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Comportamiento del arbolado urbano en el centro de la ciudad de Guantánamo
Behavior of the urban trees at Guantánamo downtown

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Resumen

El trabajo se desarrolló en el centro de la ciudad de Guantánamo, con el objetivo de evaluar el comportamiento del arbolado urbano. Se realizó un inventario florístico mediante un muestreo aleatorio simple, donde se utilizaron transeptos variables, evaluándose las especies de árboles existentes en el estrato arbustivo y arbóreo. Se evalúo el diámetro, altura, área basal, volumen, estructura horizontal, índice de valor importancia ecológica y secuestro de carbono. Se identificaron 21 familias, 33 especies y 835 individuos, las familias de mayor riqueza fueron: Boraginaceae, Bignonaceae y las especies de mejor comportamiento en CO_2 son: *Ehretia tinifolial* L., *Tabebuia angustata* Britt.

Palabras clave: Arbolado urbano; Estrategia; Transeptos variables; Muestreo aleatorio; Inventario florísticos.

Abstract

The work was carried out in the downtown area of Guantanamo city, with the objective of evaluating the behavior of urban trees. A floristic inventory was carried out by means of a simple random sampling, where variable transects were used, evaluating the existing tree species in the shrub and tree stratum. Diameter, height, basal area, volume, horizontal structure, ecological importance value index and carbon sequestration were evaluated. Twenty-one families, 33 species and 835 individuals were identified, the richest families were: Boraginaceae, Bignonaceae and the species with the best performance in CO2 were: *Ehretia tinifolial L.*, *Tabebuia angustata Britt*.

Key word: Urban trees; Strategy; Variable transects; Random sampling; Floristic inventory.

Introduction

Urban areas in the world present enormous environmental problems that are becoming more and more acute and are calling into question the sustainability of their development. That is why trees planted in towns and cities, mainly in the third world, make a positive contribution to current living conditions and their potential can be even greater according to the explanation of Jimenez (2009).

The purpose of urban forestry is the cultivation and management of trees to take advantage of their current and potential contribution to the well-being of the urban population, from a physiological, sociological and economic point of view. This activity represents a fusion between arboriculture, ornamental horticulture, landscape architecture and forest management, in line with what Sánchez (2003) discusses.

Moll and Gangloff (2007) state that trees are currently planted in cities without proper planning, correct soil preparation, adequate species selection, among other deficiencies. All this brings with it weak and/or diseased trees, poorly anchored to the ground that fall as soon as strong winds occur, trees that are drastically pruned because their branches get in the way of adjacent buildings and houses, roots that invade water pipes, raise pavements or crack walls; problems that could be perfectly foreseen and corrected with proper planning.

Cuba is taking the first steps in this discipline, and its main strength is the political will to implement a sustainable system, which is one of the important aspects dealt with in Forestry Law No. 85 of 1998, its regulations and contraventions. There are regulations for the pruning and felling of urban trees, as well as town planning and environmental regulations that protect trees in the urban environment; their projection and protection are part of territorial town planning strategies. However, there are still many roads to travel; the urban tree needs love, protection and financing, according to Sosa, et al. (2011).

The urban areas of Guantanamo city do not escape from these conditions, forest species often do not have the necessary characteristics to achieve sustainability in the different urban areas, and hence the objective is to evaluate the behavior of urban trees in the central city of Guantanamo.

Development

The data were taken in the arteries (streets) comprising the central zone of Guantanamo municipality with a surface area of 167,462 m2; 20 variable transects were taken, according to the methodology of Foster, et al. (1995), cited by Mostacedo and Fredericksenm (2000).

The inventory was carried out by simple random sampling, where variable transects were used, evaluating the tree species existing in the area that make up the shrub stratum, 1 to 4.99 m, and tree species greater than 5 m, according to Alvarez and Varona (2006), evaluating the diameter, plant height, basal area, volume and horizontal structure, relative abundance, relative dominance, relative frequency, value index of ecological importance (IVIE) and carbon sequestration.

- Diameter (m): measured at breast height with a diametric tape.
- Height (m): height was determined by the ocular method.
- Basal area (m2): it was determined by total forcipulation of the trees in the test plots and the calculation was made by the formulas:

$$G = F\sum_{i=1}^{m} g \; = F\sum_{i=1}^{m} \frac{\pi}{4} d^2$$

Where:

$\bar{V}$ = average wood volume.

$\bar{d}_i$ = average diameter.

$\bar{h}_i$ = medium height.

(f_e)= empirical morphic coefficient.

Horizontal structure of urban trees

Of individuals of a species

Species

Basal area of a species

Relative dominance = -- x 100

Basal area of all species

Of plots in which a species occurs

Relative frequency = -- x 100

Total occurrence in all plots

IVIE = Relative Abundance + Relative Dominance + Relative Frequency

The total number of individuals per diameter class of the species was determined, grouped in diameter classes with their interval, adjusted to the methodology of Hoyos (2003).

The information recorded was used to estimate biomass and carbon sequestration following the methodology described by Mercadet and Álvarez (2009). All the data obtained were processed with a file created in Microsoft Office Excel 2003, following the steps below:

- Carbon sequestered in biomass:

The conversion of standing wood volume to stem biomass was performed, using the dry wood density reported by species.

BMF (t) = Volume (m3) x Basic density of the species (kg/m3) /1000 (1)

The biomass corresponding to the branches and foliage (aerial biomass) was calculated using the Biomass Expansion Factor (BEF), which will have a minimum value of 1.74 and a maximum value of 3.00, thus:

BMA (t) = BMF (t) x FEB (FEB = e (3,213-0,506 ln BMF) (2)

Root biomass (BMR) was estimated by multiplying aboveground biomass by the default value 0.3.

BMR (t) = BMA x 0.3 (3)

Total biomass (BMT) was calculated as the sum of the following components:

BMT (t) = BMA (t) + BMR (t) (4)

Carbon retained in total biomass (CRBT) was calculated using the carbon content fraction in wood (FCCM) determined for the Cuban conditions.

CRBT (t) = BMT (t) x FCCM (5)

This operation (1, 2, 3, 4, 5) was performed for each species and the values for all trees were averaged.

- Conversion of calculated carbon to carbon equivalent (CO2e):

To calculate how much the retained carbon represented in tons of CO2 removed from the atmosphere, it was multiplied by 44/12 (3.67 t CO2), which is the ratio existing between the total weight of the CO2 molecule (44) and the carbon atom (12), according to Ramirez and Gomez (1999).

The data were processed using Bio Diversity Pro statistical programs, Microsoft Excel was used to perform the cluster analysis and to enter the data, tables and figures, and Microsoft Word was used to interpret the results obtained.

Figure 1 represents the number of individuals by strata, where it can be seen that the shrub stratum is where there is greater richness with 637 and the arboreal stratum 198, in addition, the scarce presence in the arboreal stratum is given by the pruning that is performed in order to control the height that these trees reach to serve as an improvement and beautification of the city.

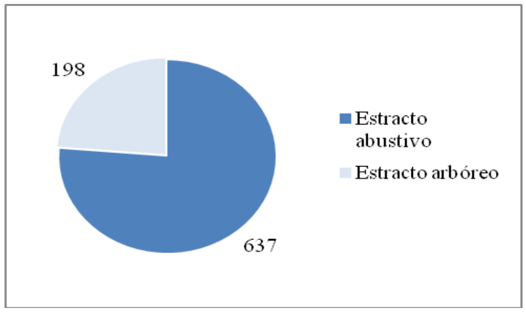

Figure 1. Total number of individuals present in the urban tree population.

Source: Own elaboration

These results coincide with Jimenez (2009), in stating that tree management should be one of the main components of an urban forestry program in communities, where tree management plans should complement the overall goals of the urban tree and park program in a community, in addition to fully integrating tree planting and maintenance activities, and emergency programs.

Table 1 shows the families with the largest and smallest individuals of each species in the city center, where it can be seen that the largest are: Apoynaceae with 327 individuals, Rubiaceae 107, Euphorbiaceae 95; Magnonaceae 54, Bignonaceae 40 and Rutaceae with 28 and the smallest: Sapotaceae, Myrtaceae, Akaniaceae, Combretaceae, all with 1, and Moraceae with 2.

Families	Species	Major individuals	Families	Species	Menor individuals
Apocynaceae	1	327	Bignoniaceae	2	7
Rubiaceae	2	107	Clusiaceae	1	7
Euphorbiacea	2	95	Moringaliaceae	1	5
Magnonaceae	1	54	Euphorbiacea	2	4
Bignonaceae	2	40	Mimosaceae	1	3
Rutaceae	4	28	Arecaceae	1	3
Boraginaceae	2	23	Papillonaceae	1	3
Annonaceae	2	17	Moraceae	1	2
Rutaceae	4	15	Combretaceae	1	1
Malvaceae	1	11	Akaniaceae	1	1
Anacardiaceae	1	11	Myrtaceae	1	1
Simarubaceae	1	10	Sapotaceae	1	1

Table 1. Families with the largest and smallest individuals

Source: Own elaboration

These richer families have effects on the climate, a situation that creates favorable conditions for human well-being by providing more pleasant temperatures and scenic beauty, in contrast to a place devoid of vegetation.

Hoyos (2003) also reached similar results by stating that these trees serve to protect against solar radiation by generating shade, their canopies are designed to capture sunlight and when they extend they shade the ground, protect the fauna, the lower flora and the human being from the direct impact of the sun's rays, in addition, they allow temperature regulation, where green areas and trees are a protective element against temperature fluctuations in the microclimates, helping to regulate it, keeping cool in summer and blocking the cold in winter.

Table 2 shows the species with the highest and lowest ecological importance value index, where the highest are represented by: Aleuritis moluccana 35, 32 %, Thevetia peruviana 33, 41 %, Ficus benjamina 16,91 %, Morinda citrifolia 15,29 %, Salix longipes 13,98 %, Mangifera indica 11,53 %, Calophyllum antillanum 10, 58 % and the minor ones: Psidium guajava 1,70 %, Akania belizensis 1,71 %, Citrus grandis 1,74 %.

Interest in hazard tree management in urban forests has increased in recent years because of the safety and liability benefits of preventing accidents. Recognizing hazardous trees and taking appropriate action can protect property and save lives.

Highest Value Index Of Ecological Importance (%)		Lowest Index of Ecological Importance Value (%)	
Gossypium barbadense	7,09	*Akania belizensis*	1,71
Thevetia peruviana	33,41	*Annona muricata*	1,89
Salix longipes	13,98	*Psidium guajava*	1,70
Aleuritis moluccana	35,32	*Ficus havanensis*	1,86
Ficus benjamina	16,91	*Citrus reticulata*	1,86
Citrus reticulata	10,52	*Citrus grandis*	1,74
Mangifera indica	11,53	*Manilkara zapotilla*	1,89
Citrus aurantium	8,79	*Jatropha curcas*	1,97
Morinda citrifolia	15,29	*Erythrina glauca*	1,80
Calophyllum antillanum	10,58	*Tamarindus indica*	1,88
Ehretia tinifolial	9,50		

Table 2. Woody species with the highest and lowest ecological value index in urban trees.

Source: Own elaboration

Chiesura (2004) also agrees with these results, making it clear that the benefits provided by urban green areas can be classified as environmental, economic and social. In environmental terms, they highlight the functionality of urban ecosystems, which includes wildlife habitat and enriched biodiversity, microclimate regulation, erosion control, air and noise pollution control, and increased biodiversity; In economic terms, they serve as a means of subsistence or income generation and materials such as food, firewood, fodder, fiber, and increase the value of real estate, and in the social sphere, they contribute to physical and mental health, reflected in sensations such as relaxation, freedom, happiness, inspiration, among others.

Figure 2 shows the total number of individuals by diameter classes in urban trees, where the largest diameters are: 34 (92 individuals), 36 (90), 30 (80), 24 (80), 22 (60), 32 (60), 30 (50), 38 (47), 2 (42), 4 (30), 20 (20) and 6 (20) and the smallest are: 14 (8), 8 (10), 12 (10), 10 (13) and 16 (15).

Total number of individuals by diameter classes in the urban tree population.

Source: Own elaboration

These values are due to the fact that the larger trees are not adequately managed, due to the lack of proper planning, without proper soil preparation, without adequate selection of species, coinciding with these results, Moll and Gangloff (2007), when they state that when work is not organized, it results in weak and/or diseased trees, poorly anchored to the ground that fall as soon as strong winds occur, trees that are drastically pruned because their branches get in the way of neighboring buildings and houses.

Figure 3 shows the average dasometric indexes of the species of economic value in urban trees, where the best wood volumes in m3 are: Ehretia tinifolia 14.34 m3, Tabebuia angustata 9.72 m3, Simaruba glauca 9.38 m3, Calophyllum antillanum 5.87 m3, Peltophorum ferrugineum 3.94 m3, Delonix regia 3.76 m3 and Albizia lebbeck 2.60 m3.

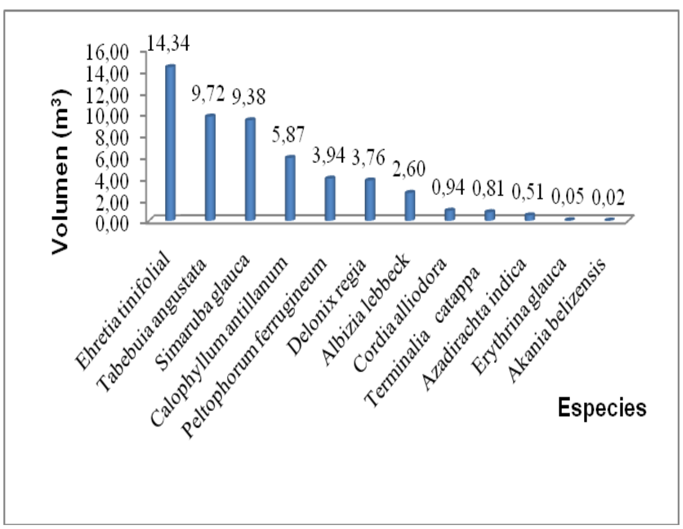

Figure 3. Volume behavior of economically valuable forest species.

Source: Own elaboration

Sosa, et al. (2011) agree with these results, stating that the purpose of tree management is to take advantage of the current and potential contribution that trees can make to the well-being of the urban population, from a physiological, sociological and economic point of view, including habitats for wild animal species, as well as opportunities for outdoor recreation, landscape design, waste recovery at the municipal level, tree care in general and the production of wood fiber as a raw material.

The species in the study, Table 3, retain a total of 6 496.48 t of carbon, at a rate of 6.74 t per individual, with false walnut, red oak and white oak standing out in their contribution with a retention of 2 106.32, 1 065.39 and 598.89 t of carbon, respectively. The rest of the species maintain a retention between 0.65 and 307.59 t, constituting these species as a whole, a carbon store, which in turn allows them to be considered as a conservation and CO2 reduction strategy.

Scientific Names	**Total species**	**Volume (m^3)**	**Density (kg / m^3)**	**Biomass Wood (t)**	**FEB**	**Biomass aerial (t)**	**Biomass roots (t)**	**Biomass Total (t)**	**Carbon Fraction**	**Total carbon in Biomass (t)**
Albizia lebbeck	3	2,60	490	1,27	1,74	2,22	0,66	2,88	46,37	133,54
Gossypium barbadense	12	0,02	490	0,01	1,74	0,01	0,00	0,02	47,08	0,90
Terminalia catappa	1	0,81	830	0,67	1,74	1,16	0,35	1,51	47,38	71,69
Annona cherimola	8	0,07	490	0,03	1,74	0,06	0,02	0,08	47,08	3,54
Azadirachta indica	7	0,51	610	0,31	1,74	0,54	0,16	0,70	49,74	35,04
Thevetia peruviana	326	0,77	490	0,38	1,74	0,66	0,20	0,86	47,08	40,28
Pieris cubensis	65	0,11	450	0,05	1,74	0,09	0,03	0,12	47,08	5,50
Akania belizensis	1	0,02	490	0,01	1,74	0,02	0,01	0,02	47,08	1,06
Juglans jamaicensis	91	41,37	490	20,27	1,74	35,27	10,58	45,85	45,94	2106,32
Peltophorum ferrugineum	3	3,94	736	2,90	1,74	5,05	1,51	6,56	46,88	307,59
Delonix regia	3	3,76	713	2,68	1,74	4,67	1,40	6,07	46,88	284,50
Simarouba glauca	10	9,38	595	5,58	1,74	9,71	2,91	12,63	46,88	592,01
Annona muricata	4	0,16	650	0,11	1,74	0,19	0,06	0,24	47,08	11,42
Psidium guajava	1	0,00	490	0,00	1,74	0,00	0,00	0,00	47,08	0,14
Crescentia cujete	7	0,16	633	0,10	1,74	0,18	0,05	0,23	46,88	10,78
Ficus crocata	3	0,23	390	0,09	1,74	0,16	0,05	0,20	46,88	9,50
Ficus benjamina	54	0,08	650	0,05	1,74	0,09	0,03	0,12	47,08	5,57
Citrus limon	15	0,01	490	0,01	1,74	0,01	0,00	0,02	47,08	0,75
Citrus reticulata	5	0,07	490	0,03	1,74	0,06	0,02	0,08	47,08	3,54
Mangifera indica	11	3,47	550	1,91	1,74	3,32	1,00	4,32	47,08	203,33
Moringa oleifera	5	0,32	490	0,16	1,74	0,27	0,08	0,35	47,08	16,64
Citrus aurantium	13	0,02	710	0,01	1,74	0,02	0,01	0,03	47,08	1,31
Citrus sinensis	2	0,01	590	0,01	1,74	0,01	0,00	0,01	47,08	0,65
Manilkara zapotilla	1	0,81	910	0,73	1,74	1,27	0,38	1,66	47,08	78,03

Morinda citrifolia	42	0,90	490	0,44	1,74	0,77	0,23	1,00	47,08	47,12
Calophyllum antillanum	7	5,87	759	4,45	1,74	7,75	2,33	10,08	48,75	491,16
Roystonea regia	3	1,93	960	1,85	1,74	3,22	0,97	4,19	46,88	196,25
Jatropha curcas	4	0,31	300	0,09	1,74	0,16	0,05	0,21	46,88	9,89
Erythrina crista	3	0,05	612	0,03	1,74	0,06	0,02	0,07	46,88	3,50
Tabebuia angustata	40	9,72	555	5,40	1,74	9,39	2,82	12,20	49,07	598,89
Ehretia tinifolia	18	14,34	693	9,94	1,74	17,29	5,19	22,48	47,42	1065,79
Tamarindus indica	1	0,55	750	0,41	1,74	0,72	0,21	0,93	47,08	43,80
Cordia alliodora	5	0,94	699	0,66	1,74	1,14	0,34	1,49	46,02	68,44
Total	**769**	**103,3127**		**60,6564**		**105,54**	**31,66**	**137,2**		**6448,47**
Per individual		**0,1077**		**0,0634**		**0,11**	**0,03**	**0,14**		**6,74**

Table 3. Calculation of carbon sequestered in urban trees in the center of the city of Guantánamo.

Source: Own elaboration

Legend: EBF (Biomass Expansion Factor)

It has been estimated that plantations have caused an absorption of 6 496.48t of carbon, thus contributing to reduce the excess of CO2 in the atmosphere, reflected in 23 842.08 t CO2 equivalent, not emitted to the atmosphere. These results validate the universal criterion that forests are natural carbon sinks, as defended by Brown (2002), demonstrating the importance of forest species for their contribution to carbon sequestration.

Conclusions

The families with the highest species richness were: Apoynaceae, Rubiaceae, Euphorbiaceae, Magnonaceae, Bignonaceae and Rutaceae. The best performing species in CO2 were: Ehretia tinifolia, Tabebuia angustata, Calophyllum antillanum, Simarouba glauca, Peltophorum ferrugineum, Delonix regia and Juglans jamaicensis, in Guantanamo city center.

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