Risk of urban tree falls in São Paulo is influenced by building height and neighborhood age, study shows

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Research also found sidewalk width and tree height to be key factors. The results will be used in tree management and urban planning. Credit: City of São Paulo

According to a study in the journal *Urban Forestry & Urban Greening*, the factors that most influence and increase the risk of tree failure in São Paulo (the capital of São Paulo state in Brazil) are the height of nearby

buildings and the age of the neighborhood. Sidewalk width and tree height are the next most significant variables.

Tree failure in streets with buildings of five or more stories is double the average for the city as a whole, the researchers found. It is also above average in districts created more than four decades ago. It is highest for trees taller than 9.58 m and planted on sloping sidewalks. Newer neighborhoods with lower buildings have 37% fewer cases.

The researchers analyzed 26,616 records of tree falls in the city's 96 districts in an eight-year period. São Paulo lost about 4% of its 652,000 street trees between 2013 e 2021, with proportions varying from 0.59% in the southern part of the city to 17% in the center.

This is the first study to evaluate a comprehensive urban tree failure dataset for one of the world's largest cities. The methodology and findings will be used in tree management and urban planning programs.

"We used an artificial technique focusing on practical application of the results and were able to set monitoring targets by identifying the building and tree heights that increase the risk of tree failure," said Giuliano Locosselli, corresponding author of the article. He is a researcher at the University of São Paulo's Center for Nuclear Energy in Agriculture (CENA-USP) and the São Paulo State Government's Environmental Research Institute (IPA).

For Priscilla Cerqueira, a co-author of the article and a technical advisor in the Urban Tree Division of the city's Department of Green Areas and the Environment, the findings will contribute to more effective and efficient assessment of tree health in São Paulo. "The data can be shared with our own technical staff and the contractors in charge of tree management so that priorities are set more accurately on the basis of the calculated risk of tree failure," she told Agência FAPESP.

Since a municipal law was passed in 2020 to allow tree pruning without publication of permission to do so in the city's official gazette, technical staff have extended the service to entire streets or blocks. "We're implementing the unified system and database called for by the municipal urban tree management plan," Cerqueira said.

Impact

São Paulo is South America's largest city and one of the top five in the world by population, according to the United Nations Human Settlement Program. Like other megacities, it suffers from the effects of climate change due to heat islands, impermeable surfaces and environmental pollution. Nature-based solutions and ecosystem services provide relief from these urban problems.

Trees and other vegetation contribute to carbon sequestration, while also mitigating global warming, absorbing air pollution and cushioning the city against flooding by increasing permeable surfaces and the capacity to intercept rainwater runoff.

The main threats to trees include verticalization, which creates "urban canyons"—rows of tall buildings that affect the microclimate by altering local wind speed and patterns of turbulence, pollution dispersion and shade.

These alterations affect key biological processes such as evapotranspiration and tree assimilation, growth and survival, contributing to early tree failure, financial and material losses, and even the risk of death for the city's residents. The impact of urban canyons on tree growth and stability helps explain the heightened risk in areas with tall buildings.

"The mechanisms behind tree failure in urban canyons are poorly

understood. Tree health is affected by many factors in these areas. Verticalization increases the risks in the medium to long term, as these effects accumulate," Locosselli said.

One of the available solutions is to plant species that are better adapted to the type of environment found in urban canyons.

Methodology

The researchers analyzed data from GeoSampa, an online open-source digital mapping platform with information on health, education and other aspects of São Paulo city, including its trees. The platform collects data from borough councils and municipal management systems relating to critical occurrences and citizen relationships.

The study focused on seven variables; neighborhood age, building and tree height, canopy cover, sidewalk width and slope, and terrain slope.

Tree and building heights were measured in a LiDAR survey available on GeoSampa. LiDAR (Light Detection and Ranging) is an airborne system that models the terrain three-dimensionally by recording laser light pulses as they bounce off objects on the ground and return at the speed of light.

Tree and building height are determined on the basis of the lag between emission and reception of the pulses. Resolution can be as high as 1 meter. LiDAR is often used to survey topography and vegetation.

The data was processed using an artificial intelligence method called Classification and Regression Trees (CART). According to Locosselli, the algorithm was easy to implement with 82% accuracy, and the methodology can be applied to other cities, although few in Brazil have detailed information on building height and tree falls.

"We conducted previous research to understand tree falls in São Paulo and appraise the influence of climate factors on this process," he said. "Here we wanted results that could be used by the municipal government to produce tree management guidelines and mitigate risks. We prioritized scientific rigor and quality in pursuit of practical outcomes."

According to a paper published in 2021, also by Locosselli among others, tree falls in São Paulo during the dry season correlated with poor management as well as a lack of adequate conditions for the survival of street vegetation.

"We wanted to end up with guidelines for day-to-day use. The project involved collaboration between academics and public administrators to support decision making and contribute to the formulation of public policy," Cerqueira said.

A new municipal law governing tree management took effect in April. The city's 2021-24 Target Plan calls for the planting of 45,000 trees per year.

More information: Rodrigo Manfra et al, Average height of surrounding buildings and district age are the main predictors of tree failure on the streets of São Paulo/Brazil, *Urban Forestry & Urban Greening* (2022). DOI: 10.1016/j.ufug.2022.127665

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