

Editorial

# The Biodiversity of Urban and Peri-Urban Forests and the Diverse Ecosystem Services They Provide as Socio-Ecological Systems

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**Abstract:** Urban and peri-urban forests provide a variety of ecosystem service benefits for urban society. Recognising and understanding the many human–tree interactions that urban forests provide may be more complex but probably just as important to our urbanised society. This paper introduces four themes that link the studies from across the globe presented in this Special Issue: (1) human–tree interactions; (2) urban tree inequity; (3) carbon sequestration in our own neighbourhoods; and (4) biodiversity of urban forests themselves and the fauna they support. Urban forests can help tackle many of the “wicked problems” that confront our towns and cities and the people that live in them. For urban forests to be accepted as an effective element of any urban adaptation strategy, we need to improve the communication of these ecosystem services and disservices and provide evidence of the benefits provided to urban society and individuals, as well as the biodiversity with which we share our town and cities.

**Keywords:** urban ecology; urban landscape; climate change adaptation; climate change mitigation; tree canopy cover; urban planning

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## 1. Introduction

The term “ecosystem service” is used prodigiously with respect to current urban ecosystems and in urban forest research [1]. These studies often regard ecosystem functions and benefits in an abstract fashion, without connecting with, or considering fully, the human–environment interactions that pervade our urban landscapes. Furthermore, many of these studies frequently refer to ecosystem services without attempting to quantify those services or qualify what enhances—or detracts—from the level of benefits to society. These two issues may be holding back the use of urban trees as a strategy that can help tackle many of the “wicked problems” that urban society faces, such as climate change, community welfare and wellbeing, and biodiversity conservation and management. The aim of this Special Issue is to help fill this void in the current research by focusing on the diversity of urban forests and the benefits (e.g., cultural, environmental, personal, and economic) that different societies across the world gain through the biodiversity and ecological functions that urban and peri-urban forests provide.

This Special Issue was conceptualised by Professor Francisco Escobedo as a means to progress our global discussion of urban forest function using a more social-ecological approach. His proposal for this Special Issue coincided with preparations for the 2nd International Conference on Urban

Tree Diversity, held in Melbourne in February 2016, and co-organised by Stephen Livesley and Justin Morgenroth amongst others. Despite the simple title, this conference aimed to provide a research and management platform to discuss the many “diverse” services and functions that urban trees provide us and our urban landscape. As such, this Special Issue was promoted at that Conference, through our combined research networks and by MDPI itself. We have been able to bring together a large number of international studies covering a wide spectrum of ecosystem services, ecological functions that urban trees and urban forests can provide—from supporting faunal biodiversity to the diversity of urban forests themselves; from urban forests for carbon sequestration to air quality improvements through particulate deposition; from indicators of resilience and health in urban forest planning to socio-economic drivers and inequity in urban forest cover. This Special Issue includes research performed in every continent except Antarctica. These studies originate from the USA, Germany, Canada, Colombia, Sweden, South Korea, Chile, South Africa, Mexico, Italy, and China. We could not have hoped to create a more internationally inclusive and relevant Special Issue, and are very proud to present as Guest Editors this collection of urban forest studies.

## 2. Human–Tree Interactions in an Urbanised Society

Östberg and Kleinschmit [2] describe the role of the media in reporting and maintaining local and national interest in the removal of a significant urban tree in Stockholm, Sweden. This case study highlights the important role of “champions”, be they from the media or private individuals making shrewd use of the media. Changes to urban forests can lead to passionate protest and demand, and this can come from any one of the many stakeholders concerned with the vegetation environment of their local street, neighbourhood, or city. A good way to minimise confusion, anger, and protest is to provide information in advance of tree-related changes, to educate communities and stakeholders on the issues at hand, and to consult and involve them in the high-level planning and decision-making for that change. This has been successfully demonstrated by several cities across the world including the City of Melbourne, through their exhaustive round of neighbourhood workshops to communicate, educate, consult, and co-plan the future of their urban forests [3].

The changing face of urban forest management and consultation is further investigated by Barron et al. [4] in their contribution to the Special Issue that looks at the disconnect between what we as urban forest managers or researchers measure and monitor and what we actually expect or want urban forests to deliver. With greater management and public demands from our urban forests comes the need for clear indicators of performance that can track progress and the success or failure of initiatives and interventions. Barron et al. [4] tackle this issue using the Delphi method to rank issues and indicators that international urban forest managers or researchers regarded as important, followed by targeted interviews with Canadian urban forest professionals. The study noted that many indicators regarded as being of “high importance” are not being measured in many municipal urban forestry programs, particularly social indicators of human health and well-being. This is a real concern for managers seeking (or being asked) to track the efficacy of funded urban forest programs to deliver the socio-ecological and ecosystem service benefits they claim and expect.

## 3. Urban Tree Inequity

It is now widely recognised that there can be considerable inequity within urban society as to access to green space or urban forests and tree cover itself [5]. In this Special Issue, Nesbitt and Meitner [6] assess the correlation between urban vegetation cover in Portland, Oregon, and socio-economic variables collected in the census of the United States. Neighbourhoods of higher population density, lower average household income, and fewer residents identifying as white or Asian had less vegetation cover. This study provides more evidence that green inequity is a very real phenomenon, and future research needs to tackle what impacts this inequity may be having upon physical and mental health and well-being. The approach presented in this study provides a guide that can be used to identify and target areas that need urban forest intervention to address

the stark inequity in urban greening. Escobedo et al. [7] add a temporal level of understanding to this issue of green inequity through a study of spatial and temporal dynamics in Santiago's urban forest over 12 years. Average tree mortality and overall tree basal area remained stable across the city, whereas tree canopy cover and basal area increased in the more affluent suburbs, whilst decreasing in the intermediate- and low-income suburbs. The study further reinforces the observation that green inequity is a universal issue, and a contemporary issue as tree canopy cover is changing now and progressing towards increasingly negative outcomes.

Tackling green inequity will mean conserving the trees and green space that exist, whilst adding new tree plantings and hopefully new green spaces in the areas of our cities that need it most. Widney et al. [8] examine the growth and survival of urban tree planting initiatives in three US cities (Detroit, Indianapolis, and Philadelphia) to model the expected ecosystem service benefits 5 and 10 years in the future. The news is not good, because the current (and accepted) levels of planted tree mortality in these three cities means that these new tree planting initiatives cannot keep up with concurrent mortality and the loss of the larger "legacy" trees already in the urban landscape. Widney et al. [8] make a plea for improved and early intervention measures to raise tree survival rates in those crucial establishment years, so that the social, ecological, and ecosystem service benefits these trees were planted to maintain, if not increase, can be realised.

#### **4. Climate Change Mitigation through Carbon Sequestration in Our Own Neighbourhoods**

Mitigation of global climate change may not be the most recognised function that urban forests can provide for society at a global scale, but there is great regional and local interest in the carbon sequestration potential of urban vegetation systems both above- and below-ground. This is probably because society needs more information so as to become more pro-active and empowered as to how green space and vegetation in "their" landscape can help in some way. In Colombia, Clerici et al. [9] developed a cost-effective method combining high-resolution, remotely sensed imagery classification with ground-truthed plot data to estimate and monitor the above-ground tree biomass and carbon stocks in peri-urban Andean forests. In China, Lv et al. [10] studied above- and below-ground carbon stocks in more than 200 plots and surmised that soil carbon increases in urban green spaces have sequestered an additional 25% on top of that stored above-ground in the existing or planted urban forests of the Harbin City region. In a similar study of South Korean cities that have developed rapidly in recent decades, Yoon et al. [11] were able to estimate soil carbon density in a range of urban green space and forest types and then scale up to make whole-of-city estimates for Seoul, Daegu, and Daejeon.

#### **5. Urban Biodiversity: The Trees Themselves and the Fauna Habitat They Provide**

Interest in maintaining and even enhancing biodiversity within urban landscapes is increasing, not only for the inherent value of biodiversity conservation itself but also because of the tangible societal benefits (e.g., environmental awareness, and the mental health and well-being) realised from viewing and interacting with biodiversity. MacGregor-Fors et al. [12] report on an extensive city-wide study of fauna and flora biodiversity in Mexico covering ten taxonomic groups in a very little studied region of the world. They are able to relate species richness to key size and location traits of the urban green space and forests that they measured. A common and passionate debate that runs throughout urban biodiversity research relates to the use of exotic, native, or indigenous plant species as the cornerstone of faunal biodiversity habitats [13]. In this Special Issue, Shackleton [14] contributes to this debate with a simple but intriguing study of over 1200 street trees in Grahamstown, Eastern Cape, South Africa. Shackleton [14] is able to demonstrate the importance of native trees for bird species richness and abundance. However, at the same time, exotic trees are important for supporting parasitic mistletoes that provide interesting habitats for invertebrates in their own right, and as such, foraging resources to insectivorous animals. This study adds a layer of complexity to the debate of urban forests being "novel ecosystems" and reiterates that the native-and-exotic tree debate in novel urban landscapes is far from black and white. Nitoslawski and Duinker [15] look at the diversity of urban forests themselves,

and again through a native and exotic lens. By assessing the impacts of sub-division development on the tree species composition of urban forests in Halifax and London in Canada, they are able to determine whether the pre-urban landscape (woodlands or agriculture) lead to differences in urban tree diversity following urbanization. In both cities, regardless of the previous landscape, the newer neighbourhoods had greater tree species richness and evenness and are characterised by substantially more native tree species. This study provides hope that these newer suburbs will provide high quality, native tree habitats to support faunal biodiversity, albeit highly fragmented habitats on small building lots, interspersed with non-native trees.

## 6. Summary and Future Directions

We are pleased to present this Special Issue and believe that many of the studies from across the world will make a lasting contribution to raising the recognition of the ecological, environmental and socio-economic value of trees to our towns and cities. Urban trees play a vital role in maintaining and enhancing the resilience and integrity of many social, cultural, and ecosystem functions. There is a real need to recognise and tackle the issues of “green inequity” or “tree inequity” in the towns and cities of all countries. Without accepting the need for action, we cannot effectively use urban trees as a single mechanism to provide greater social, ecological, and ecosystem service benefits in urban landscapes while minimising the ecosystem disservices. Urban tree planting initiatives should not contribute to the growing divide between the haves and have-nots in modern urban society. For tree planting to provide the greatest and most cost-effective ecosystem service benefit, the first areas to be planted should be those with the least green space or tree canopy cover [16]. If this can be done, it will provide a great opportunity for urban forest researchers to concurrently monitor and measure the gradual, long-term delivery of benefits that increased urban tree cover, tree diversity, and tree health can provide. Measuring the relevant social and ecosystem indicators will of course be essential to evaluating this and the success of separate municipal urban forest programs.

Engaging the urban population with greenery and nature is a must and can indeed improve our awareness, appreciation, and willingness to tackle all our pressing environmental issues, be they urban, rural, local, national, or global. Soon, the majority of the world’s population will be urban residents and they will have a profound relationship with the trees around them, providing cues for memories and a “sense of place”, and invoking emotions that these trees are perceived as active participants in urban life [17]. As such, the role of a vibrant, diverse, and healthy urban forest cannot be underestimated. Several studies point to the important role of diversity in tree populations, as well as the positive role that urban forests can have for maintaining fauna biodiversity, creating opportunities for local communities to make a greater connection with nature. There is a real need for greater research on the human health and wellness benefits of urban biodiversity and urban forests themselves. These urban forests may not provide critical habitats for threatened or endangered animals in the same way that more remote or larger nature reserves might. Similarly, these urban forests may sequester only a small fraction of the carbon sequestered by managed plantations and natural forest systems. However, an increasing number of us live an “urban life”, so it is this urban forest that provides the best, or most frequent, opportunity for society to interact with nature, to be environmentally aware in the truest sense, to directly observe the impacts of climate change, and to feel empowered that your urban landscape contributes in some small way to a better world.

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