bitki türleri üzerine bir araştırma. Journal of Anatolian Environmental and Animal Sciences 7: 156–162. doi:10.35229/jaes.1085042.
Davidson CM, Urquhart GJ, Ajmone-Marsan F, Biasioli M, Da Costa Duarte A, Dı ´az-Barrientos E, Grcˇman H, Hossack I, Hursthouse AS, Madrid L, Rodrigues S & Zupan M (2006) Fractionation of potentially toxic elements in urban soils from five European cities by means of a harmonised sequential extraction procedure. Anal Chim Acta 565: 63–72. doi:10.1016/j.aca.2006.02.014.
Davis PH (1965–1988) Flora of Turkey and East Aegean Islands, Vol. I – XI, Edinburg.
Demiroğlu D & Karadağ AA (2015) Ecosystem services approach to spatial planning in Turkey. I. Uluslararası Kent Araştırmaları Kongresi, Eskişehir, Turkey, pp. 16–17.
Dölarslan M & Göl C (2008) An investigation on the relationship between saline soil and halophytic plants in semi arid region (Acıçay Stream). International Meeting on Soil Fertility Land Management and Agroclimatology Aydın, Turkey, pp. 83–93.
Dvarskas A (2018) Mapping ecosystem services supply chains for coastal Long Island communities: implications for resilience planning. Ecosystem Services 30: 14–26. doi:10.1016/J.ECOSER.2018.01.008.
Ediş S, Tuttu G, Aytaş İ, Tuttu U & Özcan AU (2022) Analysis of temporal and spatial change in Acıçay (Çankırı) Riparian Zone. Artvin Çoruh University Journal of Forestry Faculty 23: 1–10. doi:10.17474/artvinofd.1002341.
Emilsson T & Sang ÅO (2017) Impacts of climate change on urban areas and nature-based solutions for adaptation: Theory and practice of urban sustainability transitions. Part I (2). (ed. by D Loorbach, H Shiroyama, JM Wittmayer, J Fujino & S Mizuguchi) Springer International Publishing AG, Switzerland, pp. 15–27. doi:10.1007/978-3-319-56091-5_2.
Evans DL, Falagán N, Hardman CA, Kourmpetli S, Liu L, Mead BR & Davies JAC (2022) Ecosystem service delivery by urban agriculture and green infrastructure–a systematic review. Ecosystem Services 54: 101405. doi:10.1016/j.ecoser.2022.101405.
Francini A, Romano D, Toscano S & Ferrante A (2022) The contribution of ornamental plants to urban ecosystem services. Earth 3: 1258–1274. doi:10.3390/earth3040071.
Gallo EL, Lohse KA, Brooks PD, Mcintosh JC, Meixner T & Mclain JET (2012) Quantifying the effects of stream channels on storm water quality in a semi-arid urban environment. Journal of Hydrology 470–471: 98–110. doi:10.1016/j.jhydrol.2012.08.047.
Gómez-Baggethun EG & Barton D (2013) Classifying and valuing ecosystem services for urban planning. Ecological Economics 86: 235–245. doi:10.1016/j.ecolecon.2012.08.019.
Gómez-Baggethun E, Gren Å, Barton DN, Langemeyer J, McPhearson T, O’Farrell P, Andersson E, Hamstead Z & Kremer P (2013) Urban ecosystem services: Urbanization, biodiversity and ecosystem services: Challenges and opportunities (ed. by T Elmqvist, M Fragkias, J Goodness, B Güneralp, PJ Marcotullio, RI McDonald, S Par-

nell, M Schewenius, M Sendstad, KC Seto & C Wilkinson) Springer, Dordrecht, pp. 175–251. doi:10.1007/978-94-007-7088-1_11.

Güzel EG (2023) Urban habitat trees: the case of Ordu urban cemeteries. Ordu University Institute of Natural and Applied Sciences (Master's thesis).

Hammer Ø, Harper DAT & Ryan PD (2001) PAST palaeontological statistics. https://www.uv.es/pardomv/pe/2001_1/past/pastprog/past.pdf.

Johannsmeier MF (2016) Beeplants of South Africa. Sources of nectar, pollen, honeydew and propolis-for honeybees. Pretoria. Strelitzia 37. South AfricanNational Biodiversity Institute.

Kabisch N, Korn H, Stadler J & Bonn A (2017) Nature-based solutions to climate change adaptation in urban areas—Linkages between science, policy and practice: Theory and practice of urban sustainability transitions (ed. by D Loorbach, H Shiroyama, JM Wittmayer, J Fujino & S Mizuguchi) Springer International Publishing AG, Switzerland, pp. 1–11.

Karaşah B & Sarı D (2018) An effective component in the urban identity: native plants. Social Sciences Studies Journal 4: 5539–5545.

Kiss M, Takács Á, Pogácsás R & Gulyás Á (2015) The role of ecosystem services in climate and air quality in urban areas: Evaluating carbon sequestration and air pollution removal by street and park trees in Szeged (Hungary). Moravian Geographical Reports 23: 36–46. doi:10.1515/mgr-2015-0016.

Kim G (2016) Assessing urban forest structure, ecosystem services, and economic benefits on Vacant Land. Sustainability 8: 679. doi:10.3390/su8070679.

Kremer P, Andersson E, McPhearson T & Elmqvist T (2015) Advancing the frontier of urban ecosystem services research. Ecosystem Services 12: 149–151. doi:10.1016/j.ecoser.2015.01.008.

Laille P, Provendier D, Colson F & Salanié J (2013) The benefits of urban vegetation, a study of the scientific research and method of analysis. Plante & Cité, Angers.

Le Pape P, Ayrault S & Quantin C (2012) Trace element behavior and partition versus urbanization gradient in an urban river (Orge River, France). Journal of Hydrology 472–473: 99–110. doi:10.1016/j.jhydrol.2012.09.042.

Martí E, Fisher SG, Schade JD & Grimm NB (2000) Flood frequency and stream–riparian linkages in arid lands. In Streams and ground waters. Academic Press, pp. 111–136. doi:10.1016/b978-012389845-6/50005-3.

MEA (2005) Millenium ecosystem assessment, ecosystems and human well-being: synthesis. Washington DC: Island Press.

Meerow S, Newell JP & Stults M (2016) Defining urban resilience: a review. Landscape and Urban Planning 147: 38–49. doi:10.1016/j.landurbplan.2015.11.011.

Pardee GL & Philpott SM (2014) Native plants are the bee's knees: local and landscape predictors of bee richness and abundance in backyard gardens. Urban Ecosystems 17: 641–659. doi:10.1007/s11252-014-0349-0.

Pekin Timur U (2012) Planting children's playgrounds: Çankırı city case. Journal of Food, Agriculture and Environment 10: 977–981.

PFAF (2023) Plants for a future, Database. https://pfaf.org/user/.

Rahman MA, Armson D & Ennos AR (2015) A comparison of the growth and cooling effectiveness of five commonly planted urban tree species. Urban Ecosystem 18: 371–389. doi:10.1007/s11252-014-0407-7.

Roman LA, Conway TM, Eisenman TS, Koeser AK, Ordóñez Barona C, Locke DH, Jenerette GD, Östberg J & Vogt J (2021) Beyond 'trees are good': Disservices, management costs, and tradeoffs in urban forestry. Ambio 50: 615–630 doi:10.1007/s13280-020-01396-8.

Roy S, Byrne J & Pickering C (2012) A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. Urban Forestry & Urban Greening 11: 351–363. doi:10.1016/j.ufug.2012.06.006.

Sarı D & Karaşah B (2023) Ecosystem services provided by woody landscape plants in campuses: the case of AÇU Seyitler Campus. Artvin Çoruh University Journal of Forestry Faculty 24: 129–139.

Sarı D, Kurt U, Resne Y & Çorbaci ÖL (2020) Ecosystem services provided by tree species used in urban parks: case of Rize Mesut Yılmaz (Coast) Park. Journal of Anatolian Environmental and Animal Sciences 5: 541–550. doi:10.35229/jaes.774967.

Sarukhán J & Whyte A (2005) Ecosystems and human well-being: Synthesis (Millennium Ecosystem Assessment). Island Press, World Resources Institute, Washington, DC., USA.

Schewenius M, McPhearson T & Elmqvist T (2014) Opportunities for increasing resilience and sustainability of urban social-ecological systems: insights from the URBES and the cities and biodiversity outlook projects. Ambio 43: 434–444. doi:10.1007/s13280-014-0505-z.

Scholz T, Hof A & Schmitt T (2018) Cooling effects and regulating ecosystem services provided by urban trees—Novel analysis approaches using urban tree cadastre data. Sustainability 10: 712. doi:10.3390/su10030712.

Somme L, Moquet L, Quinet M, Vanderplanck M, Michez D, Lognay G & Jacquemart AL (2016) Food in a row: urban trees offer valuable floral resources to pollinating insects. Urban Ecosystems 19: 1149–1161. doi:10.1007/s11252-016-0555-z.

Spronken-Smith R & Oke T (1998) The thermal regime of urban parks in two cities with different summer Climates. International Journal of Remote Sensing, 19: 2085–2104. doi:10.1080/014311698214884.

TEEB (2010) Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation. http://www.teebweb.org/wpcontent/uploads/2013/04/D0-Chapter-1-Integratingthe-ecological-and-economic-dimensions-inbiodiversity-and-ecosystem-service valuation.pdf.

Torbay (2013) Tree and woodland framework for Torbay. https://www.torbay.gov.uk/media/2948/tree-andwoodland-framework.pdf.

Wang HF, Lopez-Pujol J, Meyerson AL, Qiu J, Wang X & Ouyang Z (2011) Biological invasions in rapidly urbanizing areas: a case study of Beijing, China. Biodiversity and Conservation 20: 2483–2509. doi:10.1007/s10531-011-9999-x.

WFO (2023) World flora online plant list. https://wfoplantlist.org/plant-list/taxon/.

Yu P, Zhang S, Yung EH, Chan EH, Luan B & Chen Y (2023) On the urban compactness to ecosystem services in a rapidly urbanising metropolitan area: Highlighting scale effects and spatial non–stationary. Environmental Impact Assessment Reviev 98: 10697. doi:10.1016/j.eiar.2022.106975.