



Quantifying the Cooling Reach of Urban Vegetation: A Linear Park Case Study in São Paulo

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Cities are generally warmer than their surroundings due to the Urban Heat Island (UHI) effect, which can be intensified during heat waves and lead to reduced labor capacity and increased mortality. Urban vegetation is known to mitigate UHI intensity, but quantifying the cooling impact of different green infrastructures, such as parks or street trees, on urbanized areas remains challenging. The time required for trees to grow is often long enough for substantial urban changes to occur around them, making it difficult to isolate vegetation-driven temperature effects from other factors. Moreover, air temperature (T_a) and surface temperature (T_s) play different roles in the energy balance and exhibit distinct spatial patterns, although they are thermodynamically linked through heat exchange.

In this study, we assess the impact of a newly implemented linear park in São Paulo, Brazil, on surrounding T_s using clear-sky Landsat-derived T_s and Normalized Difference Vegetation Index (NDVI) at 10 a.m. (30 m resolution). T_s and NDVI were averaged in two decades (1985-1995 and 2015-2025), where trees were planted at the beginning of the first decade and became substantially denser on the latter (NDVI increase up to 0.25), while the adjacent southern urbanized area remained unchanged.

A cross-section perpendicular to the park axis was used to quantify the cooling reach, defined as the distance between the last pixel showing a statistically significant NDVI increase and the last pixel with a significant T_s decrease. The observed cooling reach was 30 m (one Landsat pixel). This result is compared with three previous case studies in São Paulo that investigated dense vegetation removal, where NDVI changes were stronger (up to 0.50) and warming reaches ranged from 64 to 168 m. Interpreted inversely, as a conceptual restoration of dense vegetation, these values provide an upper benchmark for the potential cooling reach of parks (and the present case study lies within it).

Our results indicate that even under favorable conditions, the cooling influence of parks on surrounding urban areas is spatially limited. This suggests that distributed strategies such as street trees and other forms of urban greening may be more effective for reducing overall city temperatures.