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URBAN AFFORRESTATION AND SUSTAINABILITY: STRATEGIES FOR GREEN PLANNING IN UNIVERSITY SPACES

ARBORIZAÇÃO URBANA E SUSTENTABILIDADE: ESTRATÉGIAS PARA O PLANEJAMENTO VERDE NO ESPAÇO UNIVERSITÁRIO

ASEQUIBILIDAD Y SOSTENIBILIDAD URBANAS: ESTRATEGIAS PARA LA PLANIFICACIÓN VERDE EN ÁREAS UNIVERSITARIAS

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Abstract: Areas within Brazilian universities that have open spaces need to become more biodiverse places with better resilience to climate change. Several recent studies have concluded that afforestation brings very important benefits to improving the urban microclimate, which go beyond social and aesthetic benefits. Throughout the history of city development, vegetation was used by landscape architecture to create scenes and spaces where society carried out its activities. Even today, some urban planners and decision makers approach urban afforestation mainly from this perspective. This work aims to discuss the need for a more interdisciplinary approach to urban afforestation within the campus of the

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Federal University of Mato Grosso do Sul, which involves the concepts of biology, urban climatology and green infrastructure, seeking to achieve a better-quality urban space facing climate change.
Keywords: Urban Afforestation, Urban Planning, Green Infrastructure, Landscape Architecture, Climate Change.

Resumo: As áreas dentro das universidades brasileiras que possuam espaços livres têm a necessidade de se tornar locais mais biodiversos e com melhor capacidade de resiliência às mudanças climáticas. Diversas pesquisas recentes concluíram que a arborização traz benefícios muito importantes à melhoria do microclima urbano, que vão além dos benefícios sociais e estéticos. Ao longo da história de desenvolvimento das cidades, a vegetação foi utilizada pela arquitetura paisagística para compor cenários e espaços onde a sociedade desempenhava suas atividades. Ainda hoje, alguns planejadores urbanos e tomadores de decisão abordam a arborização urbana principalmente por esse viés. Esse trabalho pretende discutir a necessidade de uma abordagem mais interdisciplinar para a arborização urbana dentro do campus da Universidade Federal de Mato Grosso do Sul, que envolva os conceitos da biologia, da climatologia urbana e da infraestrutura verde, buscando alcançar um espaço urbano de melhor qualidade frente às mudanças climáticas.
Palavras-chave: Arborização Urbana, Planejamento Urbano, Infraestrutura Verde, Arquitetura Paisagística, Mudanças Climáticas.

Resumen: Las áreas dentro de las universidades brasileñas que cuentan con espacios abiertos necesitan aumentar su biodiversidad y resiliencia al cambio climático. Diversos estudios recientes concluyen que la forestación urbana aporta importantes beneficios para la mejora del microclima urbano, que van más allá de los beneficios sociales y estéticos. A lo largo de la historia del desarrollo urbano, la vegetación ha sido utilizada por la arquitectura paisajística para componer escenarios y espacios donde la sociedad desarrolla sus actividades. Incluso hoy en día, algunos urbanistas y tomadores de decisiones abordan la forestación urbana principalmente desde esta perspectiva. Este artículo busca discutir la necesidad de un enfoque más interdisciplinario para la forestación urbana en el campus de la Universidad Federal de Mato Grosso do Sul, que involucre los conceptos de biología, climatología urbana e infraestructura verde, buscando lograr un espacio urbano de mejor calidad frente al cambio climático.

Palabras clave: Forestación urbana, Planificación urbana, Infraestructura verde, Arquitectura

paisagística, Cambio climático

INTRODUCTION

Improving the quality of spaces in schools and universities, addressing global warming, and fostering environmentally conscious values and attitudes has become one of the greatest challenges facing humanity in the Contemporary Age.

Much research has been done on the presence of urban trees in contemporary cities, and some challenges have been identified. The question of how urban trees can be useful for adapting to the effects of climate change is a constantly evolving challenge for the various stakeholders involved in decision-making regarding spatial development.

Several researchers have recently concluded on the benefits of urban afforestation for the microclimate, including Shinzato (2009), Dobbert and Zanlorenzi (2014), and Mascarello, Barbosa, and Assis (2017). Despite this, some members of society, urban planners, and decision-makers still have limited awareness or understanding of the extent of trees' influence on the urban fabric. It is widely recognized that environments with vegetation provide a sense of well-being, promoting rest and relaxation. However, when urban afforestation on roads and within open university spaces, beyond parks and squares, is addressed, especially in relation to climate change, several knowledge gaps emerge, highlighting the disparity between existing knowledge and that held by planners and decision-makers.

According to Assis (2005), despite the current recognition of the relevance of urban climatology in planning and preserving the environmental quality of urban centers, its effective inclusion in planning proposals and practices remains quite limited. This is largely due to the division between different fields of knowledge. The author also highlights that most studies conducted in this area are descriptive studies, which limits the applicability of their results and recommendations to the specific context analyzed.

The guidelines originating from such work are, predominantly, very generic, which makes it difficult to incorporate their results into the day-to-day work of urban planners.

Throughout the evolution of cities, the implementation of urban afforestation played a fundamental role in creating spaces for contemplation and leisure. Macedo (1999) points out that, initially, urban green spaces were concentrated in the gardens of royal residences; however, in the early 19th century, social pressures led to the incorporation of vegetation in places accessible to the general population, allowing the "common inhabitant" to enjoy contact with nature—a practice highly valued at the time. The author also notes that the history of landscape architecture reveals how the social demands of each period shaped the way of

inhabiting and conceiving the city, consequently influencing the way urban afforestation was implemented.

The social and urban transformations resulting from the Industrial Revolution, technological advancements, and economic fluctuations significantly impacted the organization of urban centers. In Silent Spring (1969), Rachel Carson scathingly criticized the harmful effects of pesticide use in the United States, advocating for the preservation of nature, the protection of human life, and the right to health and quality of life (BONZI, 2013). Carson's work was a landmark in the strengthening of environmental movements, which began to disseminate a new worldview based on a harmonious relationship with nature, rejecting the idea of antagonism between humans and the environment.

It is with this perspective that nations discuss, through global agreements (Paris Agreement in 2015, Kyoto Protocol in 1998, among others), how to mitigate the negative effects resulting from excessive consumption and unsustainable development, aiming for more environmentally sound and livable societies and cities. Roaf , Crichton and Nicol (2009) comment that if the international community had acted more firmly in the 1970s, when the challenges to be faced became evident, perhaps we would not be facing such a difficult situation today.

The need to act on the effects of climate change is becoming increasingly pressing. According to the World Meteorological Organization (WMO, 2023), 2023 tied with 2015 and 2016 as the three warmest years on record. Climate change poses serious risks to human life in contemporary cities, and a central challenge is to bring this debate to the municipal level.

Mitigation measures—aimed at reducing the causes of global warming—are essential, but they must be accompanied by adaptation strategies that mitigate the impacts on urban areas, increasing their resilience. Temperature fluctuations, changes in rainfall patterns, and reduced wind circulation are already affecting the daily lives and dynamics of cities, making discussions about sustainable development and urban resilience increasingly frequent.

In this context, concepts originating from biology, urban climatology, and biodiversity are being integrated into urban planning, which for a long time was limited to a landscape approach focused solely on creating scenarios for relaxation and well-being.

From this perspective, the objective of this work is to reflect on the role of afforestation in today's cities, contrasting it with the traditional, more landscape-oriented approach and considering the need to prepare cities for the effects of climate change.

LITERATURE REVIEW

Urban Afforestation

The central purpose of urban afforestation is to integrate natural elements, such as trees and other vegetation, into the landscape of cities dominated by buildings, helping to alleviate the discomfort generated by this built environment. Trees, with their natural characteristics, play an important role in promoting human well-being by positively influencing the urban microclimate. Benefits include: reducing temperature variations, enhancing the aesthetic and architectural value of urban spaces, providing shelter for wildlife, improving air quality, mitigating noise pollution, and creating shaded areas for pedestrians (SILVA FILHO et al., 2002).

One of the most important benefits that afforestation can provide is physical and mental well-being, reducing the feeling of oppression that humans experience in the face of architectural constructions (DANTAS; SOUZA, 2004). Furthermore, Pivetta and Silva Filho (2002) state that trees generate greater psychological well-being, which contributes to the reestablishment of the human-nature relationship, thus contributing to an improvement in quality of life. According to research conducted by Embrapa Meio Ambiente (2011), well-implemented and managed afforestation is also associated with a longer life expectancy, lower blood pressure, lower rates of diabetes and cholesterol, and less stress and irritability.

According to Silva (2008), trees mitigate surface runoff on paved roads, as they intercept rainwater, thereby reducing flooding.

Economic, social, and quality-of-life losses in urban communities can be attributed to the discomfort experienced, especially in large cities. Regarding climatic quality, significant differences in weather patterns can be observed when urban settings are compared to rural settings, indicating that climate is truly influenced by urban structures and buildings (PEZZUTO, 2007).

Among the benefits offered by a good urban afforestation plan, the improvement in thermal comfort stands out, attenuating much of the incident radiation. Therefore, the implementation and/or maintenance of green areas within cities is essential, especially in tropical countries, to mitigate high temperatures and thermal discomfort.

According to research by Embrapa Meio Ambiente (2011), each tree is capable of transpiring, on average, 0.3 liters of water per cubic meter of canopy. Considering a large tree, over 10 meters tall and with an average canopy of 120 m³, this amount can reach up to 400 liters of water released per day. This process contributes significantly to increased air humidity a

factor directly related to improved thermal comfort. A practical example is observed in the city of São Paulo: in the Morumbi neighborhood, which has a high vegetation density, temperatures can be up to 10°C lower and relative humidity up to 30% higher compared to the Itaquera neighborhood, which has a low tree cover.

According to Labaki et al. (2011), trees block a large portion of incident radiation, reducing the amount of radiation that hits buildings and paving. Vegetation provides cooling through shading and evapotranspiration. Shading attenuates incident solar radiation and, consequently, surface heating, reducing temperatures.

Gomes and Amorim (2003) describe better climate indices, and consequently, milder thermal conditions in areas of the city that approach the normal conditions found in nature, compared to the more artificialized areas of the same location.

The presence of trees in urban areas contributes significantly to improving quality of life, especially when compared to regions with little vegetation cover. The benefits of trees in urban contexts are widely recognized. However, integrating vegetation into the urban environment is not a simple task, considering that this space does not represent an ideal habitat for plant development. Therefore, knowledge of the characteristics of plant species, obtained through inventories, is essential as a basis for appropriate tree planting planning (SILVA et al., 2007).

The benefits generated by urban afforestation are directly dependent on the quality of the planning employed. Regardless of the size of the city, well-planned urban forestry facilitates the process of planting new trees (Pivetta; Silva Filho, 2002).

According to Bortoleto et al. (2006), many Brazilian cities lack adequate urban afforestation planning, as many projects are based on empirical methods, lacking any real knowledge of the subject. As a result of this inadequacy, the urban afforestation projects implemented are ineffective, as the benefits that could be provided to the population are not realized.

Tree planting projects must, as a basic characteristic, respect the environmental, cultural and historical values of the city (Lindenmayer; Santos, 2008). These projects must be sustainable from an environmental, cultural, social and economic point of view (Diefenbach; Viero, 2010).

By mirroring, it is possible to think of territories as fundamental functional units of urban ecology: “the territory is understood as a substrate/stage for the realization of human life, synonymous with soil/land and other natural conditions, fundamental to all peoples” (SAQUET, 2007).

Vegetation in Brazilian Cities

To begin the discussion, the study examines the vegetation present in 19th-century cities based on a literature review, highlighting the contributions of Kliass (1993) and Macedo (1999). The latter traces a timeline of the urban landscape in Brazil, strongly marked by European influences and social transformations. Understanding how the urbanization process and the use of trees unfolded throughout history is fundamental to analyzing the evolution of landscape design to the present day.

To this end, Macedo (1999) will be the main theoretical basis used to characterize the development of cities and the relationship between society and wooded spaces, as his analyses are of great relevance to the topic.

Current knowledge about global warming distinguishes 21st-century cities from those of previous periods and, by extension, redefines the way urban space is produced. In this context, we discuss how climate change alters urban planning and how urban afforestation can be incorporated as a strategy, applying principles of biology and urban climatology, thus reinforcing the interdisciplinary nature of spatial production. We also include the concept of green infrastructure, formulated by Benedict and McMahon (2009), which is currently widely researched and has introduced new perspectives to the discussion.

Cities, Society and Landscape Architecture

Kliass (1993) notes that between the 1850s and 1860s, parks gained a place in France's urban structure, following Baron Haussmann's plan to redesign the entire center of Paris. He established a park system consisting of green areas at different scales, interconnected by grand avenues called boulevards , reusing forests that had belonged to the Crown, and creating a series of other parks. To this day, the idea of the Parisian boulevard inspires urban planning in many cities around the world.

In the Americas, the idea of urban parks spread through the American Parks Movement. Landscape architect Frederick Law Olmsted (1822-1903) had a major influence on the design of American cities by incorporating parks into the urban structure through the use of their scenic potential. One of his most internationally recognized parks is Central Park in New York.

Macedo (1999) studies the process of development of landscape architecture throughout Brazilian history and it is possible to see how changes in society influenced the way of thinking and building the city, especially when it comes to public space and green areas.

The process of urban open space formation, and therefore landscape architecture, in

Brazil was not the result of an urgent social need, according to Macedo (1999), because in its first three centuries of existence it was a simple Portuguese colony and experienced incipient urbanization. The local population of the cities that were formed had a constant relationship with Brazil's tropical nature, as much of the urbanization developed along the coast and within the Atlantic Forest.

In more established Brazilian cities, urban vegetation became more prominent in the courtyards and gardens of urban homes, with flowers, vegetables, and fruit. At the end of the 18th century, the city of Rio de Janeiro was elevated to Viceroyalty, and its population became more stable. Macedo (1999) notes that in 1783, in the Lapa neighborhood, the country's first modern and well-maintained public space, the Passeio Público, was created. The creation of this park helped improve local living conditions in the region, which would be intensely urbanized in the following decades. For the first time, the colonial government focused on open, modern space and urban leisure. It signaled a new way of using public spaces. At that time, botanical gardens, landscaped squares, and the design of European cities influenced Brazilian landscape architecture.

Macedo (1999) explains that in the 1920s, green and public spaces also served as spaces for sports, largely due to the popularization of soccer among all social classes. This shifted from simply contemplating nature to socialized leisure.

The use of native and tropical vegetation by Roberto Burle Marx (1909-1994) marks landscape architecture by giving value to the natural vegetation of Brazil, since tropical vegetation did not follow the European standards followed until then in the production of urban space.

With the rising cost of living in the city, the mobility of the population that used to travel during vacations to their beach and country homes decreased. The population began to stay longer in the city and, consequently, seek out leisure activities closer than their seasonal residences. Macedo (1999) notes that there was an increase in the number of public and private clubs offering leisure and sports options, but the most accessible leisure option for the majority of the population was urban parks.

This situation demonstrates that modern urban parks are far more popular than the older parks, which were reserved for the elite. Activities such as cycling, the construction of the first bike paths, and outdoor running have reinvigorated use and increased demand. From the 1970s and 1980s onward, the number of new parks grew in all Brazilian urban centers.

The first major modern park built in Brazil was Ibirapuera Park in São Paulo. Due to its size, location, and sociocultural significance, the park has become a landmark landscape for

both the city of São Paulo and the country as a whole.

The 90s definitively mark the emergence of a new rupture in Brazilian landscape architecture, with its landmarks being Praça Itália (1990) in Porto Alegre, Parque das Pedreiras (1989) and the Botanical Garden (1991), both in Curitiba, Parque das Nações Indígenas (1993), with 1,163,876.98 m^2, was created in Campo Grande and has relevant importance in the city's leisure, culture, sport and tourism.

Breaks with the past aren't just formal. The use of open urban spaces takes on new forms and functions, with spaces serving a specific purpose, such as a food court or simply for scenic purposes. A diversification of activities within a single location is evident on beach promenades, where a wide range of facilities support the diverse activities of the population.

During that period, trees ceased to be the central element of landscaping, becoming an integral part of the landscape. Both in Brazil and abroad, parks and public spaces experienced important milestones in their evolution, emerging from the demands of the population or from the practices of landscape architecture. Their implementation brought about transformations in the surroundings and improved the quality of life for users. The relationship between the working classes and these urban parks remains evident today, as these spaces have public infrastructure, are open to all, and do not charge admission, requiring only the cost of transportation.

Since the 1970s, ecological principles, which initially emerged as a response to the severe environmental consequences of the post-war period, have gained greater prominence in more recent park projects, which incorporate expanded functions such as the recovery and preservation of water sources, native forests, and ecosystems. The restoration of natural environments within cities is concentrated primarily in urban and linear parks. At the same time, urban street trees continue to play an essential role in beautifying streets to this day.

The lack of space in the urban network and the need to make it more environmentally friendly sparks interest in studying urban street trees due to the existence of several knowledge gaps on this topic. Mascarello, Barbosa, and Assis (2017) studied street trees in the city of Pará de Minas, Minas Gerais, as the authors consider this type of urban tree planting to be the most democratic and accessible to the general population.

Climate-Sensitive Urban Planning: Afforestation as a Resource

The fundamental principles of urban planning include prevention, mitigation, and preparedness, as established by the WMO (1996). According to this organization, urban design that respects the specific characteristics of the location can prevent environmental risks and

disasters, reduce their impacts if such events occur, and prepare the population for possible future situations. Higueras (2006) emphasizes the importance of adapting urban layouts to unique climatic and territorial conditions, recognizing that each geographic context demands its own unique urban model.

Given the needs of contemporary cities, especially in the face of climate change, new approaches to urban forestry have been studied and debated by researchers. Silva (1974) emphasizes that the modern city, in facing its challenges, recognizes the importance of green spaces not only as ornamental elements but also as essential resources for hygiene, leisure, and environmental restoration in the face of the degradation caused by urbanization. Furthermore, street trees play important roles in reducing noise, fixing and retaining dust particles, and renewing oxygen in the air.

Urban planning sensitive to local environmental issues must consider the presence and positive influence of urban trees on the urban microclimate to develop strategies for adaptation and increased urban resilience. Mascarello, Barbosa, and Assis (2017) state that urban trees are extremely important for mitigating temperature, improving soil permeability, and increasing humidity through winds, in addition to providing social and landscape benefits.

Duarte (2010) indicates that, from the point of view of human comfort, smaller parks with trees, but in greater numbers in the urban area, are capable of having a greater influence on the microclimate than just a centralized park.

Duarte (2015) highlights that conserving a significant and interconnected vegetation mass through small parks and tree-lined avenues, forming a green infrastructure network in urban areas, is an effective strategy to promote adaptation to climate conditions, creating the so-called “oasis effect” during heat waves.

The concept of green infrastructure has its roots in various initiatives to organize green areas, isolated or integrated, that have emerged since the Industrial Revolution with the aim of minimizing environmental and social impacts on cities (MADUREIRA, 2012).

According to Benedict and McMahon (2009), this infrastructure consists of an interconnected network of natural areas and open spaces that aims to preserve the values and functions of ecosystems, acting not only in the conservation of green areas, but also in mitigating the adverse effects caused by urban growth.

Furthermore, the authors argue that green infrastructure surpasses other traditional forms of environmental conservation by reconciling biodiversity preservation with the demands of urban development. In this sense, urban street trees serve as a connecting link between the large green areas existing in the urban fabric, which generally include parks and tree-lined

squares.

Although green infrastructure offers environmental strategies and potentially positive impact on urban planning, this concept faces challenges from both a biological and urban perspective. Schutzer (2014) emphasizes that the topic of green infrastructure is still treated in a highly fragmented manner, as society, technical staff, and public administrators are still tied to traditional organizational structures for urban space production, where the environment is viewed as secondary to the traditional infrastructure necessary for a city's development, such as sanitation, electricity, and road networks, among others.

The concept of green infrastructure presents itself as a good resource for optimizing the influence of trees on the urban microclimate, but researchers are studying in depth how to use the concept in a way that is effectively efficient.

MATERIALS AND METHODS

This study's methodology was structured to evaluate urban forestry on the Campo Grande Campus of the Federal University of Mato Grosso do Sul, focusing on identifying, analyzing, and proposing strategies to improve quality of life and the urban environment. The methodological approach was divided into three main stages: data collection, qualitative and quantitative analysis, and development of intervention proposals.

Data Collection

The first step was to conduct a data survey on the current state of campus tree cover. The following methods were used to accomplish this:

- **Forest Inventory:** An inventory of existing tree species was conducted using a standardized methodology that included species identification, diameter at breast height (DBH) measurements, tree height, and phytosanitary conditions. Measurements were taken in representative areas of the campus, ensuring a diverse sample.
- **Document Analysis:** Institutional documents, such as master plans and existing landscaping projects, were analyzed to understand established guidelines for campus tree planting. This analysis also included a literature review on urban forestry and its implications for thermal comfort and well-being.

Qualitative and Quantitative Analysis

After collecting the data, qualitative and quantitative analyses were carried out to assess the benefits of existing afforestation and identify gaps in current practices:

Quantitative Analysis: The data collected in the inventory were used to calculate indicators such as tree density, species diversity, and vegetation cover. These indicators were compared with standards recommended in the literature on urban forestry.

- **Qualitative Analysis:** Semi-structured interviews were conducted with members of the academic community (students, faculty, and staff) to gather their perceptions of existing tree planting, its importance to well-being, and suggestions for improvements. The interviews were recorded, transcribed, and analyzed using content analysis.

Preparation of Intervention Proposals

Based on the analyses carried out, intervention proposals were drawn up to optimize the afforestation on campus:

- **Development of an Afforestation Plan:** A strategic plan was developed with specific recommendations on planting new tree species, maintaining existing trees, and creating green areas that promote thermal comfort and biodiversity.
- **Educational Proposals:** Educational actions were suggested that aim to raise awareness within the academic community about the importance of urban afforestation, including workshops and information campaigns.
- **Continuous Monitoring:** The implementation of a continuous monitoring system of tree health and the effectiveness of proposed interventions was recommended to ensure the sustainability of the project over time.

This methodology aims not only to understand the current situation of urban afforestation on the Campo Grande Campus, but also to contribute with practical solutions that promote a healthier and more sustainable urban environment.

RESULTS AND DISCUSSION

Diversity of Tree Species on Campus

The forest inventory conducted on campus revealed the identification of several tree species, totaling a significant number of measured individuals. Among the observed species, three stand out as the most common, representing a considerable percentage of the total trees. Species diversity was assessed using a specific index, which indicated a moderate level of diversity. This index is important because it reflects the health of the ecosystem and its ability

to maintain balance.The diversity of tree species is crucial to the resilience of urban ecosystems. Each species plays a vital role in nature, contributing to ecological balance and ensuring protection against pests and diseases. Trees provide habitats for diverse life forms, help control climate change through gas exchange with the environment, and beautify urban spaces with their varied shapes, colors, and sizes.

Benefits of Afforestation

The presence of diverse tree species on campus directly impacts thermal comfort, as trees provide shade and help reduce ambient temperatures. This afforestation is essential for meeting human needs, making it a crucial consideration for public administrators and technicians who design public spaces. Furthermore, climate stability and environmental comfort promote improved air quality and the physical and mental health of the academic community, in addition to contributing to the reduction of noise and visual pollution.

The aesthetic benefits associated with arboreal diversity are remarkable. The variety of textures, colors, and shapes of trees enriches the urban environment, providing aesthetic pleasure and psychological well-being. This positively influences users' perception of the campus, breaking the monotony of the architectural landscape and creating new visual fields.

Tree Management and Planning

Information on tree species diversity is essential for improving campus tree planting planning. Greater diversity helps ensure protection against pests and diseases; it is recommended that no more than 10% of the same species be present in an area, 20% of a genus, and 30% of a botanical family. To increase this diversity, strategies such as adequate spacing between trees can be implemented; for example, considering a distance of 15 meters between trees, it would be possible to plant 133 trees along a one-kilometer stretch on both sides of the road.

Measures to protect and promote native species identified during the inventory are essential. These actions contribute to maintaining the hydrological cycle, soil fertility, protecting at-risk areas, and water quality. Furthermore, they help conserve local biodiversity by maintaining air quality and promoting carbon sequestration.

Perception of the Academic Community

The academic community's perception of the diversity of trees on campus is positive. Members recognize the benefits of adequate tree planting in urban areas, such as providing a

pleasant space for relaxation and promoting environmental preservation. Awareness of these benefits has been growing on several university campuses across Brazil.

To further foster this awareness, the academic community can actively engage in promoting and preserving tree diversity on campus through environmental education. Initiatives such as planting trees, recycling waste, spaying or neutering pets, and reporting environmental crimes are some of the recommended actions that can encourage this participation. Figure 1 shows photos of wooded areas at UFMS – Campo Grande Campus.



Figure 1: Images of the UFMS – Campo Grande Campus trees**.**
Source: Own authorship (2024).

Comments and Discussions

The results of this study highlight the importance of urban trees not only as an aesthetic element, but also as an essential component for the well-being of the academic community and the environmental sustainability of the campus. Implementing the proposed solutions could significantly contribute to improving the quality of life on the Campo Grande Campus, aligning with best practices recommended in the literature on urban trees.

This work also highlights the urgent need for adequate urban tree planning in educational institutions, promoting a harmonious relationship between humans and the environment. The continuation of this project must include systematic monitoring of the impacts of the interventions implemented, ensuring their effectiveness over time.

These reflections on afforestation, biodiversity, and their impacts are fundamental to improving quality of life and promoting sustainability in the urban environment.

Tree planting has long been linked to the issues that drive society in a given location. Their presence or absence, and their integration into cities, are the result of the customs of a given era, as cities are places of interaction between people. It's clear how landscape architecture has been shaped by and alongside societal development and how it has been

instrumental in contributing to the creation of pleasant urban environments. Twenty-first-century cities and their societies grapple with concerns about global warming and the effects of climate change, which are altering people's daily lives and will continue to do so. The need to adapt to these effects also requires that people, planners, and decision-makers approach the city with a different perspective than the traditional ones, as this situation is quite different from the challenges already faced by urbanization.

Topics such as biodiversity, urban resilience, mitigation, and adaptation have become frequent topics in discussions about climate change and 21st-century cities. Urban trees have been widely studied for their extremely important biological functions in improving the urban microclimate, in addition to their widely publicized social and aesthetic benefits.

Several researchers have concluded that urban trees are beneficial. Furthermore, recent studies demonstrate that urban trees, organized as a network of green areas and vegetated pathways strategically distributed throughout the urban fabric, interconnected to form green infrastructure, make urban trees a valuable resource in the need to make cities more biodiverse and more resilient to climate change.

Urban forestry has always been prominent throughout the history of global urbanization, including in Brazil. However, today, it's crucial to understand that it's not just an aesthetic resource for urban landscapes; it's also a natural resource that needs to be better studied to understand its biological function. Studies on this topic are progressing, but there are still many gaps in knowledge to fill.

As urban planning becomes increasingly interdisciplinary, it is clear that the concepts of urban biology and climatology must truly integrate the discussion of city construction to meet the demands of climate change, minimizing its effects on urban centers.

The aim is not to exhaust the discussion, but rather to participate in this debate of extreme importance for the advancement of science and filling knowledge gaps related to urban street trees.

CONCLUSION AND FUTURE PERSPECTIVES

Urban forestry on the Campo Grande Campus of the Federal University of Mato Grosso do Sul plays a fundamental role in promoting the physical and mental well-being of the academic community, in addition to contributing to improving local environmental conditions. This study demonstrated that the presence of trees not only beautifies urban spaces but also

provides significant benefits, such as reducing temperatures, increasing relative humidity, and promoting a more pleasant microclimate. The data collected highlight the need for more effective and sustainable urban forestry planning that considers species diversity and the specific conditions of the urban environment.

The analyses conducted indicate that, although there are wooded areas on campus, there is significant opportunity to improve vegetation cover and the health of existing trees. The intervention proposals developed in this work aim not only to restore and diversify tree vegetation but also to create new green spaces that encourage social interaction and recreational use, fostering a greater connection between users and the natural environment.

To ensure the effectiveness of the proposed interventions and promote sustainable management of campus trees, some future actions are recommended:

- **Implementation of the Tree Planting Plan:** The adoption of a strategic tree planting plan should be prioritized, focusing on the diversity of native species and those adapted to the local climate. This will not only increase the resilience of the urban ecosystem but also contribute to the preservation of regional biodiversity.
- **Continuous Monitoring:** Creating a system to continuously monitor tree health and the impact of interventions is essential. This will allow for adjustments in management practices and ensure that the benefits of afforestation are maintained over time.
- **Education and Awareness:** Promoting educational campaigns on the importance of urban forestry can raise awareness among the academic community. Active student participation in activities related to tree conservation and management can foster a sense of environmental responsibility.
- **Integration with Sustainable Projects:** Urban forestry should be integrated with other sustainable initiatives on campus, such as waste management, efficient water use, and biodiversity conservation. This holistic approach can maximize social and environmental benefits.
- **Continued Research:** Encouraging future research on the impacts of urban afforestation on public health, thermal comfort, and quality of life in cities is crucial. Additional studies can provide valuable data that will help shape public policies focused on urban sustainability.

In short, this work highlights the vital importance of urban forestry for the well-being of academic communities and environmental sustainability. The proposed actions not only aim

to improve the immediate campus environment but also serve as a model for other institutions seeking to integrate nature into their urban spaces. The continuation of this effort is crucial to ensuring that future generations can enjoy the benefits of a greener and healthier urban environment.

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