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Aboveground Biomass and Carbon Sequestration of Hardwood and Palm Trees at Elaine Gordon Enchanted Park, in North Miami, Miami-Dade County, Florida

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ABSTRACT

Forests, including urban tree areas act as sinks for carbon dioxide (CO_2) by fixing carbon and storing excess carbon as biomass. In this context, urban trees affect air temperatures, energy use and climate change. In a study done in 2013, the authors estimated that trees in U.S. urban areas store 18.9 million tons of carbon per year and that this varies by state. According to the Intergovernmental Panel on Climate Change (IPCC), the amount of carbon dioxide stored in a tree is close to half the amount of its biomass. The Enchanted Forest Elaine Gordon Park is a 22-acre (8.90 Ha) oasis of subtropical plants, trees, and animals bordering Arch Creek in North Miami's heart. It offers scenic beauty, paved trails, and picnic facilities. Aboveground biomass of hardwood and palm trees on selected areas of the park was calculated indirectly by measuring tree perimeters, and carbon stock was calculated by assuming the carbon content as 47% of the total aboveground biomass. The equation by Brown & Iverson [11], 21.297-6.953 (DBH) + 0.740 $(DBH)^2$, was used to estimate an overall biomass of 592,530.057 Kg (65,836.67 Kg Ha^{-1}) and carbon stock of 267,844.57 Kg (29,760 Kg Ha^{-1}). Hardwood trees yielded greater biomass (546,995.77 Kg) and carbon stock (257,088.01 Kg) compared to palm trees (22,767.14 Kg and 10,700.55 Kg, respectively). A total of 10 species and 278 trees were identified, with most species categorized as endemic to North America.

Keywords: Elaine Gordon Park, Biomass, Carbon Capture, North Miami, Miami Dade County, South Florida, Urban Trees, U.S.

INTRODUCTION

Trees play a crucial role in reducing the amount of CO_2 in the atmosphere, thereby mitigating climate change. Approximately 50 percent of tree biomass is carbon, which means that trees are important agents of carbon sequestration. Determination of carbon sequestration potential in terrestrial ecosystems through biomass estimation has been the most widely followed approach [1-3].

Biomass refers to the total mass of all organic material that makes up a tree, including leaves, branches, trunks, bark, flowers and fruits, and compounds such as cellulose, hemicellulose, lignin, among others. Plant biomass can be subdivided into above-ground biomass (AGB) or below-ground biomass (BGB) with further subdivisions of each according to the morphology of different species. Scientists calculate the biomass of different tree species using different allometric equations based on tree measurements. The aboveground carbon stock is calculated under the premise that the carbon content is 48% to 50% of the total aboveground biomass [4-8].

Since it is affected by the overall shape of a tree, its canopy size, branching pattern, height, and trunk diameter, tree biomass can vary significantly by species due to differences in age, growth rate, wood density, and structure. In a study conducted in Amelia Earhart Park in Florida, we found that total biomass was about 40 times higher in hardwood trees

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than in palm trees, indicating the importance of hardwood trees in urban environments for their role as carbon sinks [9]. Urban trees present important considerations for global climate change. Trees within a densely populated area, including those in parks, on street ways, golf courses, natural preserves within cities, and green private properties, operate as "carbon sinks" that significantly contribute to the effort of reducing carbon in the atmosphere. Though the composition, health, age, extent, and costs of urban forests vary considerably among different cities, all urban forests offer additional common environmental, economic, and social benefits. Trees in a community help to reduce air and water pollution, alter heating and cooling costs, and increase real estate values. Trees can improve physical and mental health, strengthen social connections, and are associated with reduced crime rates. Trees, community gardens, and other green spaces get people outside, helping to foster active living and neighborhood pride [10].

This project aimed at collecting information to support the importance of increasing the number of parks and hardwood trees in urban environments that operate as "carbon sinks" as well as identifying tree species that capture the highest amounts of CO_2 within the urban area of our interest.

MATERIALS AND METHODS

Study Site: The Enchanted Forest Elaine Gordon Park is a 22-acre (8.90 Ha) oasis of subtropical plants, trees, and animals that borders Arch Creek in the heart of North Miami (**Figure 1**). It offers scenic beauty, paved trails, and 2 picnic facilities that can be rented for special events and parties. There is also a private pony ride concession within the park.

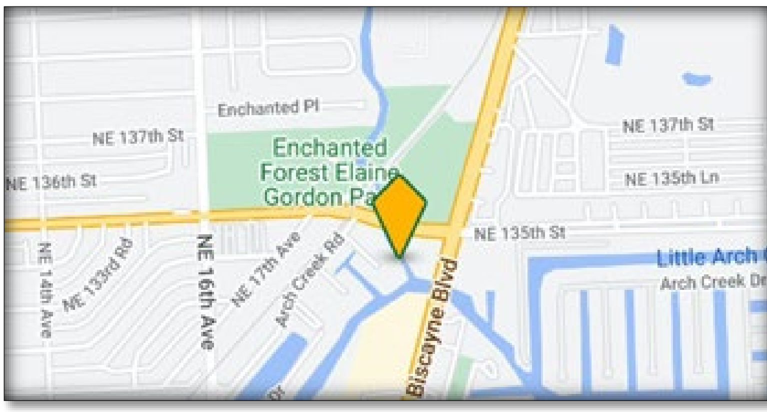

Figure 1. Mapping study site. Google Earth is used to map the area of interest.

Measurements: We measured tree perimeters in centimeters using a Tailor's tape on hardwood tree species and palm trees, as a first step to determining their biomass (**Figure 2**). We also started off measuring the height of the trees using a clinometer, but for convenience we ended up only measuring diameters. We transformed perimeters (at Breast Height, = 130 cm) into diameters.

Figure 2. Measuring tree perimeter. The Tailor's tape is used to measure the circumference of the tree.

DATA ANALYSIS

Biomass and Carbon stock derivations as well as statistical analyses were conducted using an extension of Microsoft Excel. Aboveground biomass carbon stock was calculated by assuming the carbon content as 50% of the total aboveground biomass. The equations used to quantify biomass are as follows:

Brown & Iverson [11] $Y = 21.297 - 6.953(DBH) + 0.740(DBH)^2$

Nogueira [12] $Y = e^{[-1.716+2.413 \times \ln(DBH)]}$

Donkor [13] $Y = 0.00388 * (DBH\hat{}2)\hat{}1.6063$

RESULTS AND DISCUSSION

Species Composition: A total of 10 species and 278 trees were identified, with most species categorized as endemic to North America. Of all the palm trees, the Sabal Mexicana is the most abundant, with 27 trees in the park. Of all the hardwood trees, Oaks (Quercus virginiana) were the most abundant with 168 trees (**Figures 3 & 4**).

Figure 3. Quercus virginiana.

Figure 4. Sabal Mexicana.

Overall Biomass and Carbon: An overall biomass of 592,530.057 Kg (65,836.67 Kg Ha^{-1} = 65.83 Mg Ha-1) and carbon stock of 267,844.57 Kg (29,760 Kg Ha^{-1} = 29.76 Mg Ha-1) was found based off Brown & Iverson values. Hardwood trees yielded greater biomass (546,995.77 Kg) and carbon stock (257,088.01 Kg) compared to palm trees (22,767.14 Kg, and 10,700.55 Kg, respectively).

In **Table 1** we compare the results of Biomass, Carbon, and Density of Trees in various sites studied over the last 5 years. The highest density values were obtained at the Pelican Harbor Facility, but this could be due to the influence of tree size, which has a major effect on biomass. We observed this relationship in graphs made by Srinivas [14], and how biomass increased due to the presence of *Ficus* trees in some local parks.

Table 1. Biomass, Carbon Stock, and Density of trees calculated at different parks and sites over the last 5 years. Units are IN Kg and (Mg Ha-1). Ind/Ha= Individuals per Hectare.

Biomass Kg(Mg Ha-1)	CO Kg(Mg Ha-1)	Density (Ind/Ha)	Place
22,760 (22.76)	10,700 (10.70)	31 (n=278)	Elaine Gordon Park
33,900 (33.9)	15,930 (15.93)	28 (n=584)	Amelia Earhart Park (14)
17,540 (17.54)	8,710 (8.71)	37 (n=511)	STU Campus Forest (15)
2,506,000 (2,506)	1,177,820 (1,177.82)	75 (n=103)	Pelican Harbor Facility (16)
73,000 (73)	34,31 (34.31)	30 (n=50)	Street Trees (17)

In **Figure 5** and **Tables 2-4**, we present the Biomass and Carbon Stock for Hardwood, and Palm Trees calculated with three different equations: Brown & Iverson [11], Nogueira [12] and Donkor [13]. From this point forward, we continued using Brown & Iverson [11] which provides more conservative values, as well as Donkor [13] for Palm Trees.

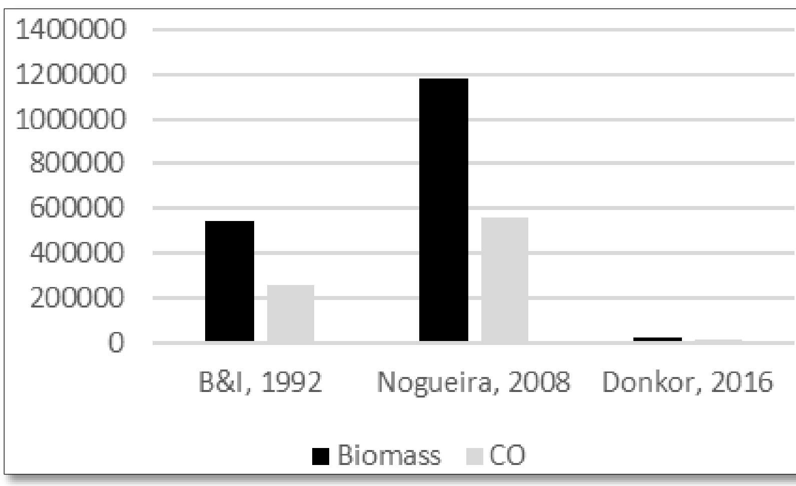

Figure 5. Biomass and Carbon Stock between Hardwood trees, and Palm trees (Units are Kg).

Table 2. Results using Brown & Iverson [11] equation (Units are in Kg).

B&I, (1992) [11]	Biomass	Carbon Stock
Mean	2378.24	1117.77
Standard Deviation	10906.72	5126.15
Range	159206.93	74827.26
Minimum	16.19	7.61
Maximum	159223.13	74834.87
Sum	546995.77	257088.01
Count	230	230

Table 3. Results using Nogueira et al. (2008) [12] equation (Units are Kg).

Nogueira et al. (2008) [12]	Biomass	Carbon Stock
Mean	5142.12	2416.8
Standard Deviation	33830.58	15900.37
Range	504499.26	237114.65
Minimum	32.36	15.21
Maximum	504531.62	237129.86
Sum	1,182689.23	555863.94
Count	230	230

Table 4. Results using Donkor (2016) [13] equation (Units are Kg).

Donkor (2016) [13]	Biomass	Carbon Stock
Mean	474.31	222.93
Standard Deviation	328.26	154.28
Range	2048.30	962.70
Minimum	4.78	2.25
Maximum	2053.09	964.95
Sum	22767.14	10700.56
Count	48	48

Total Biomass and Carbon Stock in our Enchanted Forest Elaine Gordon Park study are represented in **Figure 6**, we added the values obtained through the calculation of Biomass and Carbon with Brown and Iverson [11] equation for hardwood trees to the ones obtained for palm trees with the Donkor et al equation.

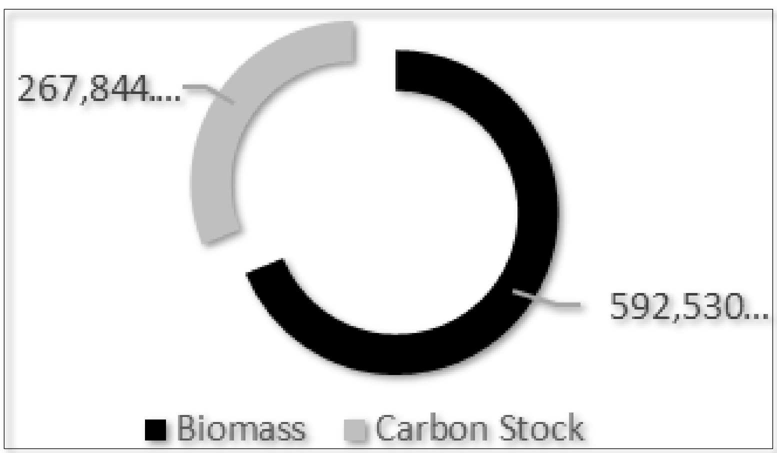

Figure 6. Total Biomass and Carbon.

Tree diameters broken down into categories are shown in **Figure 7**. We can see there that the highest number of trees belong to the 39 cm tree diameter category followed by the 70 cm tree diameter category (74 trees). As in the case of Srinivas [14], a species of *Ficus* turned out to be the species with the higher amount of biomass, and hence carbon captured (data not shown).

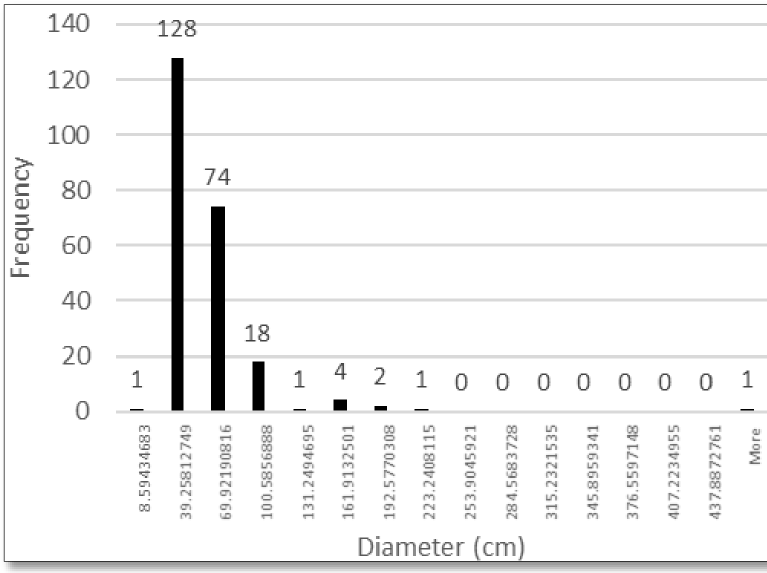

Figure 7. Trees in diameter classes.

Hardwood and palm trees: Based on Brown & Iverson [11] values, hardwood trees yielded greater biomass (546,995.77 Kg) and carbon stock (257,088.01 Kg) compared to palm trees (22,767.14 Kg, and 10,700.55 Kg, respectively). A total of 10 species and 278 trees were measured and identified, with most species categorized as endemic to North America.

The trend of hardwood tree biomass being greater than that of palm trees in areas of South Florida is constant in all projects developed by us over the last five years [9,15-17]. It points to the importance of considering planning future green areas with a higher percentage of hardwood trees instead of the typical palm trees in South Florida as an action step towards addressing reduction of carbon content in the atmosphere.

Our final remark is that we have kept using general allometric equations based on diameter only, although we continue to record clinometer information on height as well. The reason, as stated in a previous paper [16,17], is that in parks and other large green areas it is difficult to get the right distance between observer and tree to record the height. This was also highlighted by Segura & Kanninen [18] in their 2005 article.

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CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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