VARIATION IN TREE AND EPIPHYTE RICHNESS IN AN URBAN AREA OF THE ATLANTIC FOREST BIOME

VARIAÇÃO NA RIQUEZA DE ÁRVORES E EPÍFITAS EM UMA ÁREA URBANA DO BIOMA MATA ATLÂNTICA

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ABSTRACT

This study investigates the density and species richness of arboreal and epiphytic communities in a central urban area of Campo Mourão, Paraná, comparing samples from 2017 and 2025. Although the total number of trees remained relatively stable (with a slight decrease from 78 to 70 individuals), significant changes in species composition were observed. Notably, there was a 78.5% increase in the abundance of *Moquilea tomentosa*, accompanied by declines of 55.5% in *Ligustrum lucidum* and 44.4% in *Cenostigma pluviosum*. These shifts in the arboreal community influenced the associated epiphytic assemblage, which experienced a 49.6% reduction in recorded individuals (from 155 to 78) and the loss of certain species on specific phorophytes. Although overall diversity (Shannon-Wiener index) and dominance (Simpson index) showed no significant changes, spatial patterns varied considerably: areas with a higher dominance of *M. tomentosa*, zones affected by tree removal exhibited reduced diversity, and sectors with limited vegetation renewal maintained high dominance levels. These findings highlight that inadequate urban tree management can compromise epiphyte diversity and persistence, underscoring the need to conserve native, large phorophytes to support urban biodiversity.

KEYWORDS: Biomonitoring; Flora; Phorophyte; Environmental Change.

RESUMO

Este estudo investiga a densidade e a riqueza de espécies das comunidades arbóreas e epífitas em uma área urbana central do município de Campo Mourão, Paraná, comparando amostras coletadas em 2017 e 2025. Embora o número total de árvores tenha se mantido relativamente estável (com uma leve redução de 78 para 70 indivíduos), foram observadas mudanças significativas na composição das espécies. Notavelmente, houve um aumento de 78,5% na abundância de *Moquilea tomentosa*, acompanhado por declínios de 55,5% em *Ligustrum lucidum* e de 44,4% em *Cenostigma pluviosum*. Essas alterações na comunidade arbórea influenciaram a assembleia epífita associada, que apresentou uma redução de 49,6% no número de indivíduos registrados (de 155 para 78), além da perda de algumas espécies em forófitos específicos. Embora a diversidade geral (índice de Shannon-Wiener) e a

dominância (índice de Simpson) não tenham apresentado mudanças significativas, os padrões espaciais variaram consideravelmente: áreas com maior dominância de *M. tomentosa* e zonas impactadas pela remoção de árvores exibiram diversidade reduzida, enquanto setores com renovação vegetal limitada mantiveram elevados níveis de dominância. Esses resultados destacam que o manejo inadequado das árvores urbanas pode comprometer a diversidade e a persistência das epífitas, ressaltando a importância da conservação de forófitos nativos e de grande porte para a promoção da biodiversidade urbana.
PALAVRAS-CHAVE: Biomonitoramento; Flora; Forófito; Mudança Ambiental.

INTRODUCTION

Urban vegetation plays a vital role in enhancing environmental quality, contributing to a city's unique phytophysiognomic identity and its aesthetic and landscape value[1]. Urban trees are pivotal in regulating microclimate conditions by mitigating air and noise pollution and serving as natural thermal regulators[2].

Carefully selecting tree species for urban forestry is critical; unsuitable choices can interfere with infrastructure, leading to damage along walls, sidewalks, gutters, power lines, and street installations[3,4,5,6]. Prioritizing species well-adapted to local edaphoclimatic conditions minimizes phytosanitary issues and lowers maintenance costs[7]. Beyond these functional aspects, urban trees also support broader plant biodiversity, particularly influencing the composition and abundance of epiphytic communities[8].

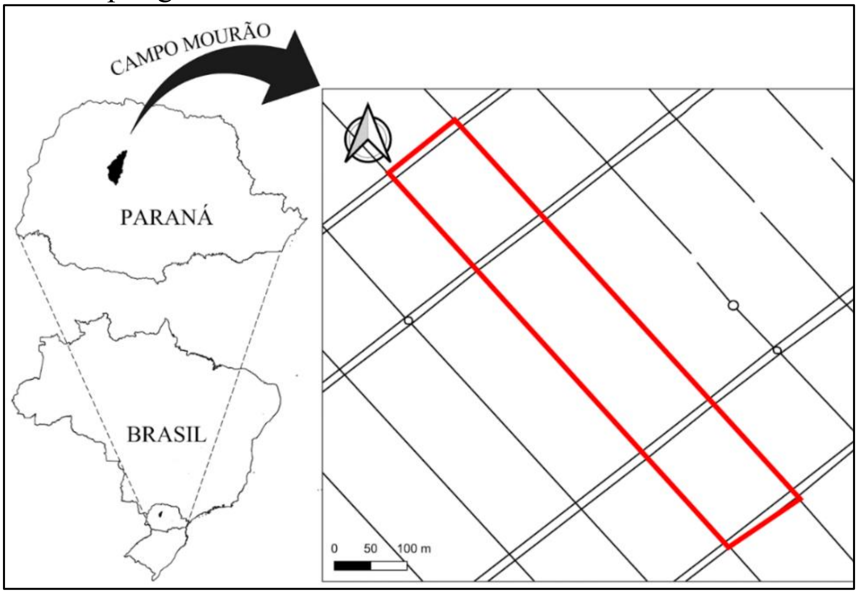
Epiphytes are vascular plants that inhabit other plants, typically trees (phorophytes), without parasitizing them. Intercepting and storing rainwater and fog play a crucial role in the urban hydrological cycle[9,10]. Their sensitivity to humidity and other abiotic factors makes them excellent bioindicators for environmental impact assessments, aiding the monitoring of climate change responses and air pollution levels[11].

Globally, approximately 10% of all vascular plant species are epiphytes, with their prevalence increasing to about 25% in certain tropical biomes[12]. In Brazil's Atlantic Forest, epiphytes occur on roughly 80% of trees, especially bromeliads and orchids, highlighting their ornamental and ecological importance[13,14]. In this context, the present study conducted a phytosociological survey in Campo Mourão, Paraná, focusing on the composition, density, and diversity of both arboreal and epiphytic species in the city's central area.

MATERIAL AND METHODS

The research was carried out in Campo Mourão, located in the central-west region of Paraná. The sampling area spans city blocks bordered by Araruna Street, José Custódio de Oliveira Avenue, Francisco Pereira Albuquerque Street, and Manoel Mendes de Camargo Avenue (Figure 1). The sampling location in the city center is precisely situated at the following coordinates: Blocky 1 is located at -24.046465661416597S, -52.37773441938187W; Blocky 2 at -24.045162555753596S, -52.37907552383558W; and Blocky 3 at -24.043937820344375S, -52.38004111907962W. These three points define the specific zones selected for environmental monitoring and data collection within the urban core.

Figure 1. Delimitation of the study area in Campo Mourão, PR. The red lines indicate the sampling area in residential blocks.



According to the Köppen-Geiger classification, the regional climate is Humid Subtropica[15], with average annual minimum and maximum temperatures of 10 °C and 25 °C, respectively, and an annual precipitation ranging between 1570 mm and 1700 mm[16]. Phytogeographically, the area represents a transitional zone between the Seasonal Semi-deciduous Forest (SSF) and the Mixed Ombrophilous Forest (MOF) of the Atlantic Forest biome[17].

Fieldwork was conducted during two distinct periods: September–October 2017 and February 2025. For each tree, researchers performed a complete circumnavigation of the trunk to ensure a thorough inspection for epiphytic organisms. Trees were identified to the species level and classified as native or exotic. The trunk circumference was measured at 1.30 meters above ground level, from which the diameter at breast height (DBH) was calculated. Epiphytic species were identified via direct observation—with the aid of binoculars—and their identifications were cross-verified using a specialized identification guide and subsequently confirmed with the Virtual Herbarium – REFLORA[18.]

To quantify tree diversity over time, the Shannon-Wiener (diversity) and Simpson (dominance) indices were calculated. The Shannon-Wiener index quantifies biodiversity by measuring the entropy associated with the distribution of individuals among species (Shannon & Wiener, 1949). In contrast, Simpson's dominance index assesses the distribution of species abundance, reflecting the degree of dominance on a scale from 0 (no dominance) to 1 (complete dominance) (Simpson, 1949).

RESULTS AND DISCUSSION

A total of ten species from seven families were recorded in 2017, comprising 79 individuals. By 2025, nine species from the same seven families were identified, totaling 70 individuals—a decline of eight individuals over the monitoring period. In 2017, the families with the greatest representation were Anacardiaceae, Bignoniaceae, and Fabaceae; however, by 2025, only Anacardiaceae and Fabaceae maintained stable representation, with two species each (Table 1). This pattern is consistent with findings from de Souza et al. (2020)[19], who observed a similar prevalence of Fabaceae and Bignoniaceae in public squares in Minas Gerais.

In 2017, native species accounted for 34 individuals (approximately 43.5% of the total), whereas non-native species represented 44 individuals (57.5%). Within the non-native group, *L. lucidum* was particularly prominent with 27 individuals, followed by *L. indica* with 15 individuals; together, these species constituted roughly 53.8% of the sample. Several studies in urban forestry have frequently cited these species[20,21]. *L. lucidum*, in fact, is commonly known as the 'mayor's tree' and is considered the most common species in cities in southern Brazil[22].

Table 1. Distribution of tree species identified in the central area of Campo Mourão in 2017 and 2025. Abbreviations: PN – Popular name; OR – Species origin (N – Native, NN – Non-native); NI – Number of individuals; B1 – Block 1, B2 – Block 2, B3 – Block 3.

Family	Species	PN	OR	NI 2017			NI 2025		
				B1	B2	B3	B1	B2	B3
Anacardiaceae	*Mangifera indica* L.	Mangueira	NN	1	0	0	3	0	0
Anacardiaceae	*Schinus molle* L.	Chorão	N	6	0	0	2	0	0
Bignoniaceae	*Handroanthus chrysotrichus* (Mart. ex DC.) Mattos	Ipê-amarelo	N	2	0	0	2	0	0
Bignoniaceae	*Handroanthus heptaphyllus* (Vell.) Mattos	Ipê-rosa	N	0	0	1	0	0	0
Chryso-balanaceae	*Moquilea tomentosa* Benth.	Oiti	N	2	11	1	5	14	6
Fabaceae	*Delonix regia* (Bojer ex Hook.) Raf.	Flamboyant	NN	0	1	0	0	1	0
Fabaceae	*Cenostigma pluviosum* var. *peltophoroides* (Benth.) Gagnon & G.P.Lewis	Sibipiruna	N	3	2	4	2	0	3
Lythraceae	*Lagerstroemia indica* L.	Resedá	NN	3	10	2	4	10	3
Melastoma-taceae	*Pleroma mutabile* (Vell.) Triana	Manacá-da-serra	N	2	0	0	1	0	2
Oleaceae	*Ligustrum lucidum* W.T.Aiton	Lingustro	NN	10	5	12	7	1	4

By 2025, however, *L. lucidum* declined markedly to only 12 individuals (17.1%), suggesting active management of this species in the study area. In contrast, *L. indica* increased by two individuals, reaching a total of 17 specimens. Consequently, the balance between native and non-native species shifted—in 2025, five native and four non-native species were recorded, with 39 native and 31 non-native individuals—aligning with São Paulo's urban tree planning guidelines, which emphasize the use of native species due to their natural adaptation to local conditions[23].

Among the native species, *M. tomentosa* was the most representative in 2017, with 14 individuals (17.9%), and its abundance increased to 25 individuals (35.7%) in 2025, representing a growth of 78.6%. This significant increase underlines its widespread appeal in urban landscaping, especially given its compact trunk and globular crown that contribute to both shade provision and aesthetic balance[24].

Conversely, *C. pluviosum*, also native and frequently used in urban afforestation, experienced the sharpest decline—from nine individuals in 2017 to five in 2025 — highlighting potential concerns regarding its continued viability in urban settings[25,26,27].

In addition, *H. heptaphyllus* was completely absent in the 2025 survey, as its sole representative from 2017 was removed; although the specific reasons for this removal are unknown, the loss of this species represents a decrease in local arboreal diversity. Given its widespread application in Brazilian urban afforestation due to its ornamental appeal and resilience[28,29], this absence is particularly notable.

A decline in tree density was observed across all three sampling areas. In B3, for instance, experienced a 10% reduction in the number of individuals between 2017 and 2025, while B1 and B2 each registered a decrease of approximately 10.3% (Figure 2).

Figure 2. Aerial image of the study area during the two sampling periods: (a) September 2017 and (b) January 2025. B1, B2, and B3 represent the sampled blocks.

In the B1, the highest species diversity was maintained in both sampling periods. Here, Ligustrum lucidum remained the most prevalent species. However, native species such as *S. molle*, *C. pluviosum*, and *P. mutabile* declined, whereas *M. tomentosa* increased. Among non-natives, increases were noted for both *M. indica* and *L. indica*. The rise in *M. indica* is particularly concerning since its large fruits can compromise pedestrian safety, damage vehicles, and harm urban infrastructure[30].

In the B2 exhibited the lowest diversity, with a reduction from five species in 2017 to four in 2025. In this area, native *M. tomentosa* increased in abundance, although individuals of *C. pluviosum* were entirely removed. Within the non-native component, *L. lucidum* declined while *D. regia* and *L. indica* maintained their numbers. It is important to note that *D. regia* is generally not recommended for urban planting due to its superficial root system and expansive crown, which can damage sidewalks and interfere with power grids[23].

In the B3, the removal of *H. heptaphyllus*, previously present with one individual in 2017, and a reduction of one individual *of C. pluviosum* were observed. In contrast, populations of *M. tomentosa* and *P. mutabile* grew, while among non-natives, *L. indica* increased and *L. lucidum* declined.

The overall diversity, as measured by the Shannon-Wiener index, and dominance, as indicated by the Simpson index, exhibited minimal variation between 2017 and 2025 (Table 2). In 2017, the indices were 1.072 (diversity) and 0.648 (dominance), shifting slightly to 1.055 and 0.636, respectively, in 2025. Such slight fluctuations are typical in urban areas, where municipal management practices tend to limit stark intervention (Campo Mourão, 2017). Nonetheless, spatial variations were evident:

Table 2. Shannon-Wiener (SW) and Simpson (D) indices for Areas B1, B2, and B3 of the study site. ▲ = Increase; ▼ = Decrease.

	2017		2025	
Índices:	SW	D	SW	D
Total	1,072	0,648	1,055	0,636
B1	1,831	0,801	1,924▲	0,801
B2	1,338	0,701	0,951▼	0,559▼
B3	1,158	0,585	1,541▲	0,771▲

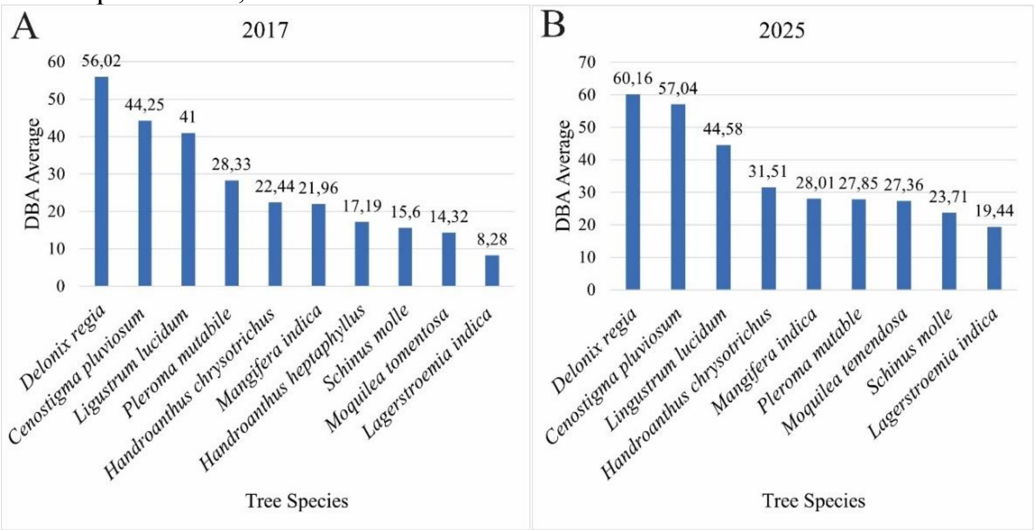
In the B1 showed an increase in species diversity while sustaining a high dominance value. In B2 experienced a marked decline in diversity along with reduced dominance. In B3 registered increases in both diversity and dominance, a pattern strongly linked to the proliferation of *M. tomentosa*.

Diameter measurements at breast height (DBH) reveal notable growth across species over the eight-year period. Overall, the mean DBH increased from 26.9 cm in 2017 to 35.5 cm in 2025. *D. regia* exhibited the highest DBH values, rising from 56.2 cm to 60.1 cm, whereas *L. indica* consistently recorded the lowest values, increasing from 8.2 cm to 19.4 cm (Figure 3). Studies in São João Evangelista (MG) reported similar DBH ranges—from 4.6 cm to 67 cm[31].

When assessed separately, native species showed an average DBH of 23.6 cm in 2017, which increased to 33.4 cm in 2025, while non-native species averaged 31.8 cm in 2017 and 38 cm in 2025. Despite these increases, the average DBH values remained below the 38 cm recorded in Almenara, in the state of Minas

Gerais[19]. Individual growth patterns further underscore the overall positive trend. For instance, the sole *D. regia* individual from 2017 grew from 56 cm to 60.1 cm in DBH by 2025. In contrast, the two individuals of *H. chrysotrichus* exhibited a 40.6% increase in DBH—from 22.4 cm to 31.5 cm—bringing their growth rate in line with that of *H. impetiginosus* (Ipê rosa) observed in Almenara, where the average DBH was 18 cm[19].

Figure 3. Average DBH (Diameter at Breast Height) in centimeters of the tree species sampled in the years 2017 (A) and 2025 (B) in a region of the central area of Campo Mourão, Paraná.



In the 2017 sampling, researchers recorded 155 epiphyte occurrences distributed among 12 species. Of these, 11 species are native to the Brazilian flora, with *D. nobile* being the sole cultivated exception. By 2025, the total number of epiphyte occurrences had dropped to 78—a reduction of 49.6% (see Table 3-4).

In 2017, *T. recurvata* was the most frequently encountered epiphyte, occurring on 39 trees across seven different phorophyte species. Although it continued to be found on the same set of phorophytes in 2025, its occurrence fell to 25 trees. Meanwhile, *L. lucidum* supported the greatest epiphyte diversity in both surveys, hosting 11 epiphyte species in 2017 and 12 in 2025. Despite this diversity, the population density of epiphytes on *L. lucidum* dropped from 85 individuals in

2017 to 45 in 2025—a decrease of 47%. Notably, *P. pleopeltifolia* stood out on this phorophyte, being observed on 11 out of the 12 examined individuals. Similar patterns in the superior epiphyte support by non-native phorophyte species have been documented in studies from the Grande San Miguel de Tucumán region in Argentina[32].

Table 3. Families and species of epiphytes recorded in a central area of Campo Mourão in 2017 and 2025, indicating the host tree species where each was found and the number of individuals in each year.

Family	Species	Phorophyte	2017	2025
Bromeliaceae	*Tillandsia pohliana* Mez	*Ligustrum lucidum*	2	2
		Cenostigma pluviosum	2	1
		Delonix regia	1	0
Bromeliaceae	*Tillandsia recurvata* (L.)	*Moquilea tomentosa*	1	8
		Mangifera indica	0	1
		Schinus molle L.	2	0
		Ligustrum lucidum	23	8
		Cenostigma pluviosum	8	3
		Handroanthus chrysotrichus	2	2
		Lagerstroemia indica	0	2
		Delonix regia	1	1
		Pleroma mutabile	2	0
Bromeliaceae	*Tillandsia tricholepis Baker*	*Schinus molle L.*	1	0
		Ligustrum lucidum	9	9
		Cenostigma pluviosum	5	0
		Delonix regia	1	1
Cactaceae	*Cereus hildmannianus* K.Schum.	*Ligustrum lucidum*	1	1
Cactaceae	*Epiphyllum phyllanthus* (L.) Haw.	*Ligustrum lucidum*	4	4
		Cenostigma pluviosum	6	3
Cactaceae	*Rhipsalis baccifera* (J.M.Muell.) Stearn	*Ligustrum lucidum*	0	1
Cactaceae	*Rhipsalis cereuscula* Haw.	*Cenostigma pluviosum*	1	1
Cactaceae	*Lepismium lumbricoides* (Lem.) Barthlott	*Ligustrum lucidum*	1	1
		Moquilea tomentosa	2	0

Orchidaceae *	*Dendrobium nobile* Lindl.	*Ligustrum lucidum*	1	1
		Cenostigma pluviosum	1	0
		Pleroma mutabile	1	0
		Lagerstroemia indica	4	0

Table 4. Families and species of epiphytes recorded in a central area of Campo Mourão in 2017 and 2025, indicating the host tree species where each was found and the number of individuals in each year.

Family	Species	Phorophyte	2017	2025
Polypodiaceae	*Microgramma squamulosa* (Kaulf.) de la Sota	*Ligustrum lucidum*	11	4
		Cenostigma pluviosum	6	2
		Delonix regia	1	1
Polypodiaceae	*Microgramma vacciniifolia* (Langsd. & Fisch.) Copel.	*Ligustrum lucidum*	5	1
Polypodiaceae	*Pleopeltis minima* (Bory) J. Prado & R.Y. Hirai	*Ligustrum lucidum*	16	2
		Cenostigma pluviosum	5	1
Polypodiaceae	*Pleopeltis pleopeltifolia* (Raddi) Alston	*Ligustrum lucidum*	15	11
		Cenostigma pluviosum	9	2
		Handroanthus chrysotrichus	2	2
		Schinus molle L.	0	1
		Delonix regia	1	1
		Pleroma mutabile	2	1

The *C. pluviosum* ranked second in terms of both epiphyte diversity and density in the study. In 2017, it hosted nine species totaling 43 individuals; by 2025, these numbers declined to seven species and 13 individuals. This reduction may be linked to the removal of some *C. pluviosum* individuals during the eight-year period.

Interestingly, while no epiphytes were recorded on *M. indica* and *H. chrysotrichus* in 2017, by 2025 epiphytes were present on all tree species surveyed. This suggests a potential temporal expansion in phorophyte colonization (Figure 4).

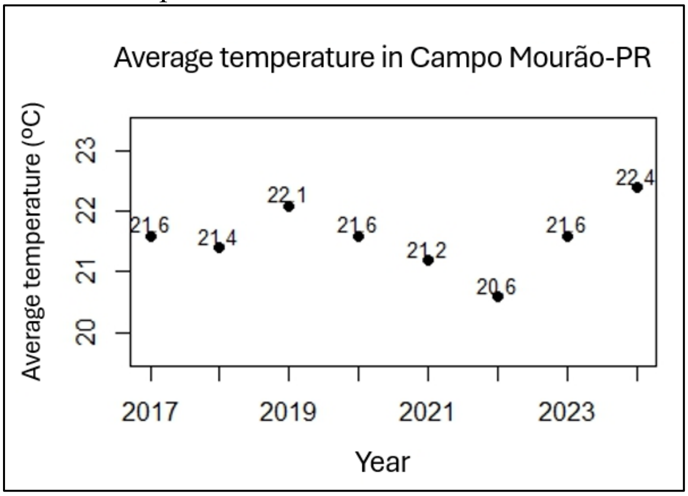
Members of the Bromeliaceae family—specifically *T. pohliana*, *T. recurvata*, and *T. tricholepis* — were found on 60 trees in 2017, a figure that fell to 38 trees by 2025 (a decline of 36.6%). According to Altafin et al. (2003)[14], the commercial exploitation of Bromeliaceae for their ornamental appeal (notably their vivid colors and delicate flowers) and their naturally slow propagation rate may contribute to their vulnerability. Moreover, epiphytes in the genus *Tillandsia* play a significant environmental role by accumulating atmospheric pollutants from both agricultural and urban-industrial sources[33].

Phorophyte size, as measured by diameter at breast height (DBH), generally correlated with greater epiphyte diversity across both sampling periods. Studies by Martins et al. (2020)[34] in urban areas of Minas Gerais support this finding, showing that increases in DBH and tree height tend to promote greater epiphyte richness. However, DBH alone did not determine the presence of epiphytes. For instance, *T. recurvata* was recorded on both *D. regia* — which had the highest DBH (56 cm) — and Maclura tomentosa, a species with one of the smallest recorded DBHs (8.2 cm) during the 2017 survey.

Figure 4. Main epiphyte species found in the central area of the Municipality of Campo Mourão, PR. a – *C. hildmannianus*, b – *D. nobile*, c1 and c2 – *E. hyllanthus*, d – *L. lumbricoides*, e – *M. squamulosa*, f – *M. vacciniifolia*, g – *R. baccifera*, h – *P. mínima*, i – *P. pleopeltifolia*, j1 and j2 – *R. cereuscula*, k1 and k2 – *T. pohliana*, l – *T. recurvata*, m – *T. tricholepis*.

The decline in urban vegetation in the study area, including arboreal and epiphytic species, between the analyzed periods may be linked to environmental variations that occurred during the sampling interval. Temperature fluctuations were recorded in the study area from 2017 to 2024. Estimates based on recent trends, along with data from Meteoblue AGX[35], indicate variations in the mean annual temperature over the analyzed period (Figure 5).

Figure 5. Mean annual temperatures from 2017 to 2024.



Although plant species that thrive in urban environments are generally adapted to conditions such as strong solar exposure, low water availability, and high nitrogen levels[,36,37,38,39], urban plants often struggle to withstand environmental changes due to their low genetic diversity[40].

Data suggest that the climatic conditions of the study region are evolving over time[35]. Research indicates a negative trend in maximum annual precipitation in Campo Mourão, the study area; however, this trend is not statistically significant at the 5% significance level[41].

Additionally, urban management influences vegetation changes. While vegetation retains its ecological and ecosystem functions, municipal plant cover can be altered based on political policies and decisions[42]. In Brazil, urban management in recent decades has prioritized real estate expansion, new traffic routes, commercial and residential developments, and pavement construction. Moreover, the remaining vegetation has been modified to favor species that minimize commercial losses or are selected based on landscaping criteria[43]. However, most of these species are exotic, reducing the richness and abundance of native plants that originally occupied urban spaces before development[44].

CONCLUSION

The results of this study highlight key ecological patterns and offer practical recommendations for improving urban vegetation management. The main findings are summarized as follows:

1. Changes in tree composition reveal imbalances in urban management: Although the total number of trees remained similar between 2017 and 2025, the decline of native species such as *Cenostigma pluviosum* and the local extinction of *Handroanthus heptaphyllus* indicate unplanned or inappropriate replacements.

2. Loss of epiphytes reflects direct impacts of inadequate arboriculture: The 49.6% decrease in epiphytic occurrences is closely associated with the removal of suitable phorophytes and the limited structural diversity of replacement trees.

3. Native species should be prioritized in urban tree planning: *Moquilea tomentosa* demonstrated ecological resilience and functional potential, emerging as a strong candidate for urban planting programs.

4. Tree size directly influences associated biodiversity: Individuals with greater diameter at breast height (DBH) supported a higher richness of epiphytes, highlighting the importance of maintaining and promoting the growth of large trees in urban environments.

5. Urban planning must integrate biodiversity conservation and ecological functionality: Tree management should adopt ecological criteria - such as species diversity, origin, and structure - rather than aesthetic or maintenance considerations alone.

We recommend that municipalities implement public policies for urban arboriculture that include regular technical assessments, region-specific species manuals, and ongoing training for environmental managers. Preserving urban vegetation is essential to ensuring ecosystem services and improving urban quality of life.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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