Growth of Palm Trees and Woods in the Urban Environment

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Abstract

Trees in the urban environment provide several ecosystem benefits to the population, such as decreasing temperature, increasing humidity, shading, improving air quality, as well as physical and mental well-being. These can be enhanced through the knowledge of the growth of the trees in function of the characteristics of the place where they are inserted. Thus, the objective was to estimate the growth in diameter, height and volume of forest species in the urban environment, in Viçosa, Minas Gerais, Brazil. For this, woody individuals and palm trees present in the urban afforestation of the headquarters campus of the Federal University of Viçosa were selected based on age and had their diameter, breast height and height measured. Allometric equations specific to the study site were used to estimate their volume, and through the relationship with age, the average annual increment was obtained. Woody individuals showed a growth rate in volume of 0.0279 ± 0.0274 m³ year⁻¹ and palm trees, 0.0139 ± 0.0119 m³ year⁻¹. The differences in the average annual increase in volume found between woody individuals and palm trees may be due to morphological differences that affect the secondary growth of individuals. The growth rate of trees in the urban environment is higher when compared to those in forest fragments and experimental plantings. The decrease in growth rates with increasing age was expected due to the relationship between them being of the non-linear type, following a sigmoidal model.

Introduction

The use of trees and palms to compose urban afforestation provides a healthier physical environment for the population (ROSSATTO; TSUBOY; FREI, 2008). Improving the quality of the local microclimate with decreasing temperature; elevation of humidity; environmental preservation; attraction of avifauna; reduction of noise and visual pollution levels; natural barrier against winds; revaluation of contemporary spaces; scenic beauty and physical and mental well-being to the population are benefits of urban afforestation (GENGO; HENKES, 2013). Thus, afforestation of this environment is also responsible for improving adverse conditions, ensuring better housing in cities (LACY; SHACKLETON, 2014).

These benefits depend on the abundance, size and growth of individuals and, in order to potentiate them, it is necessary to improve the understanding of how trees develop in the urban environment, which is still a gap, especially for native species (LACY; SHACKLETON, 2014; EVANS et al., 2017). This information is relevant also to the appropriate selection of species, choice of location of planting, spacing the plants, distances relative to other urban components, direction for shading, and necessary silvicultural practices (Semenzato; CATTANEO; DAINES 2011; PRETZSCH et al., 2015).

The growth rates of urban trees and palms vary depending on the species, local climatic condition, volume, porosity and soil chemistry, canopy irradiance and air quality (IAKOVOGLOU et al., 2001; MORGENROTH; BUCHAN; SCHAREN BROCH, 2013; BOUKILI et al., 2017; FIGUEIREDO FILHO et al., 2017). Paving the soil surface is a limiting factor for growth due to compaction and adverse conditions generated, such as reduced aeration, low water infiltration and less accumulation of organic matter (VISWANATHAN et al., 2011; LAWRENCE et al., 2012). Allied to this, the planting conditions, management...
strategies adopted, such as irrigation and pruning, and the people who benefit from urban trees also influence growth and, thus, there may be differences within and between locations (SEmenzato; Cattaneo; Dainese, 2011; Vogt et al., 2015). Understanding the annual rates at which trees and palms grow in the urban environment is essential to support correct estimates of the provision of ecosystem services over time, despite this, few studies have made these estimates (Vaz Monteiro; Levanič; Doick, 2017). Thus, the aim of this study was to investigate the growth of different species of palm and woody species in the urban environment, in Viçosa, Minas Gerais, Brazil. The hypotheses analyzed were that i) palm and woody species show different growth rates; ii) the growth rate differs, within each previous group, depending on the species, and iii) native species show a higher growth rate than exotic species.

Methods

The forest, palm and woody species present in the access roads, parking lots and lawns on the campus of the Federal University of Viçosa in Viçosa, Minas Gerais, Brazil (20°45'14" S and 42°45'53" W) were evaluated. The region's vegetation is classified as Montana seasonal semideciduous forest (IBGE, 2012), with Cwa climate (Köppen) and concentrated rainfall between the months of October and March. On average, the average daily maximum and minimum temperature and annual precipitation were 27.2°C, 16°C and 1184.9 mm, respectively (UFV, 2018).

The selection of the studied species was based on the knowledge of the age of the individuals, this being the first stage of the research. The age was estimated through orthophotocards from the city of Viçosa, available in the collection of the Department of Forestry at UFV, historical records of the institution and also with images of Google Earth Pro®.

The age (\( I_{Ind} \)) attributed to the individuals identified in the images was obtained by \( I_{Ind} = 2018 - (AP + AA) / 2 \), being AP: year of the orthophoto/image where the individual was identified and; AA: year of the orthophotocarte/image immediately preceding it. The conversion was necessary since, it is not known exactly when, between the two images (AP and AA), the individual was planting, thus adopting the average age of the period.

Individuals whose age was estimated and had more than 5 centimeters in diameter at chest height (DBH), were inventoried between April and May 2018. The total height (\( H_t \)), in meters, was measured with a Vertex Laser 5 Hypsometer and the Circumference at Chest Height (CAP), in centimeters, obtained with a measuring tape and converted to DAP by the expression \( DAP = \frac{CAP}{\pi} \). The botanical identification was carried out with the collection of vegetative material for analysis in the UFV Dendrology sector.

Volumetric equations of Shumacher and Hall were adjusted based on rigorous cubing data performed in the same study site in 2010. The volume of palm and woody individuals was obtained, respectively, by \( V_i = 0.00006067 \times (DBH_i)^{1.953} \times (H_t_i)^{1.006} \) (R\(^2\) = 99.17%) and \( V_i = 0.0005425 \times (DBH_i)^{1.6152524} \times (H_t_i)^{0.7395611} \) (R\(^2\) = 79.40%), where \( V_i \): volume of the \( i \)-th individual, in m\(^3\); \( DBH_i \): diameter at chest height of
the \( i \)-th individual, in centimeters \( e; Ht_i \): total height of the \( i \)-th individual, in meters (Brianezi et al., 2013 - adapted).

The growth of individuals was estimated with the Average Annual Volume Increase (IMA\(_V\) - m\(^3\) year\(^{-1}\) ), obtained by IMA\(_{V_i}\) = \( V_i \) / \( I_{Ind_i} \), with IMA\(_{V_i}\): the average annual increase in volume of the \( i \)-th individual, in m\(^3\) year\(^{-1}\); \( V_i \): the volume of the \( i \)-th individual, in m\(^3\), \( e; I_{Ind_i}\): the age of the \( i \)-th individual, in years. The Annual Average Increment in Diameter and Height, IMA\(_D\) (cm year\(^{-1}\) ) and IMA\(_H\) (m year\(^{-1}\) ), respectively, were obtained through the ratio between the value obtained in the forest inventory and the individual's age.

The average increments in volume, diameter and height according to the origin of the species, native to the Atlantic Forest, native to Brazil or exotic, were analyzed with ANOVA in a completely randomized design. The Tukey test was applied when there was a rejection of the null hypothesis. The analyzes of variance and comparisons between the averages were performed with confidence intervals with 99% certainty. The statistical procedures were performed using the R software.

**Results**

Through the forest inventory, 1,888 individuals were evaluated, 86.97 % belonging to the woody group. *Licania tomentosa, Michelia champaca* and *Archontophoenix alexandrae* were the species with the largest number of individuals (Table 1). *Michelia champaca, Delonix regia* and *Archontophoenix alexandrae*, on average, presented the oldest individuals with 93 years, 60 years and 53.8 years, respectively (Table 1).

Table 1. Number of individuals (Ind), average DBH (DBHm, in cm), average height (Htm, in m) and average volume (Vm, in m\(^3\)), by age range (I, in years), of the species evaluated in Viçosa, Minas Gerais, Brazil, in 2018
| Species                                              | I     | Ind | DBHm | Ht_m | V_m  |
|------------------------------------------------------|-------|-----|------|------|------|
| **Woody**                                            |       |     |      |      |      |
| *Albizia lebbeck* (L.) Benth.                       | 20 - 40 | 3   | 40.98| 17.4 | 1.9127|
| *Anadenanthera macrocarpa* (Benth.) Brenan          | 20 - 40 | 6   | 54.22| 26.9 | 4.2408|
| *Araucaria columnaris* (JR Forst.) Hook.            | 20 - 40 | 3   | 40.26| 13.9 | 1.7147|
| *Bauhinia forficata* Link                           | 20 - 40 | 140 | 27.17| 8.5  | 0.6652|
| *Bombacopsis glabra* (Pasq.) A. Robyns             | 20 - 40 | 4   | 30.25| 11.2 | 0.9984|
| *Bougainvillea glabra* Choisy                       | 20 - 40 | 15  | 11.19| 6.9  | 0.1809|
| *Delonix regia* (Bojer ex Hook.) Raf.               | 60 - 80 | 44  | 80.84| 11.8 | 4.3474|
| *Filicium decipiens* (Wight & Am.) Thwaites        | 0 - 20  | 40  | 15.39| 9.0  | 0.3864|
|                                                     | 20 - 40 | 28  | 14.96| 7.5  | 0.3041|
| *Handroanthus impetiginosus* (Mart. ex DC.) Mattos   | 20 - 40 | 62  | 26.26| 16.1 | 1.1514|
|                                                     | 40 - 60 | 3   | 37.27| 21.4 | 2.1352|
| *Handroanthus serratifolius* (Vahl) S. Grose        | 20 - 40 |      | 18.32| 11.4 | 0.5041|
| *Hibiscus rosa-sinensis* L.                         | 40 - 60 | 12  | 34.70| 15.8 | 1.4581|
| *Holocalyx balansae* Micheli                        | 20 - 40 | 9   | 17.07| 6.4  | 0.2311|
| *Lagerstroemia indica* L.                           | 20 - 40 | 6   | 30.68| 14.6 | 1.2823|
|                                                     | 0 - 20  | 25  | 9.28 | 6.4  | 0.0941|
|                                                     | 20 - 40 | 72  | 12.82| 7.3  | 0.1852|
| *Lagerstroemia speciosa* (L.) Pers.                 | 40 - 60 | 19  | 24.93| 7.3  | 0.5054|
|                                                     | 0 - 20  | 28  | 16.81| 9.1  | 0.4151|
| *Licania tomentosa* (Benth.) Fritsch                | 20 - 40 | 16  | 33.80| 12.9 | 1.3051|
|                                                     | 0 - 20  | 41  | 14.06| 7.7  | 0.2667|
|                                                     | 20 - 40 | 281 | 31.92| 12.0 | 1.0751|
| *Ligustrum lucidum* W.T.Aiton                        | 40 - 60 | 104 | 36.54| 14.0 | 1.4348|
|                                                     | 20 - 40 | 9   | 39.81| 11.0 | 1.3410|
| *Litchi chinensis* Sonn.                            | 40 - 60 | 9   | 36.27| 9.9  | 1.0856|
| *Mangifera indica* L.                               | 20 - 40 | 3   | 33.51| 9.8  | 1.4619|
| Species                                           | Diameter  | Height | Diameter  | Height | IMAv     |
|--------------------------------------------------|-----------|--------|-----------|--------|----------|
| *Michelia champaca* L.                           | 20 - 40   | 6      | 24.33     | 10.6   | 1.9185   |
| *Murraya paniculata* (L.) Jack                   | 80 - 100  | 192    | 33.37     | 7.2    | 0.7157   |
|                                                   | 0 - 20    | 23     | 10.08     | 3.8    | 0.0808   |
|                                                   | 20 - 40   | 60     | 11.91     | 4.0    | 0.1188   |
| *Paubrasilia echinata* (Lam.) Gagnon, H.C. Lima & G.P. Lewis | 40 - 60   | 33     | 11.30     | 4.1    | 0.0931   |
| *Peltophorum dubium* (Spreng.) Taub.             | 20 - 40   | 14     | 12.93     | 8.0    | 0.2589   |
| *Poincianella pluviosa* (DC.) L.P. Queiroz       | 20 - 40   | 7      | 33.68     | 12.4   | 1.2668   |
|                                                   | 0 - 20    | 8      | 18.89     | 8.5    | 0.3941   |
| *Spathodea campanulata* P. Beauv.                | 20 - 40   | 76     | 30.85     | 13.6   | 1.3527   |
| *Tabebuia roseoalba* (Ridl.) Sandwith            | 40 - 60   | 70     | 55.34     | 13.4   | 2.8216   |
| *Terminalia catappa* L.                          | 20 - 40   | 3      | 37.35     | 9.8    | 1.0862   |
| *Tibouchina granulosa* (Desr.) Cogn              | 20 - 40   | 39     | 28.62     | 11.2   | 0.9492   |
|                                                   | 0 - 20    | 12     | 10.97     | 6.2    | 0.1754   |
| **Palm Trees**                                    |           |        |           |        |          |
| *Acrocomia aculeata* (Jacq.) Lodd. ex Mart.      | 20 - 40   | 5      | 33.99     | 14.8   | 0.8924   |
| *Archontophoenix alexandreae* (F. Muell.) H. Wendl. e Drude | 0 - 20    | 12     | 20.52     | 11.2   | 0.2622   |
|                                                   | 20 - 40   | 12     | 21.62     | 11.2   | 0.2945   |
|                                                   | 40 - 60   | 27     | 24.02     | 14.1   | 0.4797   |
|                                                   | 60 - 80   | 136    | 23.40     | 15.1   | 0.4738   |
| *Syagrus romanzoffiana* (Cham.) Glassman         | 0 - 20    | 32     | 24.40     | 9.6    | 0.3979   |
|                                                   | 20 - 40   | 17     | 25.17     | 10.4   | 0.3735   |
|                                                   | 40 - 60   | 5      | 30.23     | 19.2   | 0.9793   |

Woody individuals presented an average annual increase in volume higher than that of palm trees, 0.0279 ± 0.0274 and 0.0139 ± 0.0119 m³ year⁻¹ respectively (Table 2). The same behavior was observed for the increase in diameter, however in height, the individuals of palm trees showed the highest average annual increase (Table 2). Individually, *Anadenanthera macrocarpa* and *Mangifera indica* presented the highest values of IMAv, 0.1588 ± 0.0504 m³ year⁻¹ and 0.0959 ± 0.0584 m³ year⁻¹, respectively, followed by the palm tree *Acrocomia columnaris* which presented equal IMAv at 0.0446 ± 0.0056 m³ year⁻¹ (Table 2).
Table 2. Average annual increment in Volume (IMAv, in m³), Diameter (IMAD, in cm) and Height (IMAH, in m) and standard deviation (s₁, s₂ and s₃, respectively) of the species studied in Viçosa, Minas Gerais, Brazil, in 2018
| Species                              | $IMA_V$ | $s_1$  | $IMA_D$ | $s_2$  | $IMA_H$ | $s_3$  |
|-------------------------------------|---------|--------|---------|--------|---------|--------|
| Woody                               | 0.0279  | 0.0274 | 1.0130  | 0.5155 | 0.3780  | 0.2522 |
| Albizia lebbeck                     | 0.0696  | 0.0181 | 1.5379  | 0.1540 | 0.6315  | 0.1306 |
| Anadenanthera macrocarpa             | 0.1588  | 0.0504 | 2.1251  | 0.2372 | 1.0181  | 0.1189 |
| Araucaria columnaris                 | 0.0784  | 0.0180 | 2.0059  | 0.2542 | 0.6433  | 0.2401 |
| Bauhinia forficata                  | 0.0242  | 0.0120 | 1.0637  | 0.2931 | 0.3090  | 0.0594 |
| Bombacopsis glabra                  | 0.0363  | 0.0128 | 1.2440  | 0.1684 | 0.4073  | 0.0766 |
| Bougainvillea glabra                | 0.0066  | 0.0048 | 0.6222  | 0.3334 | 0.4097  | 0.2217 |
| Delonix regia                       | 0.0725  | 0.0280 | 1.3838  | 0.2650 | 0.1968  | 0.0403 |
| Filicium decipiens                  | 0.0253  | 0.0178 | 1.4377  | 0.6570 | 0.6503  | 0.3276 |
| Handroanthus impetiginosus           | 0.0419  | 0.0276 | 1.0438  | 0.3777 | 0.5791  | 0.2208 |
| Handroanthus serratifolius           | 0.0201  | 0.0161 | 0.7153  | 0.2852 | 0.3967  | 0.1504 |
| Hibiscus rosa-sinensis              | 0.0088  | 0.0038 | 0.6769  | 0.1528 | 0.2443  | 0.0684 |
| Holocalyx balansae                  | 0.0466  | 0.0250 | 1.2484  | 0.3773 | 0.5303  | 0.1007 |
| Lagerstroemia indica                | 0.0086  | 0.0041 | 0.7514  | 0.2449 | 0.3743  | 0.1426 |
| Lagerstroemia speciosa              | 0.0470  | 0.0273 | 1.8910  | 0.4323 | 0.7480  | 0.2081 |
| Licania tomentosa                   | 0.0317  | 0.0151 | 1.0640  | 0.3437 | 0.3957  | 0.1534 |
| Ligustrum lucidum                   | 0.0445  | 0.0262 | 1.5477  | 0.6049 | 0.4067  | 0.1533 |
| Litchi chinensis                    | 0.0532  | 0.0131 | 2.3080  | 1.3011 | 0.7830  | 0.7153 |
| Mangifera indica                    | 0.0959  | 0.0584 | 3.3934  | 1.1623 | 1.7317  | 1.0115 |
| Michelia champaca                   | 0.0077  | 0.0038 | 0.5012  | 0.1223 | 0.1070  | 0.0337 |
| Murraya paniculata                 | 0.0048  | 0.0039 | 0.6520  | 0.3555 | 0.2183  | 0.1353 |
| Paubrasilia echinata                | 0.0120  | 0.0106 | 0.7364  | 0.2885 | 0.3768  | 0.1533 |
| Peltophorum dubium                  | 0.0461  | 0.0276 | 1.3078  | 0.4247 | 0.4514  | 0.1152 |
| Poincianella pluviosa               | 0.0522  | 0.0460 | 1.4416  | 0.5167 | 0.6131  | 0.3296 |
| Spathodea campanulata               | 0.0571  | 0.0341 | 1.1748  | 0.3063 | 0.2753  | 0.0730 |
| Tabebuia roseoalba                  | 0.0395  | 0.0157 | 1.3952  | 0.2912 | 0.3552  | 0.0615 |
| Terminalia catappa                  | 0.0388  | 0.0252 | 1.2771  | 0.4374 | 0.4664  | 0.1759 |
| Tibouchina granulosa                | 0.0114  | 0.0099 | 0.8326  | 0.5349 | 0.3768  | 0.2217 |
Table 3. Average annual increase in volume (IMAV, in m³), Diameter (IMAD, in cm) and Height (IMAH, in m) and standard deviation (s₁, s₂ and s₃, respectively) according to the origin of the species studied in Viçosa, Minas Gerais, Brazil, in 2018

| Group          | Origin          | IMAV  | s₁    | IMAD  | s₂    | IMAH  | s₃    |
|----------------|-----------------|-------|-------|-------|-------|-------|-------|
| Woody          | Exotic          | 0.0240| 0.0291| 0.9641| 0.6108| 0.3264| 0.2933|
|                | Native Brazil   | 0.0360| 0.0454| 1.1596| 0.6155| 0.5115| 0.3103|
|                | Native Atlantic forest | 0.0299| 0.0176| 1.0266| 0.3537| 0.3973| 0.1625|
| Palm Trees     | Exotic          | 0.0089| 0.0040| 0.5148| 0.2581| 0.3066| 0.1396|
|                | Native Atlantic forest | 0.0297| 0.0147| 1.8948| 0.7570| 0.7051| 0.2515|

Means followed by the same letter in the column do not differ by Tukey’s test (P <0.01).

The woody species showed the largest increases in volume, diameter and height in individuals aged between 20 and 40 years, and the palm group, up to the age of 20, but maintaining growth beyond those ages (Chart 1). The wide variation for each age group is associated with the diversity of species in each group.

**Discussion**

The ecosystem services provided by urban afforestation depend on the size and health of trees and palms, which in these places can be negatively or positively affected by biotic, abiotic, climatic and anthropogenic factors (VAZ MONTEIRO; LEVANIČ; DOICK, 2017). The results of this study show that the growth in diameter, height and volume varies according to the type of the studied plant, monocot or...
Eudicotiledonea with the origin of these species native of the Atlantic, Brazil or exotic and with age of individuals.

The woody plants and palm features ram different growth rates $0.0279 \pm 0.0274$ and $0.0139 \pm 0.0119$ m³ ind⁻¹ year⁻¹, respectively, mainly due to morphological differences that alter growth secondary education of individuals. In eudicotyledons, a group of woody species, secondary growth is characterized by the production of secondary xylem and the development of new protective tissues from the exchange rate (OLIVEIRA, 2011). In contrast, monocotyledons, such as palm trees, show an increase in stem diameter due to the division of fundamental tissues, these being primary growth structures (BOTÂNICO; ANGYALOSSY, 2013), which often limits the size of individuals compared to trees. Among tree species, the greatest increase in Anadenanthera macrocarpa may have occurred due to the adaptation of the species to adverse environmental conditions, with tolerance to shallow, compacted and even poorly drained soils (GONÇALVES et al., 2008). Murraya paniculata was the woody species with the lowest growth because it is a shrub (CHOWDHURY; BHUIYAN; YUSUF, 2008) with smaller size in diameter and height among all the analyzed species. Among the palm trees, the difference in the average increase in volume is due to the characteristic size of the species studied.

The average annual volumetric increase of woody species in the urban environment, $0.0279 \pm 0.0274$ m³ ind⁻¹ year⁻¹, is higher than that found for Araucaria angustifolia, in two phytographic regions of Rio Grande do Sul, where there is a natural occurrence of the species with a maximum IMAv of $0.0198$ m³ and $0.026$ m³ (HESS; SCHNEIDER, 2010). In comparison with these data, the average growth of woody species in the urban area was lower than only a third fragment, which presented an average IMAv equal to $0.031$ m³ year⁻¹ (HESS; SCHNEIDER, 2010). In planting at the Embrapa Experimental Field in the Western Amazon, an IMAv of $0.039$ m³ ind⁻¹ year⁻¹ was estimated for the species Sclerolobium paniculata and between $0.019$ m³ ind⁻¹ year⁻¹ and $0.004$ m³ ind⁻¹ year⁻¹ for Hymenae courbaril, Carapa guianensis, Bertholletia excelsa, Swietenia macrophylla, Copaifera multijuga, Cedrela odorata, Trattinickia burseraefolia and Dipteryx odorota (SOUZA et al., 2008). The volumetric growth of the studied species is greater in the urban environment than in forest fragments or plantations, which may be due to the absence or little competition. The lower density of trees in an area urban reduces the competition for light and other resources, thus fostering growth (McHALE et al., 2009), and consequently the provision of ecosystem services. Higher tree growth rates in the urban environment are also related to the climate in these locations, characterized by the effect of the heat island that causes higher temperatures in cities and can stimulate photosynthetic activity and extend the plant's growing season (PRETZSCH et al., 2017). It is important to note that the growth rate of trees and palms in the urban environment that are larger than in forest fragments also implies a faster aging of these individuals, thus indicating the need for their replacement and replanting (PRETZSCH et al., 2017). The existing variation also indicates the need to take into account the growth in the choice of species to compose urban afforestation.

Species of palm trees and woody native Atlantic Forest to and naturally occurring in Brazil showed higher average growth rates in diameter, height, and therefore volume. Native species also showed growth rates
higher than the Exotic to s ex post when the s at the same level of light, for example, in Connecticut, USA (MARTIN; KOBE, 2010). And exotic species may have shown lower values as a result of adverse environmental conditions, even with some plasticity for adaptation (MUÑOZ et al., 2015; MARTIN; CANHAM; KOBE, 2010). The temperature and precipitation significantly influence the growth of the trees (VITALI; BÜNTGEN; BAUHUS, 2018), and variations between the place of origin of the species can contribute to the reduction of the increase rates. These factors even affect the species' vitality (WILLIAMS et al., 2012), and can cause individuals to become senescent at an early stage. Climate change has altered the frequency of extreme events and this will continue to alter the growth of species, including native species, and it is important to include these effects in growth projections (ZIMMERMANN et al., 2009).

The groups of plants studied, palm and woody, showed variation in growth according to age, being for the first group, the highest rates in individuals up to 20 years old, and for the second, those between 20 and 40 years old. This variation stems from the fact that the relationship between diameter / height and age are non-linear and, in the juvenile stage, growth occurs at a faster rate (VAZ MONTEIRO; LEVANIČ; DOICK, 2017). The increase in tree dimensions with increasing age causes these individuals to reach stages with limited availability of growth factors, light, water and nutrients, which explains the growth patterns in sigmoidal form (KÖHL; NEUPARE; LOTFIOMRAN, 2017). At advanced ages, even at lower rates compared to the juvenile stage, urban trees and palms continue to grow, which has implications for the provision of ecosystem services and also for the need for management of individuals.

The ecosystem services provided by trees and palms in the urban environment are influenced by different factors, such as age, size, spacing, free area. The interception of rainwater, for example, varies according to the species and size of the individuals, with those with PAD close to 3.5 cm intercepting about 15.3%, while those with 38.1 cm of DAP, can intercept up to 66.5% (XIAO; McPHERSON, 2002). Larger trees also tend to remove and store more carbon dioxide, in addition to retaining more airborne pollutants (GRATANI; VARONE, 2006). In Rome, trees with DBH ranging from 50-80 cm, tend to remove, on average, 72% more carbon dioxide than those with DBH between 20-50 cm (GRATANI; VARONE, 2006). Thus, the growth rates of trees are indicative of carbon neutralization, expansion of the occupied area above and below ground and, consequently, provision of many ecosystem services (PRETZSCH et al., 2017). Thus, the sustainable management of the population will trees in a city can help mitigate the negative impacts of climate change and maximize the benefits generated, using, for this, information on growth rates, dimensional changes that depend on the age and situation (RÖTZER et al., 2019).

Conclusions

The growth rate of woody and palm forest species in the urban environment varies according to the type of plant, the origin of the species and the age of each individual, being, in general, faster than in forest fragments. This behavior brings several benefits to the local microclimate, such as interception of rainwater, shading, removal of carbon dioxide and interception of particles suspended in the air. On the
other hand, this accelerated rhythm can anticipate the senescence of individuals causing the anticipation of their replacement.

The growth curves according to the age of the individuals is an important indicator of the spatialization, over time, of the provision of ecosystem services, since many are related to the supply of biomass in the trunk, or to the increase and renewal of leaves in the canopy. The growth of individuals being maintained, even at lower rates, with maturity, denotes their continued contribution to climate change.

Municipal afforestation plans must also enhance the inclusion of species naturally present in the region. These species have a higher growth rate than exotic species, establishing themselves more quickly in the area, in addition to being a form of ex situ conservation.

**Declarations**

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