Wood condition, root constriction and improper pruning can be used as predictors of urban tree failure

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According to the researchers, São Paulo city sees some 2,000 street tree failures per year. The statistic excludes parks and environmental protection areas. Credit: EBC

In São Paulo, Brazil's largest metropolis, the city center is considered a tree failure hotspot, with the largest proportion of failures in the city

occurring in that area.

The main predictors of tree failure are the condition of the wood, constriction of the roots by the sidewalk, and drastic pruning, concludes a study recently published in *Urban Forestry & Urban Greening*.

The authors analyzed data for 456 tree failures in the central area of São Paulo, which is managed by one of the city government's 32 regional administrations, the Sé Regional Administration, which comprises eight districts (Sé, República, Bom Retiro, Santa Cecília, Consolação, Bela Vista, Liberdade and Cambuci). These are among the oldest and most verticalized neighborhoods in the city.

According to the article, the city has over 650,000 street trees, not counting trees in 130 parks and squares, and some 2,000 street tree failures are recorded each year. For example, on January 8-9, 2024, the fire brigade received 250 calls relating to street tree failures due to rainstorms, with winds reaching 94 km per hour in some areas.

In November 2023, disruption of the overhead power lines by falling branches and trees left more than 2 million inhabitants without electricity, in some cases for several days.

Based on the predictors, the authors propose guidelines for action by the various stakeholders to reduce the number of tree falls, especially when due to the failure of trunks and roots, and the damage they do to the city and its inhabitants, including loss of life in some cases.

The researchers advocate a detailed assessment of the conditions of trees throughout the city and urge the city government to work with private enterprises on ways of assuring appropriate pruning. Everyone involved in tree planting, from individuals to companies and government, should also take steps to make sure sidewalks have sufficient room to let roots

grow.

"Because the center has very similar characteristics to other districts, we believe the results of the study can be applied throughout São Paulo city. As for other cities, it depends on the quality of the available data. In my view, we won't solve the problem of tree failure in São Paulo unless academia, government, and the private sector join forces to this end," Giuliano Locosselli, the last author of the article, told Agência FAPESP.

His research interests include ways to optimize ecosystem services in urban forests, from carbon capture and cooling to air pollution reduction and the development of nature-based solutions to mitigate the effects of climate change.

"If a city has healthy trees and manages them properly, it will reduce health care costs, for example, given the many benefits of green areas. The guidelines we propose in the article will be of great help to São Paulo's tree management plan, but we're aware that the work involved is labor-intensive and more hands are needed."

"It's important to focus on adequate management, from planting and choosing species to proper structuring of tree pits and optimal pruning," said Aline Andréia Cavalari, first author of the article and a professor of plant physiology at the Federal University of São Paulo (UNIFESP).

The Municipal Urban Tree Management Plan (PMAU) was launched in 2020 and has a participatory basis. It covers a period of 20 years, with reviews every five years, and calls for 170 actions, including a tree inventory.

According to the Department for Green Areas and the Environment, 42 of the actions called for by the plan are in progress. "We are following the guidelines put forward by the authors in the shape of new procedures

within the framework of the PMAU, such as adaptation of the flow of routine tree inspections and assessments.

The study was conducted under the aegis of an agreement with UNIFESP, demonstrating our commitment to improve tree management in the city by making more science-based decisions," said a press release issued by the department.

The challenge of managing 650,000+ trees

Managing more than 650,000 trees in São Paulo is a challenge, Locosselli recognized, but it can be met with the knowledge accumulated on individual trees as well as maintenance techniques.

"The key is to build a holistic vision of the city's tree population, with a management plan that permits improvement and constant monitoring to ensure that its green areas are healthy, producing a maximum of ecosystem services and reducing losses due to tree failure as much as possible. The most important contribution research can make is holistic guidelines of this kind to assure progress," he said.

Locosselli and colleagues authored two other articles on tree management in São Paulo in 2021 and 2022. One showed that the factors that most influence the risk of tree failure in the city are the height of nearby buildings, the age of the neighborhood, sidewalk width, and tree height. This study involved an analysis of 26,616 records of tree failures in the city's 96 districts in an eight-year period. Between 2013 and 2021, the city lost about 4% of the 652,000 trees then present in the urban area.

The other study highlighted evidence that the main cause of tree failures during the dry season is not weather but lack of management and inadequate conditions for the survival of street vegetation.

Predicting urban tree failure is a challenge everywhere in the world, as it involves multiple factors such as weather, the condition of the trees concerned, and the characteristics of the environs. Tree stability is particularly at risk in urban canyons (streets lined with skyscrapers), where gusts of wind alternate with lulls and eddies near buildings.

Criteria

The dataset analyzed by the authors was based on 456 tree failures that occurred between January 2016 and November 2018 in the eight neighborhoods of the Sé district. Agronomists coordinated by the local authority recorded the date of each failure and other criteria such as site characteristics, tree species, type of failure, wood condition, root collar conditions, conflicts with overhead utility lines, and signs of pruning.

The analysis encompassed 59 species. Up to four failures were associated with 38 species and five or more with 21. The authors explain that only absolute numbers were available owing to a lack of detailed floristic inventories, so a breakdown of the causes of failure by species was not possible.

The most frequent species in the dataset were Ligustrum lucidum and Tipuana tipu (13% each), and these species are also the most common in the city, alongside Ficus benjamina (Weeping fig).

Branch failures accounted for 46% of the 456 cases analyzed, followed by root failures with 33% and trunk failures with 21%. The proportion of branch failures contrasted with previous studies, in which root and trunk failures predominated, but the authors note that this may be biased by the fact that branch failure has only recently been considered a potential issue.

They used artificial intelligence to analyze the data and arrived at three

predictors of failure: wood condition, root collar constriction, and pruning.

The wood condition analysis took into account degradation by fungi, the presence of xylophagous (wood-eating) insects such as termites and wood borers, and signs of trunk cavities. On this basis, trees were divided into three categories: healthy, low degradation with early signs of decay such as discoloration, and high degradation with advanced signs of decay and changes in texture and structure due to significant hollows.

With regard to root collar, the criteria related to possible constriction by compacted soil, sidewalk cutouts, and girdling. The main conflict with overhead cables involved crossing tree crowns.

In the case of pruning, the authors identified four types: raising (to make room for pedestrians), reduction (of tree height), V-shaping (to increase the distance between branches and overhead cables), and topping (removal of all or most of the crown). The latter two are considered drastic and potentially dangerous as they increase the probability of trunk failure.

Most of the trees that lost branches had no clear signs of wood degradation by fungi, termites, etc., while more than 40% of the trees with trunk or root failure exhibited signs of low or high degradation. About 14% of root failures and 11% of trunk failures were associated with signs of constricted root collars, compared to only 4% of branch failures.

Collaboration

The study was a collaborative project involving scientists at the University of São Paulo (USP), the Federal University of São Paulo (UNIFESP), the Technological Research Institute (IPT, an arm of the

São Paulo State Department of Economic Development), and the government of São Paulo city.

"It's very important to be proactive in addressing this problem. Having identified the causes of tree failure, front-line professionals, academia, and government must work together. In addition to suggesting tree management guidelines, the study's results should persuade authorities, private enterprise, and citizens to stop using practices that endanger the city's trees and the benefits they provide," Locosselli said.

In this connection, Cavalari pointed out that UNIFESP and the city government have partnered to offer a course in urban tree management, initially to train employees of the Department for Green Areas and the Environment. The course has reached its fifth edition with an expanded attendance of contractors, service providers, and municipal government workers from other cities.

"The project is bearing fruit. Cities are doing surveys to collect data of their own, and academia is contributing a significant amount of research with results that improve tree management," Cavalari said.

More information: Aline Andreia Cavalari et al, Predicting tree failure to define roles and guidelines in risk management, a case study in São Paulo / Brazil, *Urban Forestry & Urban Greening* (2023). DOI: 10.1016/j.ufug.2023.128181

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