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Editorial

Urban Forest and Urban Microclimate

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1. Introduction

Urban environments are challenging places for urban greenspaces, especially for trees, which have the greatest impact on ecosystem service provisions. High temperatures and high levels of radiation, reduced water availability, limited above- and below-ground growing space, and high levels of pollutants are just some of the challenges urban greenspaces are facing and are expected to face more frequently in the near future [1–5]. In addition to these site conditions, cities themselves are often warmer than their rural surroundings due to the urban heat island effect [6–8]. Future climate change and increasing urbanization are expected to significantly exacerbate the UHI effect and its associated environmental problems such as changes in local precipitation, the spread of disease from warmer climates, and air pollution [9]. Despite these conditions, urban greening is still one of the most feasible strategies to address major urban challenges: urban greening can be considered a nature-based solution to improve quality of life, conserve biodiversity, and enhance climate resilience [10,11]. In particular, urban trees and forests are highly capable of mitigating the urban microclimate and ameliorating the effects of urban heat islands and ongoing climate change [12–14]. They provide cooling through evapotranspiration and shading, store carbon, reduce runoff, and improve air quality.

The provision of ecosystem services is highly dependent on many factors, including climate; the type of urban greening (trees, vertical greening, roof greening, shrubs, etc.); tree species, age, and vitality; as well as the drought tolerance of a species (e.g., [12,15–17]). In addition, the location within a city and surrounding urban structures should be considered when quantifying the provision of ecosystem services by urban greenery. However, knowledge regarding the ecosystem service provision of different types of urban greening and especially urban tree growth in relation to these factors and conditions is still insufficient. There is a great need for such knowledge for the sustainable planning and management of urban greenspaces. Therefore, detailed knowledge of dimensional changes, growth rates, and ecosystem services in urban greenspaces in general as well as urban trees in particular as a function of their age and environmental conditions is needed.

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Citation: Rötzer, T.; Moser-Reischl, A.; Rahman, M.A.; Pauleit, S. Urban Forest and Urban Microclimate. *Forests* **2023**, *14*, 2391. https://doi.org/10.3390/f14122391

Received: 24 April 2023
Accepted: 1 December 2023
Published: 7 December 2023

2. Outline of Urban Forests and the Urban Microclimate

This Special Issue, "Urban Forest and Urban Microclimate", addresses the above-mentioned topics that influence the growth and ecosystem services of urban greenspaces and urban trees, the species characteristics that affect growth patterns and ecosystem service provision, potential sustainable designs of urban trees, and the functions of urban trees in improving the microclimate. Ten research papers form this Special Issue, and they can be divided into the following topics:

(1) Tree growth and vitality assessments across multiple urban space designs using allometric studies;
(2) Benefits of the cooling effects from urban greenspaces at different spatial and temporal scales for indoor and outdoor thermal comfort;

(3) Assessment of hydrology in urban areas and soil properties;
(4) Understanding and mapping urban greenspaces across scales to promote multi-functional landscapes and resilient cities with focus on climate vulnerability and drought tolerance.

The articles by Amer et al. (2023) [18], Franceschi et al. (20122) [19], and Wang et al. (2023) [20] can be classified within the first topic of tree growth assessment, while the articles by Li and Zheng (2022) [21], Bao et al. (2022) [22], and Zhang et al. (2022) [23] deal with ecosystem service provision and thermal comfort. The articles by Schütt et al. (2022) [24] and Liang et al. (2022) [25] can be assigned to the third theme on soil property studies, and the articles by Shu et al. (2022) [26] and Dervishi et al. (2022) [27] address the fourth topic of mapping urban greenspaces as well as drought tolerance analysis. In the following, each study is briefly summarized.

The work of Amer et al. (2023) [18] addresses the allometric relationships between the dimensions of urban trees, their aboveground biomass as carbon stores, and their shading potential. This study is of great interest because it focuses on three typical species growing in the arid city of Jericho, Palestine. The study presents a novel quantitative approach to estimating the ecosystem services of urban trees in arid cities that will be most affected by climate change. Such studies are very important for extending our knowledge base on sustainable urban development. Similarly, the study by Franceschi et al. (2022) [19] also focuses on tree allometry, but in a contrasting temperate climate. The main aspect of this study is the canopy shape of common European urban tree species and its influence on the calculation of canopy volume and the provision of ecosystem services. Franceschi et al. (2022) [19] demonstrated that urban tree crowns are mostly ovoid, but that aspects of the tree's environment, such as buildings in close proximity, can also influence their crown shape. In addition, the work by Wang et al. (2023) [20] addressed the effects of canopy size and shape and tree cover on cooling performance. Using a combination of field experiments and modeling approaches, it was shown that small canopies have better cooling performance than large canopies for the same amount of cover, but these relationships can change with different levels of cover.

In the study by Li and Zheng (2022) [21], the effects of vertical greening on indoor thermal comfort were analyzed using different modeling approaches. Through a more realistic approach, it was shown that vertical greening often does not have as positive an impact on indoor comfort as expected. Therefore, the use of vertical greening should be carefully considered. Bao et al. (2022) [22] conducted another study published in this SI focusing on human thermal comfort. Here, the effects of plant community characteristics on temperature and humidity in urban areas were investigated. The results showed that thermal comfort (i.e., cooling and humidity) is affected by tree canopy density and greenery, as well as by different types of plant communities. Tree–grassland and tree–shrub–grass species had the most significant effects on thermal comfort, so plant communities should be considered when designing parks or urban greenspaces. On the other hand, Zhang et al. (2022) [23] presented a LiDAR approach to study thermal comfort under street trees, which is influenced by the morphological structure of trees and microclimatic factors in the lower canopy. The results show a strong negative correlation between tree structures such as canopy volume, area, and diameter and air temperature, humidity, and brightness, which is also dependent on tree species and canopy shape. Therefore, Zhang et al. (2022) [23] recommended planting tall oval- and peaked-crown tree species with a dense and wide canopy and dense foliage to maximize the effects on the understory microclimate.

In the work of Schütt et al. (2022) [24], the hydrological properties of artificial urban planting soils were investigated. Using an experimental field, different structural soils were tested for their effects on tree growth as well as the influence of tree morphological characteristics on ecosystem service provisions. Urban soils reduced tree growth and thus the provision of ecosystem services. The study suggested that trees with finer rooting systems may be planted in sandy soils, while others may respond to drought stress by reducing their water potential. Liang et al. (2022) [25] also studied the diurnal and seasonal variations in soil heat flux in urban riparian areas. In particular, the relationships between soil heat flux and net radiation were analyzed in relation to different time points, soil moisture levels, and vegetation conditions. The results show a large influence of leaf area index, soil water content, and net radiation on soil heat flux in relation to canopy cover and forest type.

In their paper, Shu et al. (2022) [26] described how to unify urban tree assessment and improve information transfer/communication between different professionals. Using a TIM modeling approach, they showed how tree structure data such as the topological geometry of trunk and branches can be included and how the information can be evaluated and used by other users. Dervishi et al. (2022) [27] conducted a dendrochronological analysis of common urban tree species in Central Europe and showed the influence of climate on tree growth. Overall, trees had 8.3% lower DBH at 100 years of age in dry climates than in wet climates. In general, drought-tolerant tree species showed less or no influence of soil aridity. In contrast, drought-sensitive tree species were negatively affected by a dry climate.

3. Concluding Remarks

The papers published in this Special Issue, "Urban Forest and Urban Microclimate", cover a wide range of topics on growth patterns and drought tolerance, microclimatic effects and thermal comfort, and green management of urban greenery, including urban trees. Geographically, different climatic zones and continents are covered: one study was conducted in the arid climate of the Middle East, three studies in subtropical China, two studies in continental regions of Germany and China, one study with a temperate climate in Germany, and one study covering different climatic zones worldwide as well as a modeling study. Overall, the articles provide information about important aspects of urban green infrastructure and are essential for sustainable green management focusing on thermal comfort and climate adaptation.

Conflicts of Interest: The authors declare no conflict of interest.

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