A Systematic Review of the Cooling Effects of Urban Forests

Abstract

The newly released Fifth National Climate Assessment (NCA5) concludes that climate change impacts (e.g., heatwaves) are of serious concern in disadvantaged communities, especially in cities. According to National Oceanic and Atmospheric Administration (NOAA), compared to disasters like flooding, tornadoes, and hurricanes, heat is the top one weather-related killer in the United States causing an average of 158 heat-related deaths each year during 1992- 2021. As a Nature-based Solution to provide cooling effects and help heat mitigation and climate change adaptation, urban forests have been widely adopted by many urban communities around the world. However, the sciences to support such efforts are still lacking. To address the research gap, we conducted a systematic literature review to document the state of science about the cooling effects of urban forests. Specifically, we ask: 1) What are the mechanisms of the cooling effects of urban forests? 2)What are the factors that affect the cooling effects? 3) How can we better manage urban forests to optimize cooling effects? We used 13 keywords related to urban forests climatic effects (e.g., cities, street trees, cooling, heat, temperature) and reference databases included in the Web of Science platform. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method, 102 peer-reviewed articles were selected for review from a total of 4,073 studies. We found that areas with a predominance of green spaces usually were cooler than areas with no green spaces. Several factors affect urban forests' cooling effects, including land-cover patterns, urban greenspace types, tree species, tree cover and canopy structures, and leaf area index (LAI). In addition, the cooling effects might be affected by local background climate and the distance from the sea. We show the importance of tree species selection, planning, and design in urban forest management for heat mitigation and climate change adaptation. The findings can help guide diverse stakeholders for their future urban greening efforts to achieve maximum cooling effects with limited spaces in cities.