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Impact of Change in Tree Canopy Cover on Ecosystem Services in Desert Cities: A Case in Phoenix, USA

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Abstract

The study aims to answer the question of how the change in tree canopy cover in desert cities due to the urbanization process affects ecosystem services. The city of Phoenix, which is located in the northern part of the Sonoran Desert in the southwestern United States, was determined as the study area. The i-tree canopy software was used to assess the 20-year (2004-2023) change in the tree canopy cover of the Phoenix and to calculate the ecosystem services and benefits obtained from trees. The findings show that the tree canopy cover in the study area decreased by 58.26 km^2 (4.34%) in 20 years. Therefore, the amount of carbon sequestration, the rate of removing air pollution, and the hydrological benefit values of trees decreased. The results obtained from the study will contribute to decision-makers and planners in urban planning processes in regions with similar ecological characteristics.

Keywords: *Urbanization, ecosystem services, desert city, i-tree canopy.*

Ağaç Kanopi Örtüsündeki Değişimin Çöl Kentlerindeki Ekosistem Hizmetleri Üzerine Etkisi: Phoenix, ABD Şehri Örneği

Öz

Çalışma, kentleşme sürecine bağlı olarak çöl kentlerindeki ağaç örtüsünde meydana gelen değişimin ekosistem hizmetlerini nasıl etkilediği sorusuna cevap bulmayı amaçlamaktadır. Bu kapsamda Amerika Birleşik Devletleri'nin güneybatısındaki Sonoran Çölü'nün kuzey kesiminde yer alan Phoenix şehri çalışma alanı olarak belirlenmiştir. Phoenix'in ağaç örtüsündeki 20 yıllık (2004-2023) değişimi değerlendirmek ve ağaçların ekosistem hizmetlerini ve ekonomik fayda değerlerini hesaplamak için i-tree canopy yazılımı kullanılmıştır. Çalışmanın bulguları çalışma alanındaki ağaç örtüsünün 20 yılda 58,26 km^2 (%4,34) azaldığını göstermektedir. Buna bağlı olarak ağaçların karbon tutma miktarı, hava kirliliğini giderme oranı ve hidrolojik fayda değerleri azalmıştır. Çalışmadan elde edilen sonuçlar, benzer ekolojik özelliklere sahip bölgelerdeki kentsel planlama süreçlerinde karar vericilere ve planlamacılara katkı sağlayacaktır.

Anahtar kelimeler: *Kentleşme, ekosistem hizmetleri, çöl kenti, i-tree canopy.*

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1. Introduction

Ecosystems are a whole in which each component is interdependent and interacts with each other (Yılmaz Kaya & Uzun, 2019). Ecosystems provide many benefits to humans and other living things in their environments (Dinç, 2023). These benefits, which occur as part of the natural processes that continue in ecosystems, are defined as ecosystem services. Regulatory ecosystem services provided by ecosystems have an important role in reducing the impacts of climate change in cities and increasing the resilience of cities against these impacts (Tzoulas et al., 2007; Hansen et al., 2019). Among the services that ecosystems provide as regulators; are improvement of air and soil quality, climate regulation, mitigation of natural disasters such as floods and landslides, disease control, water purification, waste management, pollination/pollination, biodegradation or control of harmful species, etc. (Benedict & McMahon, 2002; Davis et al., 2009; Pugh et al., 2012; Wagner & Breil, 2013; Eckart et al., 2017). However, in the last quarter century, natural areas are being damaged and forests, agricultural, and wetlands areas are decreasing or disappearing due to rapidly increasing urbanization and population density in the world (Liu et al., 2023; Esendağlı & Selim, 2024; Moazzam & Lee, 2024). Thus, these changes in land cover and land use over time lead to degradation and damage of ecosystems at local and regional levels.

The green areas in cities including parks, recreation areas, urban forests and agricultural areas are land uses that provide important ecosystem services (Eyileten et al., 2022; Çakır & Gül, 2024). The vegetation in these areas contributes to the sustainability of ecosystem services such as reducing air pollution, controlling rainwater, storing carbon, reducing land surface temperature, providing bioclimatic comfort and protecting biodiversity (Ekwe et al., 2021; Tuğluer & Çakır, 2021; Dadashpoor et al., 2024). Especially in desert cities, trees are of great importance because they reduce the reach of solar radiation to the land surface, provide a cooling effect on the urban environment through evaporation and transpiration, and are home to many living species (Wang et al.; 2018; Yu et al., 2020; Shahfahad et al., 2022).

There are various mathematical methods for quantifying the ecosystem services provided by trees (Ahern et al., 2014). One of these methods is the “i-tree canopy model”, which is based on tree canopy cover to calculate the benefits of trees for ecosystem services such as air pollution, hydrological impacts and carbon balance. This model is used to obtain statistical data on the benefits of trees to the ecosystem and to calculate the economic value of these ecosystem services to the region (Coşkun Hepcan & Hepcan, 2017; Ersoy Tonyaloğlu & Atak, 2021; Alpaidze & Salukvadze, 2023). In this context, the i-tree canopy software was developed by the U.S. Department of Agriculture Forest Service to create the necessary data infrastructure and perform statistical analyses (Cakmak & Can, 2020). Thus, the measurement and calculation of tree canopy cover, which is difficult and costly to measure through software, has become both economical and faster (Parmehr et al., 2016; Riemann et al., 2016; Atasoy, 2020).

It is observed that i-Tree Canopy software has been used in many of the recent academic studies on mapping tree canopy cover and estimating ecosystem services. In this context, the study conducted by Ersoy Tonyaloğlu and Atak (2021) in Aydın/Turkey has evaluated the effects of land cover change on urban tree cover and the ecosystem services they provide in the case of Efeler District of Aydın Province between 2004-2021. Costemalle et al. (2023) estimated the ecosystem services provided by urban and peri-urban forests of Juiz de Fora/Brazil. In Suwon, Republic of Korea, Kim and Kang (2022) assessed the impact of the change in tree canopy on ecosystem services between 2003 and 2021. They evaluated the contribution of green roofs to the ecosystem services of the tree canopy. Atasoy (2020) estimated urban tree cover and impervious surface cover density using i-tree canopy software and assessed how these affect forest gain and loss in Turkey. Tbilisi's green cover was estimated and surface cover classes, volumes and ecosystem services were determined by Alpaidze and Salukvadze (2023). While evaluating the impact of residential cover and urban growth form on runoff in urban areas, Xu et al. (2020) quantified the surface cover characteristics of Munich/Germany through 'i-Tree Canopy' based on high-resolution aerial imagery. The i-tree canopy software was utilized to determine the regulatory ecosystem services for improving air quality in Ankara/Turkey by Cakmak and Can

(2020), to measure the ecosystem services of Mirador Sur Park/Santo Domingo park by Mancebo and Liz (2022), and to determine the benefits of urban trees for improving air quality in Curitiba and São Paulo cities of Brazil by Ribeiro et al. (2023). Moreover, Tülek (2022) evaluated the contribution of the vegetation cover of trees and shrubs in Wageningen/Netherlands to regulatory ecosystem services for air quality improvement.

The impact of urbanization on ecosystem services and ecological structure depends on the climatic conditions of the region, even if the land uses of the regions are similar. Because, there are significant differences between the natural land cover in humid regions with heavy rainfall and the natural land cover in desert cities. Therefore, the impact of urbanization in desert cities and the ecosystem benefits provided by natural vegetation are not similar to those in regions with other climate types.

The Earth's surface is about 29% covered by land and about 33% of this land surface is covered by deserts (Alsharif et al., 2020). Therefore, understanding the functions, global roles and values of deserts and managing them sustainably is important for biodiversity, geodiversity and ecosystem services (United Nations, 2010; Durant et al., 2012; Lortie et al., 2020). Major deserts in the world are distributed in the Sahara, Arabian Peninsula, Western Asia, Southwest Africa, Central and Southern Australia, Argentina, Southwestern United States and Northern Mexico (Keith et al., 2020). In this context, Phoenix, which is located in the northern part of the Sonoran Desert in the southwestern United States and is the hottest city in America, was determined as the study area. The study aims to answer the question of how the change in tree cover due to the urbanization process affects ecosystem services and what its economic value is.

2. Material and Method

2.1. Study Area

The City of Phoenix, located at the northern edge of the Sonoran Desert and the capital of the state of Arizona, is determined as the study area. Its latitude and longitude coordinates are 33.448376 and -112.074036 respectively (Anonymous, 2024). Although much older than its colonial founding, European settlers founded Phoenix in 1867 as an agricultural community and it became a city in 1881 (Figure 1). In 1889, Phoenix became the capital of Arizona. Especially until the 2nd half of the 20th century, agricultural activities were the main source of income for the region. Phoenix had a low population growth rate for many years. However, the development of air conditioning along with other technologies has led to rapid population growth and urbanization in recent years (Falcone et al., 2020; Helmrich et al., 2023; Olgun et al., 2024a).

Figure 1. Aerial view of downtown Phoenix, Arizona (Kwak, 2016)

Phoenix is the most populous city in the state of Arizona, with 1,608,139 residents as of 2020. The female population living in the region is 49.7% of the city's population. The city's population consists of 25.3% of people under the age of 18 and 11.1% of people aged 65 and over. Moreover, 42.7% of the population is Hispanic (U.S. Census Bureau, 2020).

Phoenix has a subtropical desert climate with very hot and dry summers and mild winters. Therefore, it is one of the hottest regions in the United States (Arizona State Climate Office, 2023). The average temperature in Phoenix exceeds 38 °C for 110 days during the year and reaches 43 °C or higher for 18 days (Zhang et al., 2017). The average annual rainfall is approximately 210.82 mm. Most of the rainfall occurs during the winter season and the summer monsoon season (Meerow et al., 2021; Helmrich et al., 2023; National Weather Service, 2023). Due to the rapid urbanization in Phoenix over the last 50 years, the average daily air temperature has increased by 3.1°C and the night minimum temperature by 5°C (Brazel et al., 2000). Studies have shown that the urban heat island effect will increase in the next decades due to climate change and increasing urbanization, and water withdrawals will also occur (Zhang et al., 2017; Dinç, 2024) (Figure 2).

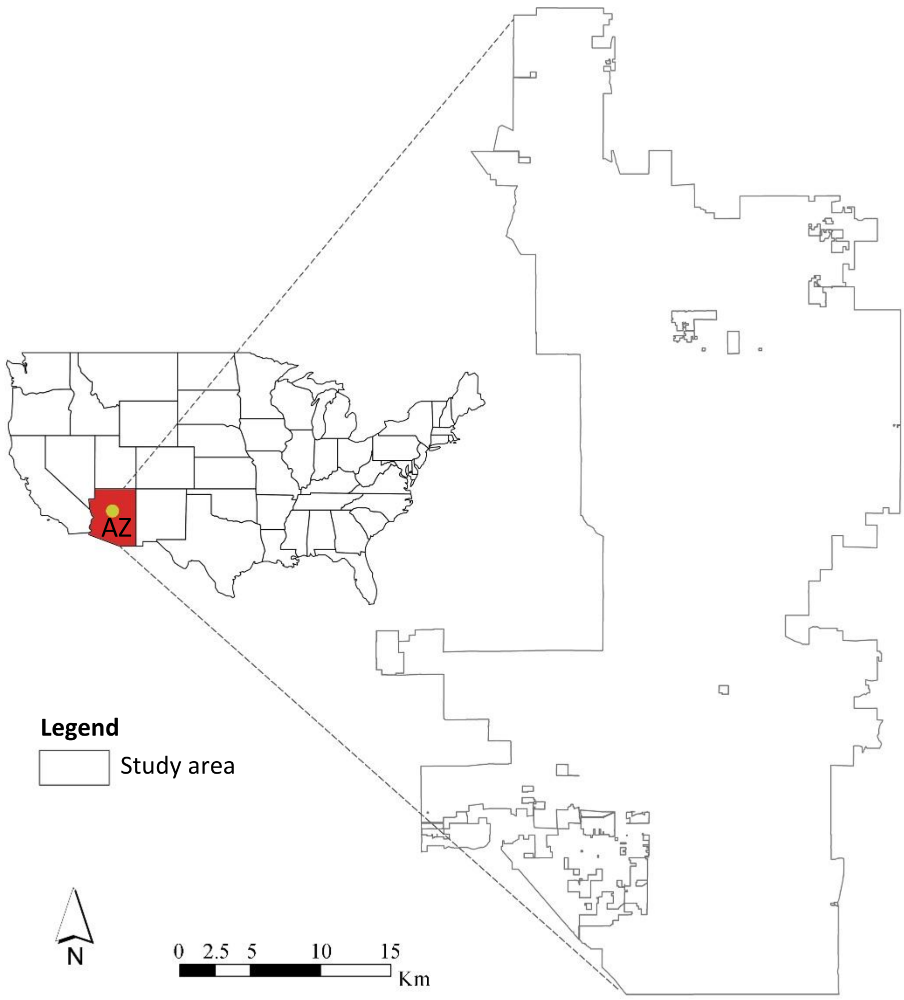

Figure 2. Map of the study area boundary in Phoenix, AZ, USA (Olgun et al., 2024a)

2.2. Method

The study was carried out in 3 stages. In the first stage of the study, the literature on the study topic and the study area was reviewed and systematically evaluated. In the second stage of the study, the land cover in the study area was classified using a random point sampling approach using satellite images from 2004 and 2023. Then, the percentage of land cover types, ecosystem services (carbon storage and sequestration, air pollution removal and hydrological benefits) and economic benefits of trees were statistically calculated for two different years. In the last stage of the study, the results obtained were evaluated and recommendations were developed.

The i-Tree Canopy 7.1 software, originally designed by the USDA Forest Service and later updated by The Davey Tree Expert Company, was used to assess tree cover in the study area. This tool uses current Google Maps aerial imagery to assess land cover. Several land cover types were identified in the study, including Tree, Grass/Herbaceous, Impervious Buildings, Impervious Road, Impervious Other, Bare

Land Cover and Water (Table 1). The software then randomly placed points in the study area and the researcher classified each point according to the respective land cover type.

Table 1. Cover classes used for land cover assessment (i-Tree Canopy, 2024)

Abbr.	Cover Class	Description
T	Tree	This cover class is used to identify plants with canopy cover
H	Grass/Herbaceous	This cover class is used to define areas covered with grass or ground cover vegetation
IB	Impervious Buildings	This cover class is used to define buildings.
IR	Impervious Road	This cover class is used to define roads (streets, sidewalks or other paved surfaces).
IO	Impervious Other	This cover class includes areas with other impervious surfaces excluding buildings and roads.
S	Soil/Bare Ground	This cover class is used to define soil, non-tree, non-grass/crops
W	Water	This cover class is used to define water body

Approximately 500-1000 survey points are recommended by software developers to assess any region (i-Tree Canopy, 2024). Endreny et al. (2017) state that 500 random points are adequate to survey megacities. In the study carried out by Doick et al. (2017) in the UK, the survey points were determined according to the spatial sizes. It was determined as 400 survey points for areas under 600 ha, 500 survey points for 600-10000 ha, 1000 survey points for areas over 10000 ha, and 3000 survey points for much larger areas. Moreover, Selim et al. (2023) found that 760±32 survey points were sufficient for a 1 ha area and that more than 800 survey points in any area made no statistically significant difference. However, increasing the survey points is important to increase the accuracy of land cover estimation (Parmehr et al., 2016). Therefore, a total of 3000 survey points were assigned throughout the study area (Figure 3).

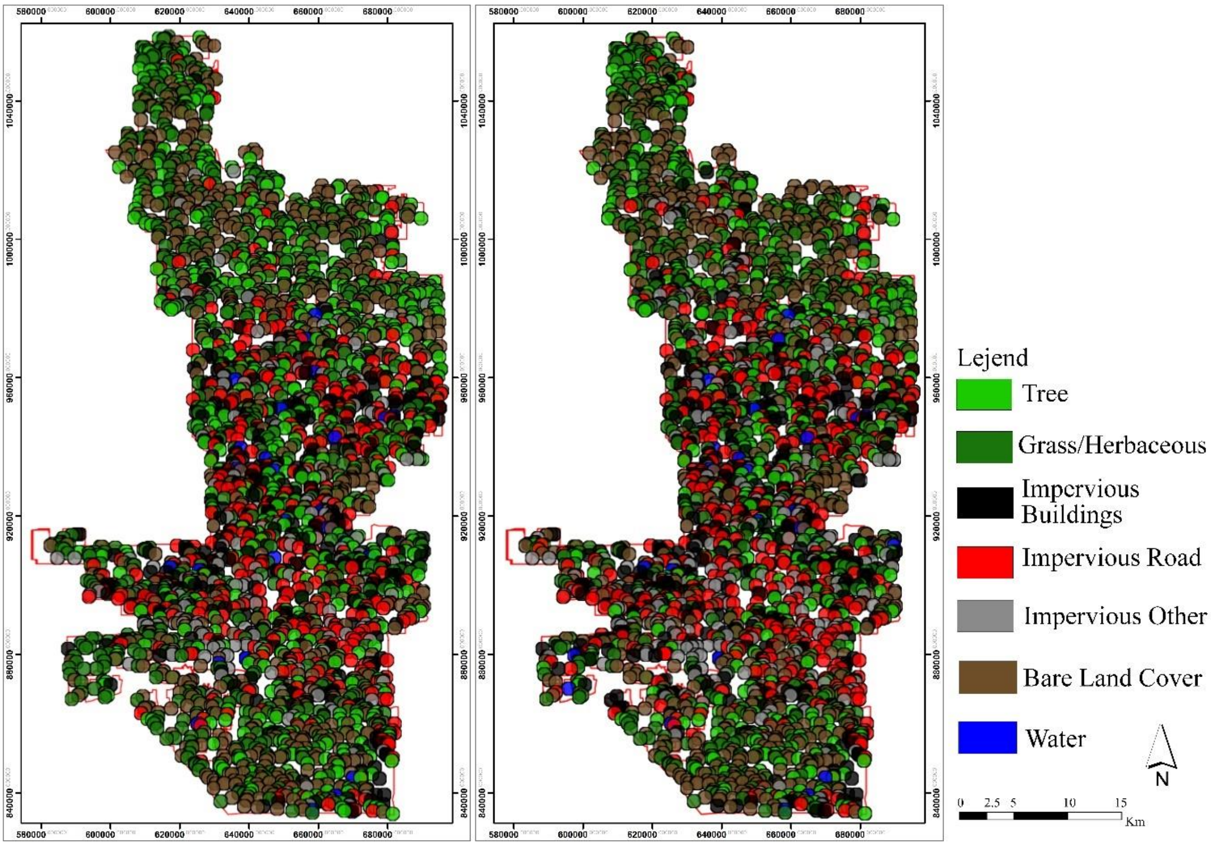

Figure 3. Map of the study area boundary in Phoenix, AZ, USA (Prepared by authors)

To calculate the percent tree cover and Standard Error (SE) using Eq. 1 (i-Tree Canopy, 2024).

$p = n/N \quad q = 1 - p \quad SE = \sqrt{(pq/N)}$ (1)

Where; N represents the total number of sampled points, n represents the total number of points identified as trees.

After determining the current land cover, Google Earth Pro software was used to classify the past land cover. In this context, the geographical coordinates of the existing measurement points were transferred to Google Earth Pro software without changing them. In the software, the land cover classes of the study area in 2004 were compared with 2023. If there was a change in land cover, this change was recorded in the database of i-tree canopy software. Following the 2004 and 2023 land cover classifications, tree benefit values (air pollution benefits, hydrological benefits and carbon benefits) were calculated. The coefficients used in the calculation of tree benefit values differ by region. Therefore, the location of the study area was defined in the program. Then, the benefit values of the tree cover in the study area for 2 periods were calculated through the coefficients defined by region.

3. Findings and Discussion

Increasing population growth in cities and the related increasing rate of urbanization cause changes in the land cover of cities. In the study area, which has a surface area of 1344.56 km^2, the largest land cover was soil in 2023 (368.86 ± 10.95 km^2, 27.43 ± 0.81%) and 2004 (376.03 ± 11.02 km^2, 27.97 ± 0.82%). Tree canopy cover was 15.13 ± 0.65% (203.48 ± 8.80 km^2) in 2023 and it was 19.47 ± 0.72% (261.74 ± 9.72 km^2) in 2004. Tree canopy cover in the study area decreased by 58.26 km^2 (4.34%) over a 20-year period (Table 2).

Table 2. Distribution of land cover classes for 2004 and 2023

Cover Class	2004			2023		
	Points	% Cover ± SE	Area (km²) ± SE	Points	% Cover ± SE	Area (km²) ± SE
T	584	19.47 ± 0.72	261.74 ± 9.72	454	15.13 ± 0.65	203.48 ± 8.80
H	581	19.37 ± 0.72	260.40 ± 9.70	467	15.57 ± 0.66	209.30 ± 8.90
IB	330	11.00 ± 0.57	147.90 ± 7.68	422	14.07 ± 0.63	189.14 ± 8.53
IR	433	14.43 ± 0.64	194.07 ± 8.63	498	16.60 ± 0.68	223.20 ± 9.13
IO	203	6.77 ± 0.46	90.98 ± 6.17	307	10.23 ± 0.55	137.59 ± 7.44
S	839	27.97 ± 0.82	376.03 ± 11.02	823	27.43 ± 0.81	368.86 ± 10.95
W	30	1.00 ± 0.18	13.45 ± 2.44	29	0.97 ± 0.18	13.00 ± 2.40
Total	3000	100.00	1344.56	3000	100.00	1344.56

3.1. Ecosystem services

3.1.1. Carbon storage and sequestration

One of the main causes of climate change and global warming is carbon emissions from activities including deforestation, transportation, industry, and urbanization. Emissions of carbon trap heat, leading to ozone depletion, air pollution, global warming, and ecological destruction. More than 70% of the anthropogenic carbon dioxide (CO_2) emissions that result in greenhouse gasses are emitted by cities, according to studies. However, the effects of these gases are reduced by carbon sinks such soils, forests, and oceans (Hu et al., 2018; Han et al., 2020; Sandoval et al., 2023). Since they store carbon as biomass and use photosynthesis to convert carbon dioxide (CO_2) into oxygen, trees in particular help to mitigate the effects of carbon emissions (Letter & Jäger, 2020).

The amount of carbon and equivalent CO_2 stored by trees, as well as the annual carbon and equivalent CO_2 sequestration in 2023, decreased compared to 2004. In 2004, trees sequestering 92.66 kt of carbon (339.74 CO_2 Equiv.) annually provided $17,419,421 of added value to the city economy. However, in 2023, trees sequestering 72.03 kt of carbon (264.11 CO_2 Equiv.) annually provided

$13,541,810 of added value to the city's economy. Additionally, while in 2004, trees stored 2,011.43 kt of carbon (7,375.26 kt CO_2 Equiv.) and added $378,149,465 to the city's economy, in 2023 they stored 1,563.68 kt of carbon (5,733.50 kt CO_2 Equiv.) and added $293,972,358 to the city's economy (Table 3).

Table 3. The amount of C and CO_2 sequestered and stored by trees and their economic value

Description	Carbon (kt ± SE)		CO_2 Equiv. (kt ± SE)		Value ($ ± SE)	
	2004	2023	2004	2023	2004	2023
Sequestered annually in trees	92.66±3.44	72.03±3.11	339.74±12.62	264.11±11.42	$17,419,421±646,867	$13,541,810±585,487
Stored in trees*	2,011.43±74.69	1,563.68±67.61	7,375.26±273.88	5,733.50±247.89	$378,149,465±14,042,515	$293,972,358±12,710,047

*Note: this benefit is not an annual rate. Amount sequestered is based on 0.354 kt of Carbon, or 1.298 kt of CO_2, per km²/yr. Amount stored is based on 7.685 kt of Carbon, or 28.178 kt of CO_2, per km². Value (USD) is based on $188,000.00/kt of Carbon, or $51,272.73/kt of CO_2. (Metric units: kt = kilotonnes, metric kilotons, km^2 = square kilometers).

Trees offer numerous indirect benefits to cities, in addition to their ecological and economic advantages. For instance, the study area's climate leads to the frequent use of cooling systems throughout much of the year. This high energy demand increases carbon emissions, harming the environment and causing economic strain. By implementing energy-efficient landscape designs with strategic tree planting, the need for cooling systems can be reduced, leading to savings on electricity costs ranging from $4 to $166 per tree each year (Song et al., 2018; Oliveira et al., 2022).

3.1.2. Air pollution removal

Air pollutants and greenhouse gas emissions affect human health, productivity of agricultural crops, disruption of ecological balance, reduced rainfall and increased air temperature (Guerreiro et al., 2014; Oliveira et al., 2022). Trees play a sustainable and effective role in mitigating these air pollution and greenhouse gas emissions that increase with urbanization and industrialization (Letter & Jäger, 2020).

Using i-tree canopy 7.1 software, the annual amount of air pollution removed by trees and its contribution to the economic value of the region were calculated for the years 2004 and 2023. Air pollutants considered are Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ozone (O_3), Sulfur Dioxide (SO_2), Particulate Matter less than 2.5 microns ($PM_{2.5}$) and Particulate Matter greater than 2.5 microns and less than 10 microns (PM_{10}).

In 2004, the study area's trees removed 2,328.71 t of air pollution, providing $1,690,728 in value to the city's economy each year. Nevertheless, the decrease in tree canopy cover by 58.26 km^2 over the 20-year period resulted in a decrease of 518.37 t of air pollution removed by trees and a decrease of $376,361 in the contribution to the city economy. In both 2004 (1,316.51 tons) and 2023 (1,023.45 tons), trees removed the most ozone pollution. This was followed by the removal of PM_{10}, NO_2, SO_2, CO, and $PM_{2.5}$ air pollutants (Table 4).

Table 4. The amount and economic value of air pollution removed by trees annually

Abbr.	2004				2023			
	Amount (t)	**±SE**	**Value (USD)**	**±SE**	**Amount (t)**	**±SE**	**Value (USD)**	**±SE**
CO	40.86	±1.52	$10,556	±392	31.76	±1.37	$8,207	±355
NO_2	144.53	±5.37	$14,487	±538	112.36	±4.86	$11,262	±487
O_3	1,316.51	±48.89	$312,447	±11,603	1,023.45	±44.25	$242,895	±10,502
SO_2	47.09	±1.75	$707	±26	36.61	±1.58	$549	±24
$PM_{2.5}$	15.40	±0.57	$566,834	±21,049	11.98	±0.52	$440,655	±19,052

PM_{10}*	764.32	±28.38	$785,697	±29,177	594.18	±25.69	$610,799	±26,408
Total	2,328.71	±86.48	$1,690,728	±62,785	1,810.34	±78.27	$1,314,367	±56,827

Air Pollution Estimates are based on these values in t/km²/yr and $/t/yr: CO 0.156 and $258.38 | NO_2 0.552 and $100.23 | O_3 5.030 and $237.33 | SO_2 0.180 and $15.01 | $PM_{2.5}$ 0.059 and $36,797.65 | PM_{10}* 2.920 and $1,027.97 (Metric units: t =tonnes, metric tons, km² = square kilometers)

3.1.3. Hydrological benefits

Impervious surfaces (buildings, roads, etc.) are one of the major factors impacting the hydrological structure of cities. Because impervious surfaces reduce the infiltration of water and increase surface runoff. Thus, the quality of water decreases due to surface runoff, the groundwaters are not supplied and flood disasters may occur. However, the vegetation in cities reduces the surface runoff of stormwater through permeable surfaces and allows water to infiltrate into the soil without contamination (Kim & Coseo, 2018). Phoenix is not a city that has intense precipitation throughout the year due to its location in an arid region. However, at certain times of the year, instantaneous heavy rainfall causes floods (Meerow et al., 2021; Helmrich et al., 2023; National Weather Service, 2023). Therefore, trees and green spaces are needed to reduce flash flooding in areas with a high density of impervious surfaces, to recharge groundwater, and to relieve the burden of gray infrastructure.

Reduced tree canopy cover and an increase in the percentage of impervious surface have led to a decrease in added value to the region's economy of $129,533 and a decrease of 54.87 Ml in avoided runoff (AVRO). With a decrease in tree canopy cover, so did the amount of hydrological benefits (Ml) that trees provided, such as transpiration (T), potential evapotranspiration (PET), evaporation (E), interception (I), and transpiration (T). However, it was not possible to calculate the additional value of these hydrological benefits to the region's economy because the monetary value multipliers of the yearly Ml the amount of these benefits were uncertain (Table 5).

Table 5. The amount and economic value of hydrological benefits provided by trees annually

Abbr.	2004				2023			
	Amount (Ml)	**±SE**	**Value (USD)**	**±SE**	**Amount (Ml)**	**±SE**	**Value (USD)**	**±SE**
AVRO	246.50	±9.15	$581,905	±21,609	191.63	±8.29	$452,372	±19,559
E	6,005.89	±223.03	N/A	N/A	4,668.96	±201.87	N/A	N/A
I	6,013.70	±223.32	N/A	N/A	4,675.03	±202.13	N/A	N/A
T	76,263.48	±2,832.03	N/A	N/A	59,287.02	±2,563.31	N/A	N/A
PE	246,037.84	±9,136.57	N/A	N/A	191,269.14	±8,269.62	N/A	N/A
PET	208,738.85	±7,751.48	N/A	N/A	162,273.01	±7,015.96	N/A	N/A

Hydrological Estimates are based on these values in Ml/km²/yr and $/Ml/yr: AVRO 0.942 and $2,360.64 | E 22.946 | I 22.976 | T 291.369 | PE 940.003 | PET 797.500 (Metric units: Ml = megaliters, km² = square kilometers)

Trees are one of the most important keystone structures for the sustainability of ecosystem services in the City of Phoenix. However, due to the scarcity of water resources in the study area, located in an arid desert city, the selection and positioning of tree species should be carefully considered. Otherwise, overconsumption of water leads to high economic costs for local governments and deterioration of the ecological structure (Gage & Cooper, 2017). Therefore, preferring arid-tolerant tree species (low-water-use trees) in afforestation projects will make a significant contribution to the sustainability of ecosystem services and water conservation (Olgun et al., 2024b).

4. Conclusion

Today, rapidly increasing urbanization has caused more negative effects of climate change to be felt. Because, population density and the expansion of urban areas have led to the emergence of problems that negatively affect human health and comfort, such as deterioration of the natural structure, increase in the urban heat island effect, deterioration of air quality, insufficient water resources, and climate injustice. Therefore, the ecosystem services provided by trees have become much more important in urban areas, particularly in this century.

The natural structure of the city of Phoenix, located in the north of the Sonoran desert, has the characteristics of a desert ecosystem. However, due to population growth and urbanization in the region over the last 20 years, there has been an increase in impervious surfaces and a decrease in tree cover. For this reason, ecosystem services, which are directly related to the presence of trees, have decreased in this process.

To increase the ecosystem services provided by trees in Phoenix, it is necessary to promote tree cover throughout the city. In this context, The Tree and Shade Master Plan was prepared by the City of Phoenix, which aims to increase the amount of green space in the city (The City of Phoenix, 2010). This master plan focuses on increasing the tree canopy from 10% to 25% by 2030. Moreover, with the increase in tree canopy cover, the planning of the green infrastructure system throughout the city will increase the benefit value of ecosystem services.

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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 Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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