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QUANTITATIVE INVESTIGATION OF URBAN ARBORIZATION: A CASE STUDY IN AN ELEMENTARY SCHOOL IN IPAUMIRIM/CE

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ABSTRACT

The changes observed in natural landscapes, resulting from population growth and urban expansion, represent alterations in environmental quality and the amount of remaining natural ecosystems, negatively impacting the life of flora, fauna, and, by extension, society. This occurs due to phenomena such as climate change and the depletion of essential resources. Therefore, it is crucial to develop alternatives that promote more sustainable growth, minimizing environmental damage. In this study, a quantitative survey of plant species was conducted through an inventory, investigating all arboreal individuals present in the arborization of José Alves de Oliveira School, in the municipality of Ipaumirim, Ceará, Brazil. A total of 26 individuals were recorded, distributed among three species: Azadirachta indica (Neem, 20 individuals - 76.90%) and Ficus benjamina (Ficus, 5 individuals - 19.20%), both of exotic origin, accounting for 96.10% of the total trees; and Carica papaya (Papaya, 1 individual - 3.90%), of native origin. The results reveal a tree planting process lacking technical standards and marked by randomness, as evidenced by the low diversity and the predominance of exotic species, especially Azadirachta indica, characterizing urban monoarborization. It was observed that the trees were introduced (planted) without technical-scientific knowledge, prioritizing species characterized by rapid growth and greater shade provision, which explains the predominance of the Neem species in the school's arborization. This situation could harm the local flora and fauna. Through proper planning, issues such as local biodiversity could be considered, ensuring the maintenance, balance, and preservation of native vegetation. Therefore, the specific issue identified in this study highlights the importance of this investigation, pointing to the urgent need for strategic and effective interventions to manage urban arborization, including in large urban centers, where the impacts may reach even greater proportions.

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INTRODUCTION

Contemporary reports in the specialized literature on problems associated with industrialized countries point out that heat levels, or temperature, are among the most important environmental factors for the functioning of living organisms (Davidovits, 2025), as heat directly affects the soil, creating specific energy demands. The world faces several challenges, such as wars and conflicts, poverty, climate change, and urbanization. Among these, urbanization has become the main problem (Abebe, 2024).

In this context, forest landscape connectivity is a key indicator that reflects the quality and functionality of the ecological environment. In urban ecosystems, analytical frameworks are needed to prioritize and optimize afforestation projects capable of maintaining and enhancing forest landscape connectivity. These initiatives help mitigate the increasing fragmentation of urban habitats, coordinate the relationship between urban development and ecosystem services, and guide decision-making processes (Jin & Song, 2023).

Thus, the ongoing process of urbanization on the planet presents several negative environmental consequences. These consequences are related to increased soil impermeability, suppression of native vegetation, higher air pollution from fossil fuel combustion, greater energy consumption, higher risks of floods and inundations, and, consequently, a decline in urban environmental quality (Duarte et al., 2017).

Studies that contribute to understanding the impact of urbanization on urban tree canopy cover and to formulating potential policies and strategies to promote sustainable urban development in South America have identified that the direct effect of this process pertains to the reduction in tree canopy cover due to increased urban intensity, compared to scenarios with extremely low urbanization levels. Meanwhile, the indirect impact relates to changes in tree canopy cover resulting from human management practices and alterations in urban environments (Guo, Hong, & Zhu, 2024).

Urban green areas play a crucial role and are key elements for quality of life, as they perform functions and provide ecosystem services of ecological, social, and economic nature within urban environments. These areas play significant roles in preserving the genetic diversity of native flora, while also helping to mitigate air pollution and providing thermal comfort. Moreover, they act as natural barriers, shielding against strong winds, intense noise, and excessive brightness.

Given the increase in urbanization in Brazil in recent decades, it is a priority to develop alternatives that enable more sustainable growth, minimizing impacts on environmental

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quality and, consequently, on urban quality of life. In this regard, the ecosystem services provided by urban tree cover can be used as a form of compensation for the loss of environmental quality caused by urbanization processes (Duarte et al., 2017).

For instance, unique challenges are faced in urban environments within Brazil's semi-arid region regarding biodiversity and natural resources. Crucial tree species are recommended for landscaping in squares in this region of Brazil. The inclusion of densely forested green areas in small Brazilian municipalities stands out for promoting urban ecological resilience (Lisboa et al., 2024). Therefore, expanding conservation and/or preservation efforts is an urgent need, as analyses of environmental policies indicate that municipalities must improve their practices (Farinha et al., 2024).

Trees in urban areas act as carbon sinks and provide ecosystem services to residents (Guo, Hong, and Zhu, 2024). Urban forestry refers to the presence of trees in a city, including spaces such as forests, riparian areas, orchards, and others that are part of the urban perimeter. In summary, it encompasses all trees located within the boundaries of an urban area. The topic of urban forestry has been widely discussed, and it is worth highlighting some reports in the literature.

Urban forestry is the set of public or private areas with predominantly arboreal or natural vegetation that a city presents, which can be represented as groups or formations of trees from different origins. It includes trees present on public roads, avenues, public parks, and other green areas, performing various functions (Antunes and Santos, 2023). Thus, urban forestry is the organic fusion of the city and the forest, involving various disciplines and departments, such as silviculture, landscaping, and ecology (Ai and Zhou, 2023).

Urban forestry requires increasing care, as trees contribute to a more pleasant landscape, bringing other environmental benefits, such as shading, temperature moderation, air quality improvement, and noise pollution reduction (Blum et al., 2008).

According to Frigerio et al. (2023), urban trees are recognized for providing important regulatory, provisioning, and cultural ecosystem services. They help improve air quality by intercepting, modifying, and reducing the flow of atmospheric pollutants through a filtering action, contributing to the reduction of atmospheric CO_2 levels (Frigerio et al., 2023).

Investigating vegetation productivity and its interannual variability is highly beneficial for understanding the underlying mechanisms of carbon balances between atmospheric CO_2, concentration, and carbon sequestration in terrestrial ecosystems through land-atmosphere exchanges (Tian et al., 2024).

In the urban-environmental context of a city, green areas are important for a variety of factors, such as regulating the urban climate, which directly influences the thermal comfort of individuals who use these areas for recreational, sports, and other purposes (Barros et al., 2017).

Vegetation improves air quality through the photosynthetic process, by which plants absorb CO2 and release O2 into the atmosphere. Additionally, the deposition of solid particles on the foliage reduces pollution from factories, vehicles, and the burning of fossil fuels (Silva, Meunier, and Freitas, 2007). Just like essential services such as electricity distribution, water supply, telephone services, and urban cleaning, green areas in a city are a necessary urban service that contributes to the quality of life in a region.

Furthermore, trees improve water infiltration in the soil, as vegetation acts as a cover, also reducing soil loss due to water erosion. In urban centers with few green areas, rainwater that falls on paved soil has no chance of infiltrating, runs off the surface, and causes flooding, resulting in significant disturbances (Silva, Meunier, and Freitas, 2007).

The quality of life of biodiversity, in general, depends on various factors, one of which is of fundamental importance: urban forestry. This factor is an important means of making the environment more ecologically and aesthetically pleasant, providing biological diversity as well as quality of life for living beings.

Vegetation is an irreplaceable element that participates in several essential processes on Earth, including hydrological regulation (Qiu et al., 2022). The preservation of urban vegetation plays a key role in promoting sustainable development, making cities more livable, healthy, and resilient. This measure is linked to several United Nations Sustainable Development Goals (SDGs - 11, 15, 13, 3, and 2, in this order of importance), as it affects not only the environment but also the quality of life for people living in urban areas.

However, the lack of initiatives aimed at guiding the increase in urban forestry is evident, with a focus on planning according to desired ecosystem services, adapted to local specificities and current latent needs. On the contrary, even with the technical advances mainly achieved in the last decade, erroneous practices regarding the planning and management of urban green spaces are still identified (Zea et al., 2015).

This fact highlights that urban forestry is still widely regarded as a merely aesthetic element in the urban landscape. In this context, a deeper understanding of local realities is essential for developing proposals tailored to these specific conditions (Duarte et al., 2017).

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In addition to quantitative data, it is crucial to consider local needs and priorities regarding vegetation to analyze the species present in specific areas. To quantitatively assess urban forestry, it is necessary to individually count tree and palm species. Shrub species should be measured, taking into account data such as height and diameter. Different plant groups must be classified according to the current binomial nomenclature system (Angelis et al., 2004).

Gathering information on urban forestry allows for a better understanding of the arboreal flora within cities. An important aspect of such studies involves conducting censuses in which tree individuals are counted and identified by species, providing data such as the percentage of native and exotic (non-native) tree species in the local vegetation. The process of cataloging and analyzing these characteristics is fundamental to developing effective planning focused on the specificities of the area.

In this study, a quantitative inventory of plant species used in the landscaping of a school in the municipality of Ipaumirim, Ceará, Brazil, was carried out. A diagnosis of the floristic composition was also conducted, providing data such as scientific name, height, diameter, and species diversity, aiming to support a better understanding of this important aspect.

MATERIALS AND METHODS

Data collection was conducted at the Escola de Ensino Infantil e Fundamental (EEIF) José Alves de Oliveira, located in the city of Ipaumirim-CE (Figure 1), during the period from August to October 2016. The municipality covers an area of 273.8 km² and has an approximate population of 12,083 inhabitants, resulting in a population density of 43.70 inhabitants per km². It is situated at an altitude of 262 meters, with geographic coordinates of Latitude 6° 46' 49'' South and Longitude 38° 42' 54'' West, located in the Central-South Ceará mesoregion, Brazil (Cidade-Brasil, 2023; IBGE, 2024).

All tree individuals present at the school were quantified and identified. Data collection was carried out using a form that included information such as the collection date, number of existing trees, common name of the individual, synonyms, total tree height, and Diameter at Breast Height (DBH). For the phytogeographic classification of the species (exotic or native), the studies of Calixto Junior et al. (2009) and Araújo and Moreira (2015) were used as references. The tools used for data collection included a measuring tape and a graduated rod, employed to measure tree height and DBH.

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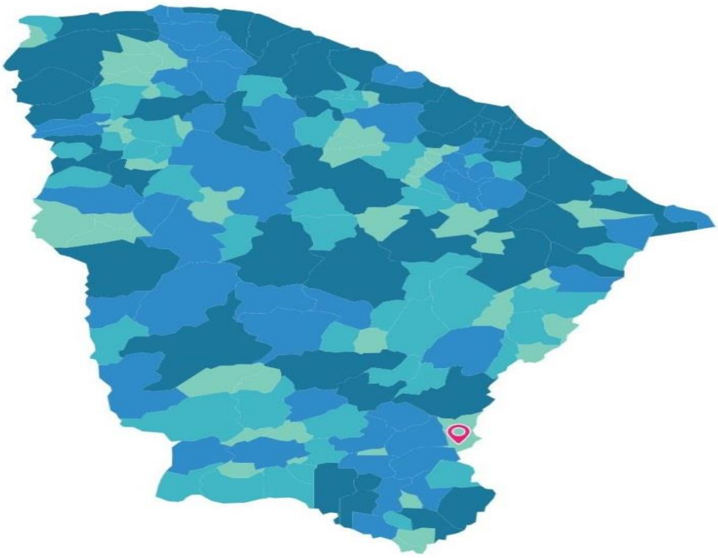
Figure 1. Geographical location of the municipality of Ipaumirim, CE, Northeast of Brazil.



Source. IBGE, 2024.

RESULTS AND DISCUSSION

In general, the results obtained in this study demonstrate that the studied area, José Alves School, exhibits low floristic diversity compared to other studies conducted in different Brazilian states. A total of 26 trees were quantified, distributed across 3 species, highlighting the limited floristic diversity in the school's urban forestry.

The survey revealed a higher prevalence of exotic species compared to native ones. Of the total identified individuals, 25 are exotic in origin, and only 1 is native, as shown in Table 1.

Table 1. Quantitative relationship of species composing the urban forestry of José Alves de Oliveira School, Ipaumirim, CE.

Commun Name	Scientific Name	N°	%	Origin
Ficus	*Ficus benjamina L.*	5	19.20	Exotic
Indian Neem	*Azadirachta indica A. Juss*	20	76.90	Exotic
Papaya	*Carica papaya*	1	3.90	Native
Total	**3 species**	**26**	**100.00**	**-**

The values presented correspond to 96.10% and 3.90%, respectively, as illustrated in Figure 2.

The results presented regarding the origin of species corroborate the study conducted in two neighborhoods of the municipality of Picos, Piauí, analyzed by Coelho Júnior et al.

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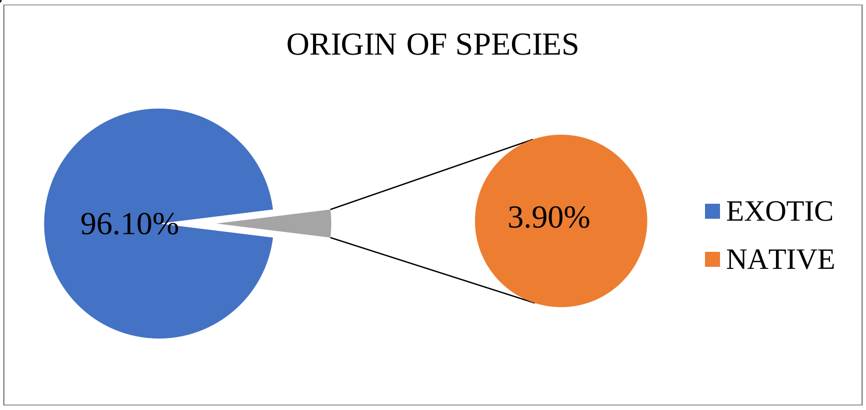
(2023), in which exotic trees account for 98.9% of urban tree cover, while native species represent only 1.1% of the individuals. These findings are concerning, as exotic species, being plants from other regions that were not originally part of the studied environment, have been introduced and now dominate most of the vegetation comprising the urban tree cover of northeastern cities. However, widely documented discrepant results demonstrate a balance in species origin, as observed by Assunção et al. (2014), where 58% of the tree cover consisted of native species and 42% of exotic ones.

Figure 2. Percentage referring to the origin of the individuals in the urban forestry of José Alves de Oliveira School, Ipaumirim, CE.



The tree individuals composing the existing urban tree cover at the school under study are described in Table 1. Among these, 20 belong to the species Azadirachta indica (Figure 3), accounting for 76.90% of the total. This results in an urban tree cover predominantly composed of a single species, displaying characteristics of homogeneous vegetation. Comparing the percentage per tree species, it becomes evident that the school's tree cover is below the recommended standard. It is advised that no single species, regardless of origin, should represent more than 15% of the total tree population in an urban area (Brandão et al., 2011).

It is important to emphasize that the use of these exotic species occurs due to their rapid growth, regular trunks when well-managed, and large, dense canopies that provide shade, making them a viable alternative in urban planning. However, this comes with negative consequences, particularly for birdlife and other species. Neem, for example, has stood out as a frequent choice for urban tree cover due to its remarkable adaptability and ease of development. With its rapid growth, it meets the demand for shade in a short period. Nevertheless, it is crucial to note that amidst these positive aspects, some problems associated with this species may go unnoticed. Azadirachta indica, known as Neem, exhibits a highly aggressive tendency towards territorial invasion, which warrants attention when considering its use (Moura et al., 2017).

Figure 3. Azadirachta indica A. Juss. (Indian Neem). Exotic species most commonly found in the tree cover of José Alves de Oliveira School, Ipaumirim, CE.

Source. Authors’ collection, 2024.

The other plant species found as part of the school's tree cover are Ficus benjamina (Figure 4), representing 19.20%, and Carica papaya (Figure 5), accounting for 3.90%.

Figure 4. Ficus benjamina L. (Ficus). Exotic species found in the tree cover of José Alves de Oliveira School, Ipaumirim, CE.

Source. Authors’ collection, 2024.

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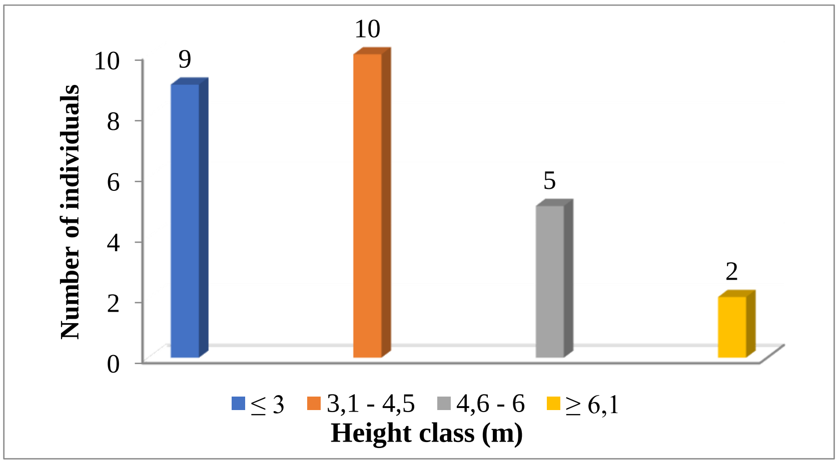
Figure 5. Carica papaya (Papaya). The only native species found in the tree cover of José Alves de Oliveira School, Ipaumirim, CE.

Source. Authors' collection, 2024.

It can be observed that Ficus trees constitute the majority of green areas when analyzing inventories related to tree cover, according to Silva et al. (2022) in their study on the urban tree survey in the municipality of Aperibé/RJ. The authors report that Ficus is one of the four most frequent species present in the studied urban green area.

Other observations pertain to the total height of the trees, where only 2 individuals (7.70%) demonstrated growth exceeding 6 m, while 24 (92.30%) displayed a height equal to or less than 6 m (Figure 6), indicating the recent planting of trees in the region.

Figure 6. Height classes of the individuals present in the tree cover of José Alves de Oliveira School, Ipaumirim, CE.



In a study conducted by Calixto Junior et al. (2009), it was found that 95.5% of the individuals had a height equal to or less than 10 m, a fact attributed to the recent tree planting in the city. Sales et al. (2023), when analyzing the total height of tree individuals, pointed out

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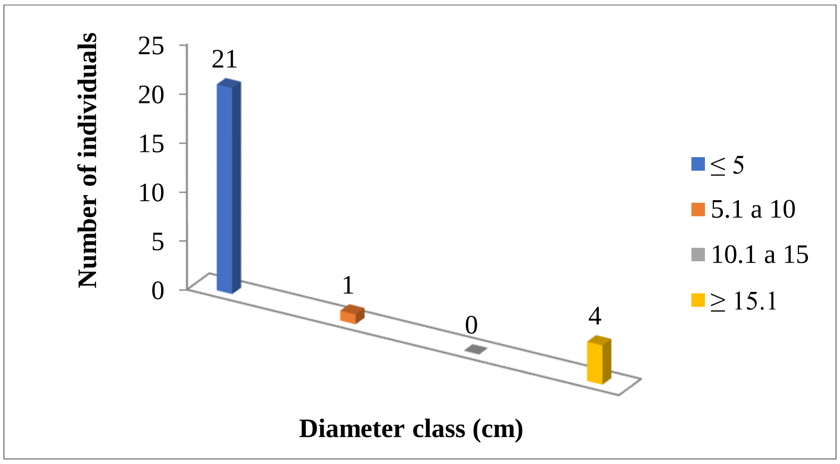
that over 70% of the individuals were small-sized, young, indicating that urban vegetation was still in the development stage.

Regarding DBH (Diameter at Breast Height), about 84.62% of the trees (22 individuals) had a DBH of 10 cm or less, no individual showed a DBH between 10.1 and 15 cm, and 15.38% (4 individuals) had a DBH greater than 15.1 cm (Figure 7).

Figure 7. Diameter classes of the individuals present in the tree cover of José Alves de Oliveira School, Ipaumirim, CE.



Discrepant results were observed by Calixto Junior et al. (2009) in a study conducted in the city of Lavras da Mangabeira, where about 46% of the trees had a DBH smaller than 10 cm. Moura et al. (2017) also reported in their research that approximately 30.2% of the trees had a DBH of 10 cm or less. Conversely, opposing data were identified in a study conducted in the Santo Antônio neighborhood, in the city of Pombal, state of Paraíba, where over 92% of the individuals had a diameter greater than 25 cm, representing a tree cover predominantly composed of mature trees (Rodolfo Júnior et al., 2008).

CONCLUSIONS

The arborization of Escola José Alves de Oliveira shows low species diversity, predominantly composed of exotic trees such as Neem (Azadirachta indica). Most of the trees are small, indicating that they are young and were planted without considering scientific criteria. The selection of species was primarily based on their rapid growth and ability to provide shade, neglecting the negative impacts on local flora and fauna.

To improve the quality of arborization, it is recommended to increase the proportion of native trees and promote greater floristic heterogeneity. The selection of species should consider the specific conditions of the region, such as drought tolerance, heat resistance, and

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adaptation to poor soils. Native species like Pau Brasil (Paubrasilia echinata), Canafístula (Peltophorum dubium), and Brasileirinho (Erythrina indica-picta) are examples that can contribute to local biodiversity.

Furthermore, soil management practices, such as adding organic matter to improve its structure and water retention, should be implemented. Environmental education for the population, combined with effective planning and monitoring by responsible authorities, is essential to reverse the loss of native species, especially fruit trees that traditionally characterize the natural environment of the region.

Finally, proper planning should prioritize local biodiversity, ensuring the preservation of vegetation and ecological balance. These actions can transform urban arborization into a functional and aesthetically integrated element of the environment, promoting quality of life and sustainability.

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REFERENCES

1. Abebe, M. G. (2024). Impacts of urbanization on food security in Ethiopia: A review with empirical evidence. Journal of Agriculture and Food Research, 15, 100997. https://doi.org/10.1016/j.jafr.2024.100997.

2. Ai, H., & Zhou, Z. (2023). Green growth: The impact of urban forest construction on economic growth in China. Economic Modelling, 125, 105076. https://doi.org/10.1016/j.econmod.2023.105076.

3. Angelis, B. L. D., Castro, R. M., & Angelis Neto, G. (2004). Metodologia para levantamento, cadastramento, diagnóstico e avaliação de praças no Brasil. Engenharia Civil, 4, 57–70.

4. Antunes, L., & Santos, R. C. (2023). Análise qualiquantitativa da arborização das vias públicas pavimentadas e da praça do santuário Nossa Senhora da Saúde do município de Tupanci do Sul/RS. Revista Gestão e Sustentabilidade Ambiental, 12, 1–20.

5. Araújo, Y. R. V., & Moreira, Z. C. G. (2015). Composição florística, fitogeografia e diversidade da arborização urbana implantada em 2011-2013: Uma análise da cidade de João Pessoa, PB, BR. Revista Científica Eletrônica de Engenharia Florestal, 25(1).

6. Assunção, K. C., Luz, P. B., Neves, L. G., & Sobrinho, S. P. (2014). Levantamento quantitativo da arborização de praças da cidade de Cáceres/MT. Revista da Sociedade Brasileira de Arborização Urbana, 9(1), 123–132.

7. Barros, A. P. S., Azevedo, A. C. J., Dias, E. R. S., & Oliveira, H. M. P. de. (2017). Planejamento urbano, áreas verdes e qualidade de vida: Uma análise comparativa entre os bairros Terra Firme e Cidade Velha – Belém/PA. Revista Eletrônica Geoaraguaia, 7(2), 68–85.

8. Blum, T. T., Borgo, M., & Sampaio, A. C. F. (2008). Espécies exóticas invasoras na arborização de vias públicas de Maringá-PR. Revista da Sociedade Brasileira de Arborização Urbana, 3(2).

9. Brandão, I. M., Gomes, L. B., Silva, N. C. A. R., Ferraro, A. C., Silva, A. G., & Gonçalves, F. G. (2011). Análise qualiquantitativa da arborização urbana do município de São João Evangelista-MG. Revista da Sociedade Brasileira de Arborização Urbana, 6(4), 158–174.

10. Calixto, S. L. (2009). Análise quantitativa da arborização urbana de Lavas da Mangabeira, CE, Nordeste do Brasil. Revista da Sociedade Brasileira de Arborização Urbana, 4(3), 99–109.

11. CIDADE-BRASIL. (2023). Município de Ipaumirim. Disponível em: https://www.cidade-brasil.com.br/municipio-ipaumirim.html. Acesso em 4 setembro 2023.

12. Coelho Júnior, W. P., Oliveira, Y. R., Barbosa, F. S. Q., Pacheco, A. C. L., Bendini, J. N., & Abreu, M. C. (2023). Análise da arborização urbana de dois bairros do município de Picos, Piauí. Revista Valore, 8, e-8037.

13. Davidovits, P. (2025). Chapter 11 - Heat and life. In Physics in Biology and Medicine (6th ed., pp. 159–187).

14. Duarte, T. E. P. N., Angeoletto, F., Richard, E., Vacchiano, M. C., Leandro, D. S., Bohrer, J. F. C., Leite, L. B., Santos, M. C. J. W. (2017). Arborização urbana no Brasil: Um reflexo de injustiça ambiental. Terr@Plural, 11(2), 291–303. Disponível em: https://revistas.uepg.br/index.php/tp/article/view/9677. Acesso em 18 outubro 2023.

15. Farinha, M. J. U. S., Berezuk, A. G., Filho, A. S., Silva, L. F., Ruviaro, C. F., & Bernardo, L. V. M. (2024). Public environmental actions and urban land use planning in the Central-West region of Brazil. Urban Forestry & Urban Greening, 92, 128209. https://doi.org/10.1016/j.ufug.2024.128209.

16. Frigerio, J., Capotorti, G., Vico, E. D., Larbi, M. O., Grassi, F., Blasi, C., Labra, M., & Nissim, W. G. (2023). Tree tracking: Species selection and traceability for sustainable and biodiversity-friendly urban reforestation. Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology, 157(4), 920–934.

17. Guo, J., Hong, D., & Zhu, X. X. (2024). High-resolution satellite images reveal the prevalent positive indirect impact of urbanization on urban tree canopy coverage in South America. Landscape and Urban Planning, 247, 105076. https://doi.org/10.1016/j.landurbplan.2024.105076.

18. IBGE - Instituto Brasileiro de Geografia e Estatística. (2023). Censo Brasileiro de 2022. Ipaumirim-CE: IBGE. Disponível em: https://cidades.ibge.gov.br/. Acesso em 18 outubro 2024.

19. Jin, L., & Song, Y. (2023). Forest landscape connectivity to prioritize afforestation in urban ecosystems: Seoul as a case study. Urban Forestry & Urban Greening, 90, 128122. https://doi.org/10.1016/j.ufug.2023.128122.

20. Lisboa, M. A. N., Silva, L. V. A., Nascimento, A. S., Silva, A. O., Teixeira, M. R. A., Ferreira, M. F. R., Ferreira, S. C., Silva, A. C. V., Colares, A. V., & Calixto Júnior, J. T. (2024). Diversity, structure, and carbon sequestration potential of the woody flora of urban squares in the Brazilian semiarid region. Trees, Forests and People, 16, 100561. https://doi.org/10.1016/j.tfp.2024.100561.

21. Moura, I. A. A., Lopes, R. M. B. P., Nacimento, J. F., Silva, I. B., Thomas, H. Y., Silva, M. C. D. (2017). Arborização de Quitaiús, Lavras da Mangabeira, Ceará, Nordeste do Brasil: Levantamento quantitativo. In Anais do Congresso Brasileiro de Gestão Ambiental e Sustentabilidade – CONGESTAS, 5, 240–248. João Pessoa. Disponível em: http://eventos.ecogestaobrasil.net/congestas2017/trabalhos/pdf/congestas2017-et-01-027.pdf. Acesso em 5 setembro 2024.

22. Qiu, D., Xu, R., Wu, C., Mu, X., Zhao, G., & Gao, P. (2022). Vegetation restoration improves soil hydrological properties by regulating soil physicochemical properties in the Loess Plateau, China. Journal of Hydrology, 609, 127730. https://doi.org/10.1016/j.jhydrol.2022.127730.

23. Rodolfo Júnior, F., Melo, R. R., Cunha, T. A., & Stangerlin, D. M. (2008). Análise da arborização urbana em bairros da cidade de Pombal no Estado da Paraíba. Revista da Sociedade Brasileira de Arborização Urbana, 3(4), 3–19.

24. Sales, D. C. M., Rodrigues, N. M. M., Luz, A. L. S., Duarte, V. B. R., Freitas, J. M. N., & Pessoa, A. C. (2023). Arborização no Centro Urbano de Santo Antônio do Tauá, Pará. Revista Científica Eletrônica de Engenharia Florestal, 18(1), 19–30.

25. Silva, L. R., Meunier, S. M. J., & Freitas, A. M. M. (2007). Riqueza e densidade de árvores, arvoretas e palmeiras em parques urbanos de Recife, Pernambuco, Brasil. Revista da Sociedade Brasileira de Arborização Urbana, 2(4), 34–49.

26. Silva, N. C., Thomé, M. P. M., & Thomé, C. C. S. V. (2022). Levantamento da arborização urbana em cinco bairros do município de Aperibé – RJ. Revista Ibero-Americana de Humanidades, Ciências e Educação, 8(9), 1207–1220.

27. Tian, F., Zhu, Z., Cao, S., Zhao, W., Li, M., & Wu, J. (2024). Satellite-observed increasing coupling between vegetation productivity and greenness in the semiarid Loess Plateau of China is not captured by process-based models. Science of The Total Environment, 906, 167664. https://doi.org/10.1016/j.scitotenv.2023.167664.

28. Zea, C. J. D., Barroso, R. F., Souto, P. C., Souto, J. S., & Novais, D. B. (2015). Levantamento e diversidade da arborização urbana de Santa Helena, no semiárido da Paraíba. Agropecuária Científica no Semiárido, 11(4), 54–62.