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Benefits of Urban Forests and Determining Their Value

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Urban forests are often overlooked as they are "hidden in plain sight." Urban forests and the services they provide can be vague concepts. This article gives a definition of urban forests, detailing their functional and structural values. Terminology associated with both terms and determining valuation of the benefits is provided. Quantitative information on these benefits helps land-use planners, local governments, and decision-makers see the contributions often overlooked in urban forests and can help plan on where to continue to plant trees within a complex urban environment.

Introduction

A simple definition of an urban forest is the trees or forest just outside our front doors. It is also an urban ecosystem, a complex human-environment system, that requires understanding to ensure sustainable urban planning. Urban forests come in various shapes and sizes, including urban parks, street trees, greenways, river corridors, gardens, and wetlands.[1] They are interconnected networks of open, green spaces and green infrastructure that provide multiple ecosystem services in urban environments.[2] Green infrastructure, with urban trees as an integral component, can serve as a natural solution to drainage, heat, air, and water quality issues common in urban landscapes.[3]

Escalating urbanization has led to increasing demands for the ecosystem benefits provided by urban forests. Four-fifths of Americans and two-thirds of South Carolinians live in urban areas (on approximately 6% of the land area).[4] National and state urbanization trends make urban trees even more important to sustaining and improving the quality of life in these urban areas.

Benefits of Urban Forests

Understanding the function and value of urban forests can promote management decisions that improve human health, environmental quality, and even local economies by increasing property values and aesthetics in urban communities.[5] The social benefits of urban forests are more difficult to value. Urban trees provide physical, mental, emotional, and psychological benefits to urban residents (humans and wildlife) and add to the beauty, aesthetics of their local environment, and reduce crime rate, as well as a myriad of other social issues.[6]

Structural Benefits

Structural benefits represent the cost to replace a tree with one of similar value (considering factors like tree species, diameter, condition, and location) [7] and correspond to replacement value, serving as an indication of forest health. The structural value of urban forests depends upon the extent of canopy cover over an urban area.

Functional Benefits

Functional benefits represent the contribution to ecosystem functions, such as [7]

- Air Pollution Removal: The urban forest helps improve air quality by reducing air temperature, directly removing pollutants from the air through their leaves,[8] offsetting carbon dioxide emissions. Reducing energy consumption in buildings consequently reduces air pollutant emissions from the power sources.[9]
- Oxygen Production: Oxygen is needed by all humans and wildlife and is one of the most commonly cited benefits of urban trees. However, this tree benefit is somewhat insignificant because of the large and relatively stable amount of oxygen in the atmosphere and extensive production by aquatic systems.

- Climate Management: Urban vegetation provides direct and indirect benefits, including heat regulation. Trees cool air through evapotranspiration and provide shade.
- Carbon Sequestration: Trees reduce the carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered increases with the size, age, and health of the trees. Carbon storage has attracted significant attention due to climate change.[10]
- Stormwater Management: Surface stormwater runoff can cause concern in many urban areas as it can contribute to pollution of surface waterbodies such as streams, wetlands, rivers, lakes, and oceans. [9]
- Energy Savings: Trees reduce building energy use in warm months and allow warmth from sunlight in winter while protecting from wind.

Valuing Urban Forest Benefits

Recognize that the urban environment is a dynamic and complex landscape, where socio-ecological processes interact to provide multiple ecosystem services at multiple scales. The structure and composition of urban forests influence the supply of these valuable ecosystem services.[11] Both the annual functional and structural values increase with the increase in the number and size of healthy trees.[12]

The structural estimate represents the overall compensatory value and can be determined using the Council of Tree and Landscape Appraisers method. Models allow for determining the monetary value of many urban forest benefits. For example, the Eco 6 version of the i-Tree Eco Model merges tree inventory data with local air pollution and weather data.[13] This model was used to estimate the value of Clemson University's urban forest (figure 1).

The structural value of Clemson University's urban forest is $13.2 million. Functional value estimates included:

- Clemson campus trees remove 1.5 tons of air pollution [ozone (O_3), carbon monoxide (CO), nitrogen oxide (NO_2), particulate matter less than 2.5 microns (PM2.5), and sulfur dioxide (SO_2)] per year with an associated value of $1,590.
- Clemson University campus trees sequester about 77.44 tons of carbon per year with an associated value of $13,200.
- Clemson University campus trees are estimated to produce 206.5 tons of oxygen per year. Our atmosphere has an enormous reserve of oxygen for free use, so we estimated no dollar value for this benefit.
- Clemson University campus trees and shrubs can help reduce runoff by an estimated 99.2 thousand cubic feet per year with an associated value of $6,630.

The structural and functional value estimates for Clemson University were similar to values obtained on other campus areas around the country using the same model (Auburn University in Alabama,[14] University of Pennsylvania,[15] and Ohio State University[16]).

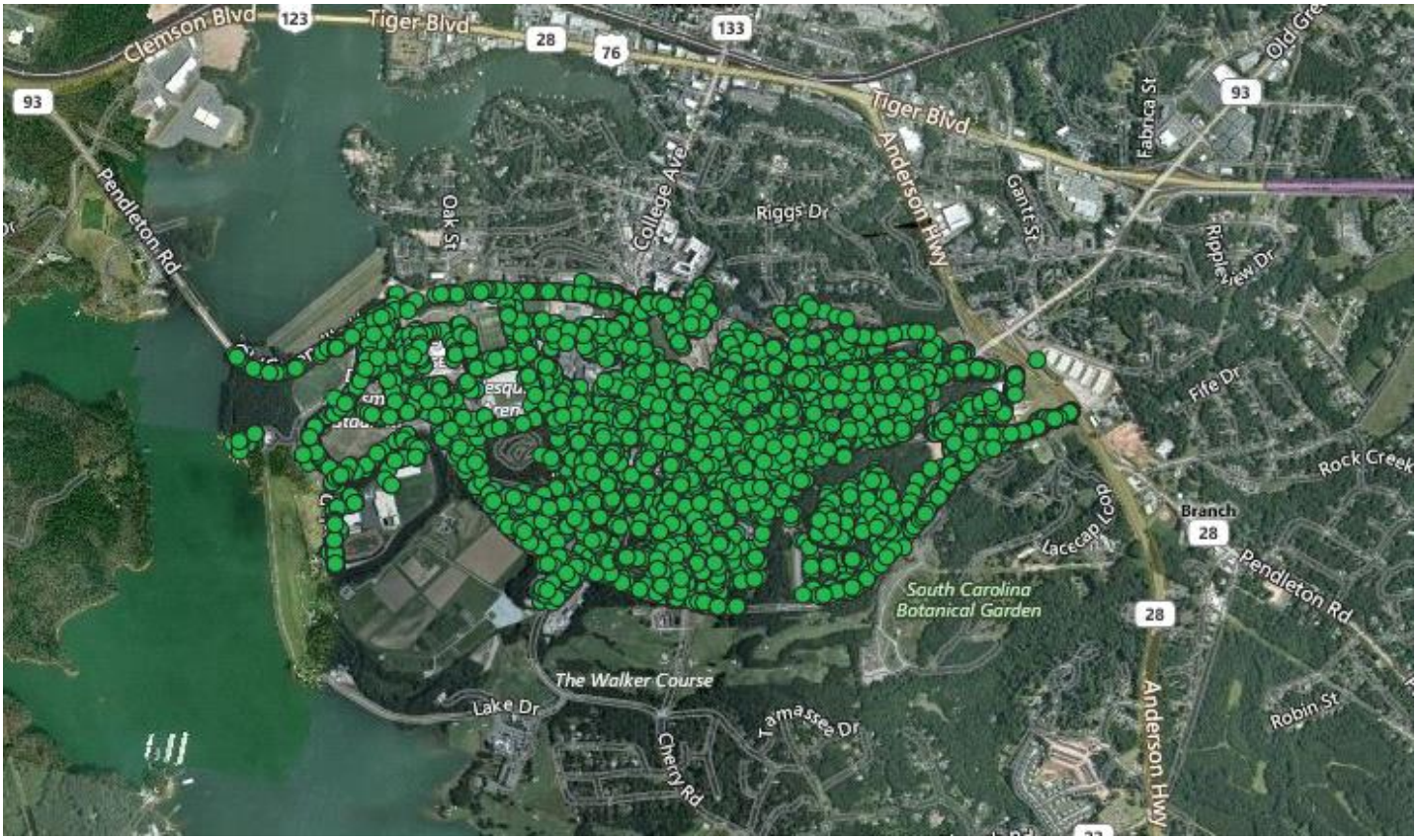

Figure 1. Distribution of trees across the Clemson University campus (N=6,361 trees). Image Source: Clemson University Landscape Services.

Summary

Urban forests provide valuable ecosystem services, such as air pollution removal, carbon storage, oxygen production, and runoff prevention. Species distribution and size of trees are significant factors controlling these ecosystem service's present and future supply. Considerable attention in selecting forest establishment, protection, and species management is needed to meet ecosystem services current and future demands. The demand for these ecosystem services is increasing in urban population centers. Yet development strategies often encompass natural spaces rather than renovation of existing (underutilized) spaces as new development is less expensive than redevelopment. Urban forests need management and protection strategies to meet the challenge this presents. Quantification and valuation of ecosystem services are tools urban forest managers can use to protect mature, high-value trees during development planning. Other benefits of urban forests, including improved health, emotional well-being, and energy savings, should also be included in any urban forest valuation.

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