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New Approach to Monitor the Life Cycle of Urban Street Trees

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AGENDA

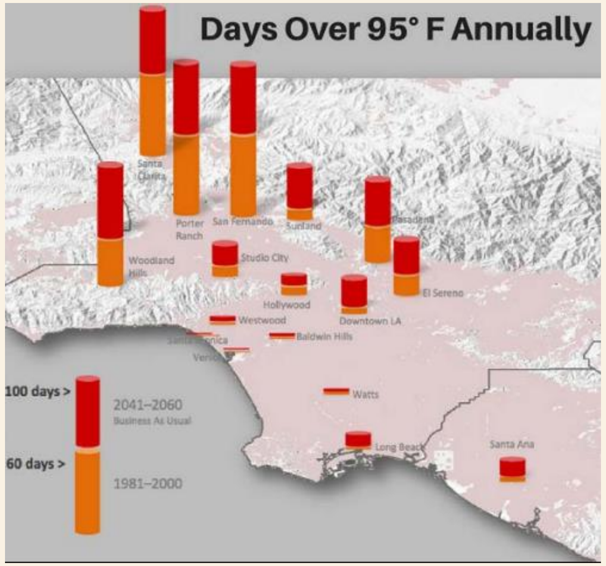
- Introduction
- Research Motivations &Goals
- Research Method
- Introducing Study Area
- Results
- Closing Comments

Challenges of the warming climate…

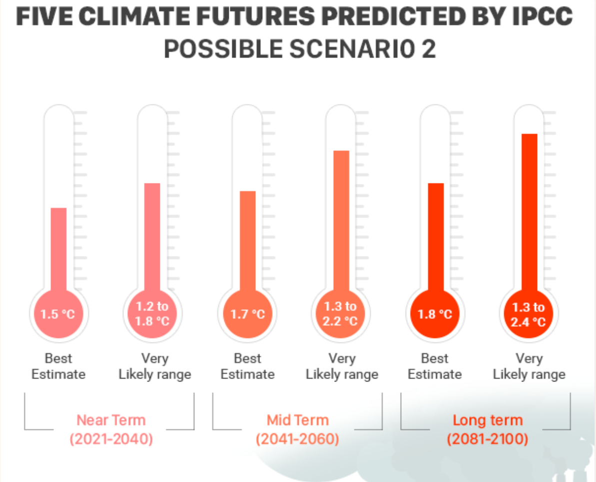
- Increase in temperature by an average of 0.3° to 4.8°C by the end of century
- More pronounced impacts in cities due to increased urbanization, the prevalence of impervious surfaces, and reduced vegetated cover
- Higher vulnerability, higher exposure level

→ Higher risk in urban areas

- Role of urban tree canopy in reducing ambient temperatures



Source: UCLA institute of the Environment and Sustainability, Center for Climate Science



Source: https://swachhindia.ndtv.com/climate-change-un-panels-five-possible-temperature-rise-scenarios-explained-63192/

Tree mortality and impacts on long-term cooling benefit

- Negative impact on the long-term cooling capacity of current urban tree canopies
- Factors influencing tree mortality:

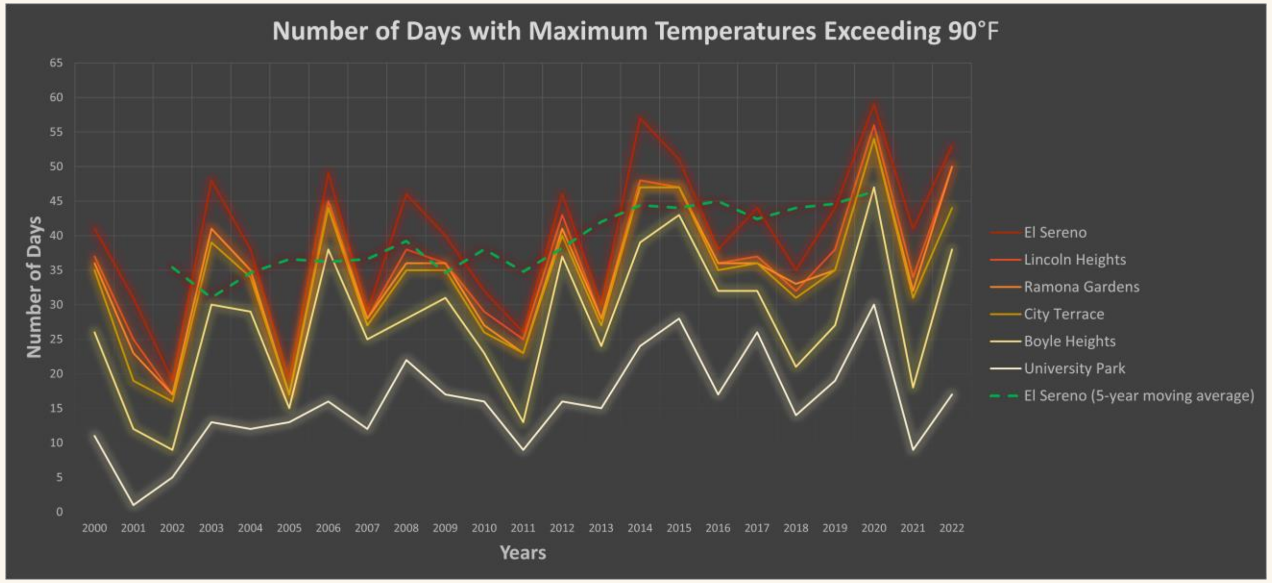
- Biophysical/climate-induced factors (such as high temperatures, drought, fire, invasive species, and pathogens)

- Human-induced factors (land use changes, construction, and development)

- Natural tree mortality due to aging

Research Motivation

- Maximize the associated benefits of urban trees
- Cities often use cross-sectional data to make decisions about the number of trees that should be planted **without considering tree growth and mortality rates**
- Rising temperature and the crucial role of urban trees in reducing heat exposure



Number of days exceeding 90 F in the case study area over the past few decades

Research Goal

- Estimating the number of trees that should be planted in the case study area to **exceed the number of tree losses by the end of century**

Tree Losses < New Tree Planting

- Help authorities make informed decisions about the quantity, location, and types of trees that need to be planted each year

(McPherson et al., 2016)
Urban tree growth equations can be used to estimate age of trees to help managers decide about tree removals and reduce infrastructure repair costs

Research Method

- Calculating **the number of tree losses due to aging** and estimating **the number of trees that should be planted**
- Using trees **Diameter at Breast Height (DBH)** and **growth coefficients** to estimate trees age
- Estimating trees mortality and survival rate based on three longevity scenario:

- Better-than-normal (maximum longevity)

- Middle-of-the-road (average longevity)

- Worse-than-normal (minimum longevity

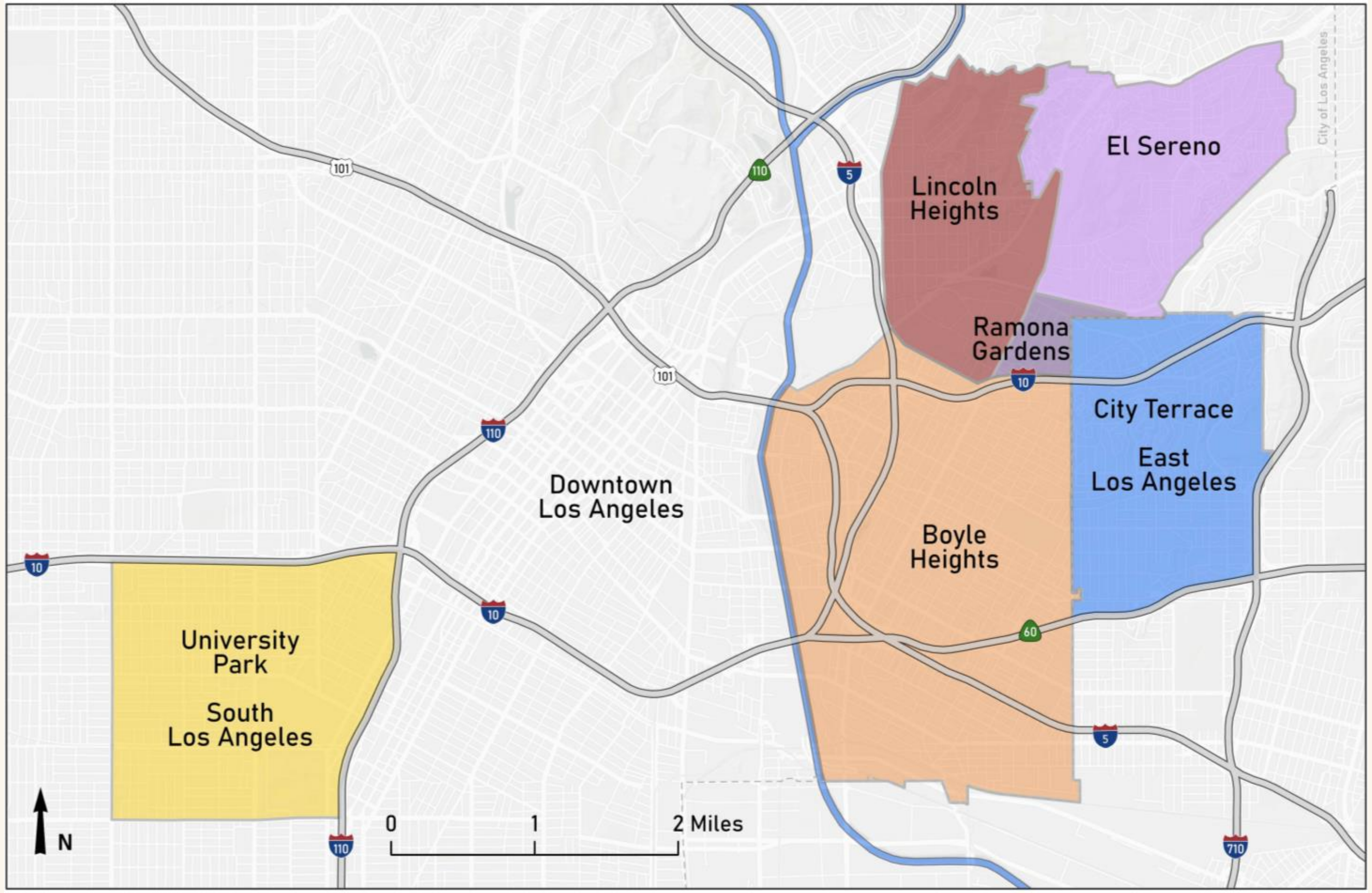
Linear	$y_i = a + bx_i + \frac{\epsilon_i}{\sqrt{w_i}}$	(1)
Quadratic	$y_i = a + bx_i + cx_i^2 + \frac{\epsilon_i}{\sqrt{w_i}}$	(2)
Cubic	$y_i = a + bx_i + cx_i^2 + dx_i^3 + \frac{\epsilon_i}{\sqrt{w_i}}$	(3)
Quartic	$y_i = a + bx_i + cx_i^2 + dx_i^3 + ex^4{}_i + \frac{\epsilon_i}{\sqrt{w_i}}$	(4)
Log-log	$\text{In}(y_i) = a + b\text{In}(\text{In}(x_i + 1)) + \frac{\epsilon_i}{\sqrt{w_i}}$	(5)
Exponential	$\text{In}(y_i) = a + bx_i + \frac{\epsilon_i}{\sqrt{w_i}}$	(6)

where y_i represents the calculations of tree i, a is the mean intercept, b is the mean slope, x_i is the DBH of tree i, ϵ_i is the random error for tree i with $\epsilon_i j \sim N(0, \sigma^2)$ following a normal distribution, σ^2 is the variance of the random error, and w_i is a known weight

Tested models in Urban Tree Database (McPherson et al., 2016)

Study Area

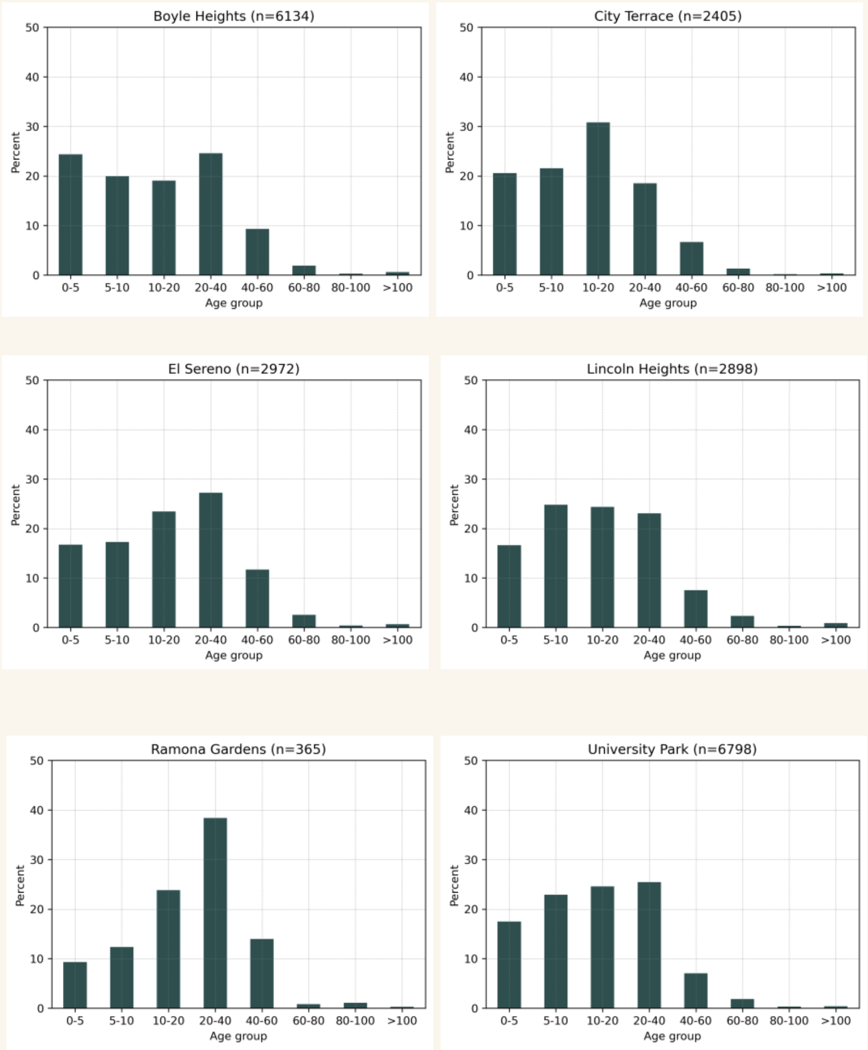
- Study area includes 6 neighborhoods
- Located within a mile of Downtown Los Angeles
- A series of vulnerable communities surrounding the USC University Park and Health Sciences campuses
- Residents are majority people of color with low incomes and are more likely to face environmental inequalities



Results

- The majority of trees in the case study area fall within the age range of 0 to 40 years
- The population of newly planted trees (0-5 years of age) in the case study area is relatively low
- The most common age group category for trees in all six neighborhoods is between 20 and 40 years old

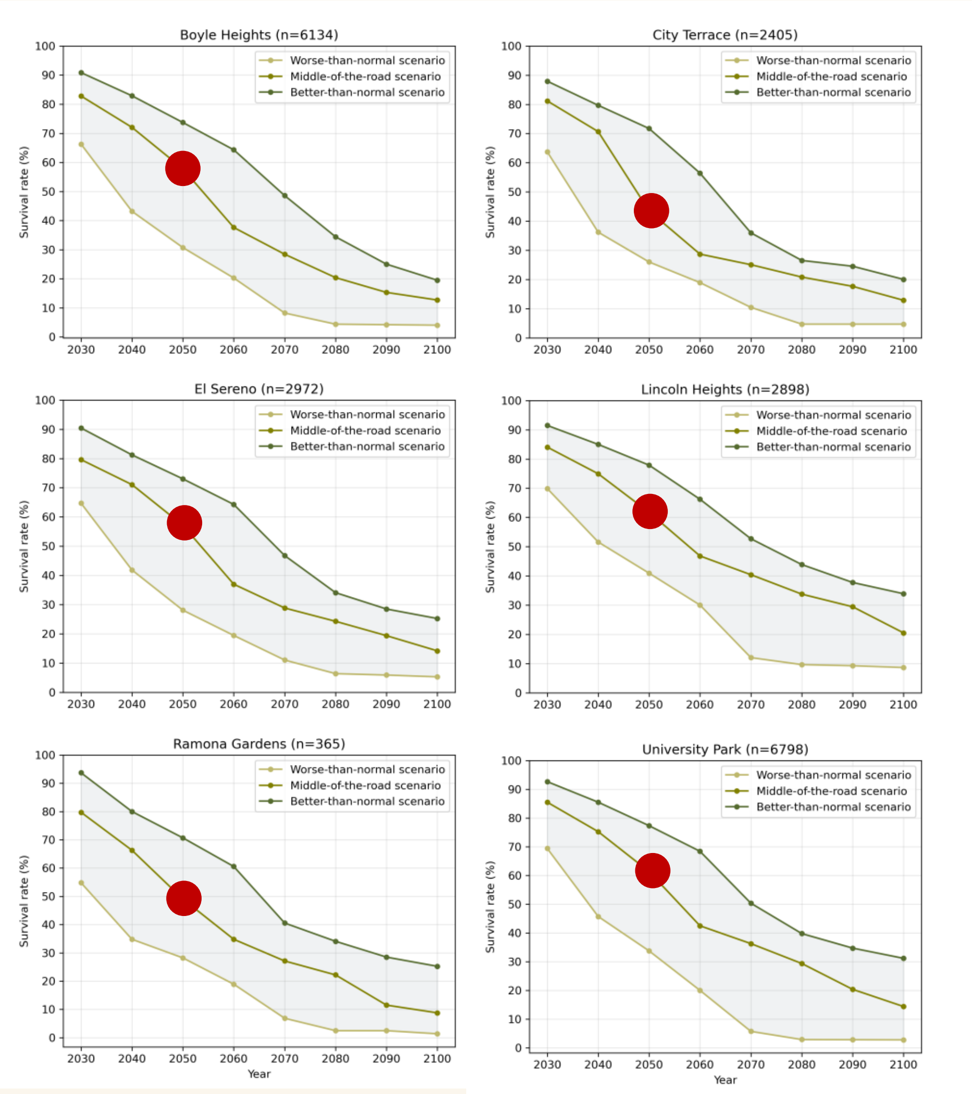
Age class distribution of urban tree canopy in the study area



Results

Survival rate of current urban tree canopy in the study area

- The overall trend of survival rates in all six neighborhoods is **declining**
- Under the **middle-of-the-road** scenario it's projected that **almost 50 percent of the analyzed trees will be dead by mid-century**
- By the end of the century, under this scenario, **less than 10 percent of the current trees are expected to survive**

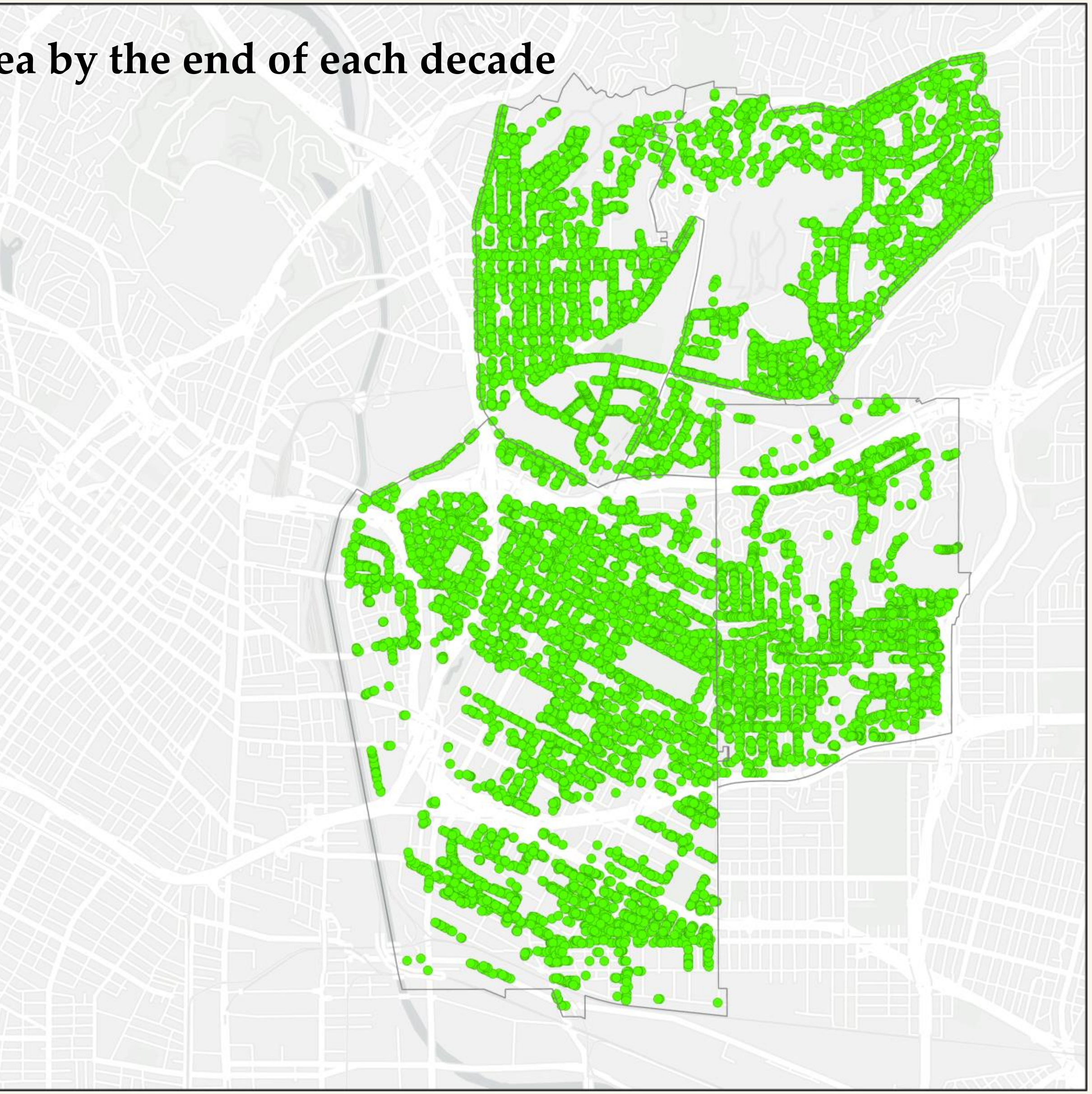


Results

Vulnerability analysis of tree losses in the study area

The current condition and the prediction of spatial distribution of street trees mortality in Boyle Heights neighborhood based on the middle-of-the-road scenario

Tree losses in the study area by the end of each decade over the century (2023-2100)



Closing Comments….

- Under the middle-of-the-road longevity scenario, on average, the case study area will lose about 10.8 percent of its tree inventory by the end of each decade
- Considering that by mid-century, near half of today's trees will no longer be alive, need to plan accordingly to at least maintain the current status quo

"As an example: Boyle Heights needs ~2500 new trees by the mid-century to maintain the same inventory!"

- Shift the focus to the number of trees lost and emphasize the importance of considering the age of the current tree canopy for making decision about tree planting

An efficient and appropriate tree mortality model can assist cities in moving towards more resilient urban forests to combat warming climate

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Original article

A new approach to monitor the life cycle of urban street tree canopies

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ABSTRACT

One common measure to mitigate the impacts of rising temperatures within cities is increasing the amount of vegetation, especially urban trees and their canopies. To maximize the associated benefits of urban trees in a given city or neighborhood, it is important that the canopy of newly planted trees matches or exceeds the canopy of the trees that are lost. However, cities often use cross-sectional data to make decisions about the number of trees that should be planted without considering an individual tree's growth and life span. In this study, individual tree growth and longevity data were used to portray the current and future conditions of street trees in six neighborhoods near Downtown Los Angeles and to identify locations in those neighborhoods that are in urgent need of interventions for tree planting. The results of this study indicate that, under the typical tree mortality scenario, near half of the current tree canopy will disappear by 2050, and on average, approximately one percent of the existing street trees will be lost due to aging each year. The approach used in this study shows how cities can monitor the age and mortality rate of the urban tree canopy over time. This approach informs tree planting campaigns that will preserve the long-term vitality and size of urban tree canopies and contribute to the resiliency of cities in a warmer future climate.

1. Introduction

According to the Intergovernmental Panel on Climate Change (IPCC), it is predicted that global surface temperatures will increase by 0.3–4.8°C by the end of this century under different global warming scenarios (Pachauri and Mayer, 2015). The impacts of a warming climate in cities will be particularly pronounced due to increased urbanization, the prevalence of impervious surfaces, and reduced vegetated cover (Dibaba, 2023; Dutta et al., 2021; Stone and Rodgers, 2001). In addition to the heightened vulnerability of urban areas, they also face greater exposure to rising temperatures due to the increasing size of cities (Chakraborty et al., 2019; L. Hu et al., 2019). It is estimated that by mid-century, 68 percent of the world's population will be living in urban areas (United Nations, 2018). The impacts of climate change, especially rising temperatures, pose significant threats to human health and well-being (Lawrance et al., 2021; F. Liu et al., 2023), create economic burdens (Tol, 2018), and exacerbate existing societal inequalities (Islam and Winkel, 2017; Smith et al., 2022).

One common measure to mitigate the impacts of increased temperatures, which has been well-proven to be effective in cooling surfaces and ambient temperatures in cities, is the increase in the amount of vegetation, especially in the form of urban trees (Ellison et al., 2017; Iungman et al., 2023). Trees also contribute to lowering air pollution (Nowak et al., 2018), reducing stormwater and runoff (Selbig et al., 2022), providing opportunities for recreation and exercise (Jones, 2021), noise attenuation (Salmond et al., 2016), blocking unwanted views, and improving aesthetic aspects (T. Hu et al., 2022). These benefits can enhance public health and well-being, promote resiliency and climate adaptation, and, if tree planting initiatives are sensitive enough to equity measures, ameliorate the burden of environmental inequities (Chiabai et al., 2018; Nesbitt et al., 2018). Those benefits address several UN Sustainable Development Goals, including (3) Good Health and Well-Being, (10) Reduced Inequalities, (11) Sustainable Cities and Communities, and (13) Climate Action (United Nations, 2024).

In terms of cooling benefits, green spaces and particularly trees

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