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Quantifying tree height and canopy structure in a forest in Davao Oriental State College of Science and Technology, Mati City, Davao Oriental

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ABSTRACT. Forests are landscapes dominated by trees and cover approximately 30% of the earth's land surface, housing most of its biodiversity. This study aimed to quantify the tree height and canopy structure of a man-made forest in the locality, particularly the density, relative density, frequency, relative frequency, coverage, relative coverage, diversity, and importance value of the trees in the study area. The establishment of the study area was conducted on 8, September 2017, and a transect-quadrat method was employed to assess the trees in the forest. Two (2) species of trees were found in the study area. These were paper tree (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*). The densest tree species was mahogany with 0.53 followed by paper tree with 0.47. Mahogany was also observed to have a higher frequency than paper tree. Paper tree in the study area has larger canopy coverage and circumference at breast height than mahogany attributed to its fast-growing nature. The diversity of tree species in the study area was found to be low, attaining only 0.47 on the Shannon-Wiener Diversity Index and 0.69 on Simpson's Diversity Index due to the small number of tree species present. The results of the importance value were low, with 1.32 for paper tree and 1.68 for mahogany since they are relatively young and have similar number of individuals.

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INTRODUCTION

Forests are defined as local or regional segments of landscapes in which biological and ecological conditions and processes are dominated by the presence of large trees, generally long-lived perennial plants characterized by a large woody stem and a large woody root system (Kimmins, 2007). There are three major types of forests, according to Ollinger et al., (2008), these are the tropical, temperate, and boreal forests. Tropical forests occupy regions that lack a distinct period of winter dormancy, although dormant periods can still occur as a result of seasonal patterns of rainfall. In tropical regions, it is the seasonality of rainfall that determines the type of forest that occurs in a particular area. Temperate forests occur at mid-latitudes where winter temperatures fall below 0 °C, but rarely as low as -40 °C. Most temperate forests are made up of broad-leaved deciduous species, but evergreens are also common. Although these groups frequently coexist, differences in their geographic distributions are related to both climate and resource availability. Boreal forests or 'taiga' ecosystems occur at high latitudes and upper elevations with a short growing season (30 to 120 days) and where minimum temperatures of -40 °C and colder are not uncommon in winter. These conditions are beyond that which can be tolerated by most broad-leaved deciduous species and so cold-tolerant conifers gradually become dominant. Boreal forests represent the world's largest biome and needle-leaf coniferous trees are the dominant tree type although some broad-leaf species such as alder and aspen are present in early successional communities.

Forest ecosystems are valuable to the ecosystem as well as the human population. The importance of forests was enumerated in the analysis of Krieger (2001) and included its role in soil stabilization and erosion control, wherein forest vegetation would help in stabilizing the soil and reduce erosion and sedimentation. Air quality: trees in the forests trap airborne matter and thus improve air quality and human health. Climate regulation and carbon sequestration: trees help regulate climate by trapping moisture and cooling the earth's surface (Heckbert et al., 2011). Recreation and tourism, scenic beauty, and recreational amenities associated with forests make them popular recreation destinations. Non-timber commercial forest products: forests produce many commercially valuable products other than timber, including mushrooms, floral greens, medicinal plants, edible plants and wildlife species. And lastly, cultural values, where cultural values associated with forests include what economists call passive use values for forest goods and services, the aesthetic value of forest scenery, and values associated with a region's cultural heritage. This study was designed in an endeavor to characterize and quantify the tree height and canopy structure in a man-made forest in the locality. The specific aspects of the forest ecosystem that were determined were the density, relative density, frequency, relative frequency, coverage, and relative coverage. These were all conducted within the Davao Oriental State College of Science and Technology main campus on September 5, 2017.

MATERIALS AND METHODS

Study site

This study was conducted on a man-made forest (Figure 1) near the Science building of the Davao Oriental State College of Science and Technology (DOSCST). The area was characterized by the presence of tall trees and interspersed weeds and grasses underneath. The trees present were relatively young not native to the area since they were only introduced, with individual ages of the trees not exceeding 15 years at most.

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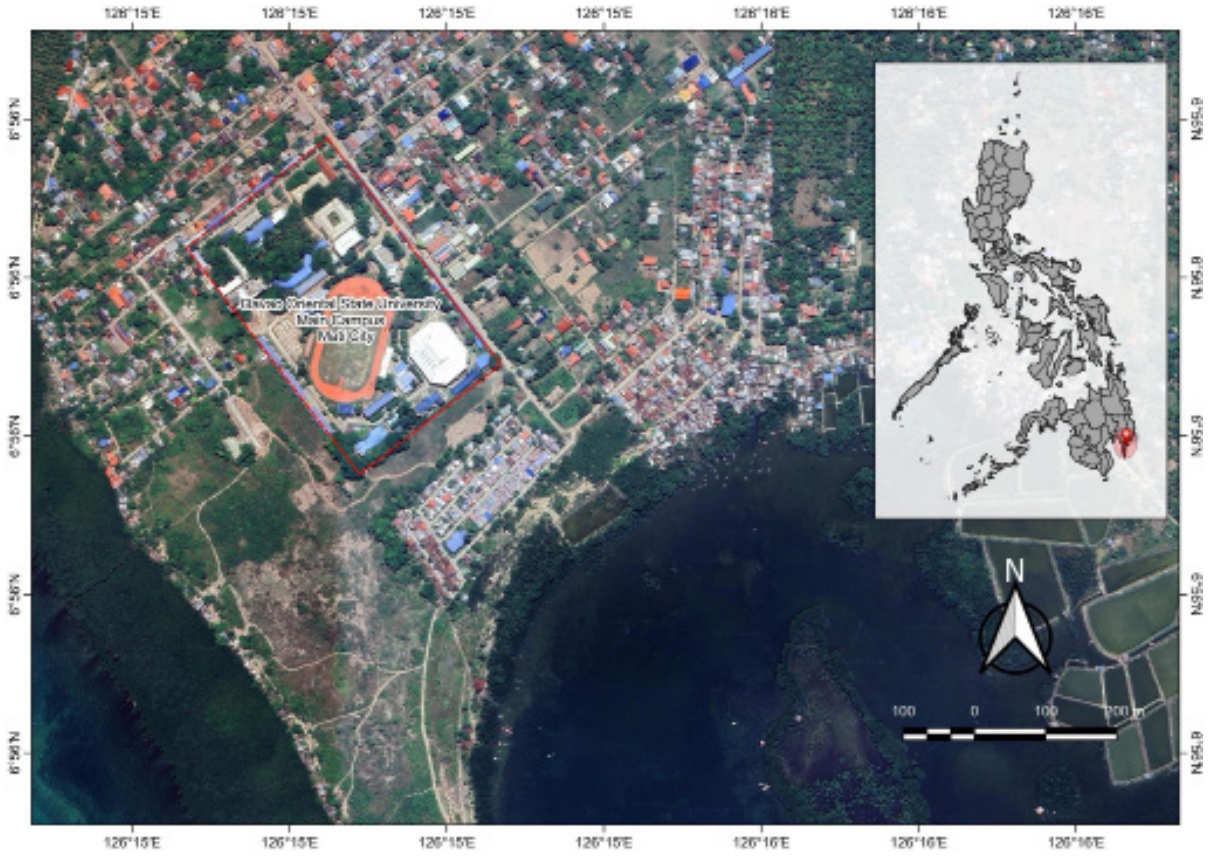

Figure 1. Establishment location of the study area in the City of Mati, Davao Oriental.

Establishment of study site

The study was conducted in the man-made forest near the Science Building of Davao Oriental State College of Science and Technology, and transect-quadrat method (Figure 2) was used. A 30 m transect was laid at the center of the man-made forest to cover and represent the outward and middle parts of the man-made forest. In the transect, three 5 x 5 m (25 m^2) were established in both ends of the transect and in the middle. An interval of 5 m was observed between each quadrant. To randomly determine which side of the transect the quadrant will be established on, a coin was tossed, with the head signifying its establishment on the left part of the transect and the tails signifying its right.

Gathering of data

The trees present within each established quadrant were identified at the species level using the published reference of Lanting and Palaypayon (2002) as a field guide. The number of individual trees per species was counted. Trees with a height exceeding 3 m were measured for height through careful estimation and expressed in the unit of a meter. Circumference at Breast Height (CBH), or trunk circumference at 1.5 m from the ground, was also measured through the use of a tape measure and expressed in the unit of a centimeter. The coverage of the canopy inside the transect by each tree that is present inside or near the transect was measured with a meter stick and expressed in the unit of a square meter. The data gathered was duly noted, and photos of the individual trees were taken for documentation.

Data analysis

The data gathered from the transects were analyzed in this study for the following components: density, relative abundance, frequency, relative frequency,

coverage, and relative coverage, using the appropriate formulas and indices adopted from Bower et al., (1990).

Density

$$D=n_i/A$$

Wherein:
D = Density; number of individuals per unit area
n_i = Total number of individuals of species sampled
A = Total area of all transects sampled

Relative density

$$RD_i=n_i/\sum n$$

Wherein:

RD_i = Number of individuals of a given species as a proportion of the total number of individuals of all species
n_i = Total number of individuals of species sampled
$\sum n$ = Total number of individuals counter for all species

Frequency

$$f_i = j_i/K$$

Wherein:
f_i = Chance of finding a given species in a plot
j_i = Number of line intercept intervals containing species
K = Total number of intervals on the transects

Relative frequency

$$Rf_i = f_i/\sum f$$

Wherein:
f_i = Frequency of species *i*
$\sum f$ = Sum of the frequencies of all species

Coverage

$$C_i = a_i/A$$

Wherein:
a_i = Total area covered by species (basal area)
A = Total area sampled

Relative coverage

$$RC_i=LC_i/\sum LC_i$$

Wherein:
LC_i = Linear coverage index for species *i*
$\sum LC_i$ = Sum of the values of the linear coverage index for all species

Important value

$$IV_i = RD_i + Rf_i + RC_i$$

Wherein:
RD_i = Relative density
Rfi = Relative frequency
RC_i = Relative coverage

RESULT

Taxonomic identification

Only two (2) species of trees were found and identified in the study area of the man-made forest in front of DOSCST's Science Building. These were of paper tree (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*).

Paper tree

Paper tree (*Gmelina arborea*) was introduced in large tropical areas due to the well-known silvicultural techniques and wood quality produced by fast-growing trees that were managed in short-rotation systems. Also, paper tree is a moderate-sized to large buttressed deciduous tree (Figure 2A) with opposite, broadly ovate, acuminate, usually cordate leaves, glaucous beneath, or stellately hairy or tomentose beneath in one variety (Dvorak, 2004).

The bark on young trees and on the crown and the upper part of the stem in older trees is smooth, corky, pale brown to grey in color. It exfoliates near the swollen base of the stem in trees over five to eight years old, exposing smooth, paler-colored bark beneath. The form varies greatly with varying conditions of growth. If grown in the open, heavy branches and a

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wide crown develop, and the stem is short, seldom straight, swollen at ground level, and markedly tapered. The root system varies in depth of penetration with soil depth and texture. Roots have the same pale, corky bark on the ground surface as the branches (Lamb, 1968).

Figure 2. Paper tree (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*) as found in the study area.

Mahogany

Mahogany is an evergreen tree with a dense, dome-shaped, rounded, but sometimes spreading crown (Figure 2B). It is native to the West Indies and southern Florida. This tree is best known for its heavy, dark reddish-brown wood. Mahogany typically grows to 40–50 feet tall, but mature trees in its native habitat will grow to 80 feet (less frequently to over 100 feet) tall. Mature trees are distinctively buttressed at the trunk base. Scaly gray bark often splits to expose the reddish inner bark. Branches are clad with pinnate-compound deep green leaves. Each leaf has 4–10 pairs of ovals, glossy, leathery green leaflets (Orwa et al., 2009).

Density and relative density

Results on the density and relative density of the trees in the study area were tabulated in Table 1. The gathered data revealed an inconsistent trend in the domination of paper tree and mahogany on the different plots, with equal densities of both trees in Plot 1, a higher density of paper tree in Plot 2, and a higher density of mahogany on Plot 3.

Table 1. Density and relative density of the trees in the study area.

	Scientific name	Common name	Count	Density (m^2)	Relative density (m^2)
Plot 1	*Gmelina arborea*	Paper tree	2	0.08	0.5
	Swietenia macrophylla	Mahogany	2	0.08	0.5
Plot 2	*Gmelina arborea*	Paper tree	4	0.16	0.8
	Swietenia macrophylla	Mahogany	1	0.04	0 2
Plot 3	*Gmelina arborea*	Paper tree	1	0.04	0.83
	Swietenia macrophylla	Mahogany		0.20	0.17

Relative density	
Paper tree (*Gmelina arborea*)	0.46 m^2
Mahogany (*Swietenia macrophylla*)	0.53 m^2

Mahogany was observed to dominate the entire tree population in the study area, attaining over 0.53 m^2 of relative density compared to that of paper tree, with only 0.47 m^2.

Frequency and relative frequency

The data in Table 2 shows the frequency and relative frequency of the trees in the study area. It was revealed that both tree species attained equal frequency in Plot 1, with 0.67. A higher frequency of paper tree was observed on Plot 2 with 1.33, mahogany followed with only 0.33, and a higher frequency of mahogany was observed on Plot 3 with 1.67 and paper tree with only 0.33.

A trend was observed in the aggregated calculation of frequency and relative frequency of the trees in all plots

Table 2. Frequency and relative frequency of the trees in the study area.

	Scientific name	Common name	Count	Frequency	Relative frequency
Plot 1	*Gmelina arborea*	Paper tree	2	0. 66	0.13
	Swietenia macrophylla	Mahogany	2	2.66	0.13
Plot 2	*Gmelina arborea*	Paper tree	4	1.33	0.26
	Swietenia macrophylla	Mahogany	1	0.33	0.26
Plot 3	*Gmelina arborea*	Paper tree	1	0.33	0.26
	Swietenia macrophylla	Mahogany		1.66	0.33

	Frequency	Relative frequency
Paper tree (*Gmelina arborea*)	2.33	0.46
Mahogany (*Swietenia macrophylla*)	2.66	0.53

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in the study area, with the noticeable dominance of mahogany attaining 2.67 on the frequency of all plots and 0.53 on the relative frequency of all plots. paper tree only attained 2.33 on the frequency on all plots and 0.47 on the relative frequency on all plots.

Coverage and relative coverage

Figure 4 shows the coverage and relative coverage of the tree canopies in the study area. The data revealed that Plot 2 and 3 have the same trend in the dominance of canopy cover, where in Plot 2, paper tree has the highest average canopy cover (Figure 3) with 8.08 $m^{2,}$ while mahogany only has an average of 4.68 m^2, and in Plot 3, paper tree has an average of 46 m^2, while mahogany only has 28 m^2. A different trend was observedin Plot 1, with mahogany having a higher average canopy cover of 28.26 m^2 while paper tree had 23 m^2, and the same was also observed on the relative canopy cover of all plots, with mahogany having an average of 25 m^2 while paper tree had 18 m^2.

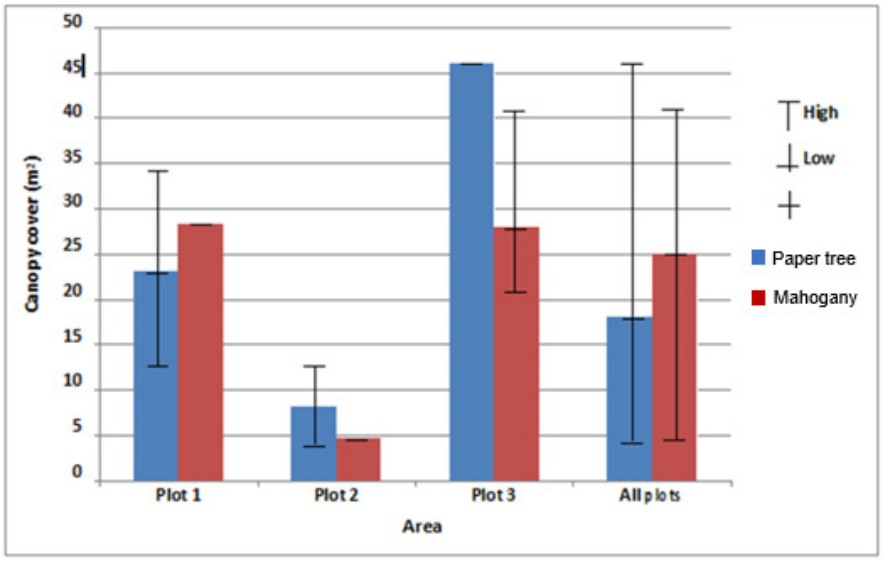

Figure 3. Range and average of the canopy cover from the different plots.

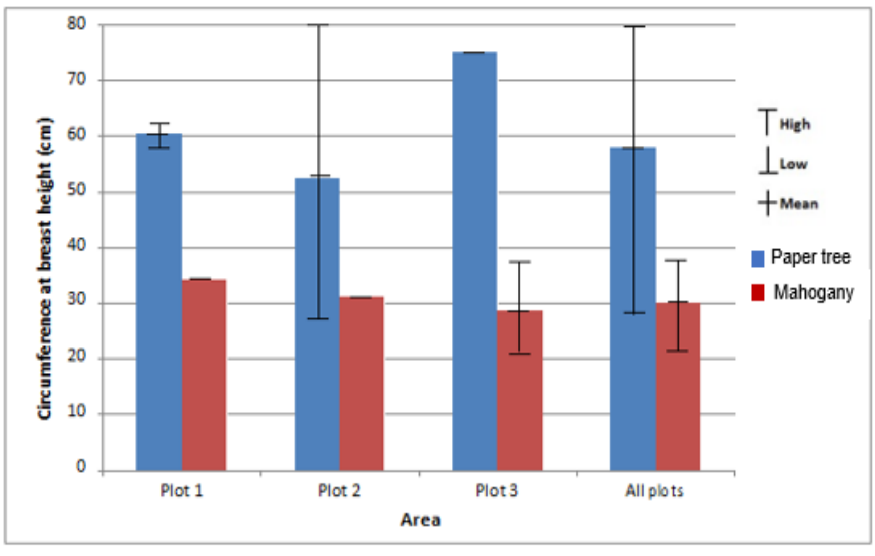

Figure 4. Mean and range of the circumference at breast height (CBH) from the different plots.

Circumference at breast height (CBH)

The data in Figure 4 shows the measured and calculated circumference at breast height (CBH) of the trees inside the plots in the study area. A trend is observable, with paper tree dominating in terms of having the higher calculated average and highest maximum in the range of CBH.

Importance value

The importance value is the sum of these three measures (relative density, coverage, and frequency), with results ranging from 0 to 3.00. A high importance value indicates that a species is well represented in an area because of some combination of a large number of individuals of a species compared with other species in the area or a smaller number of individuals of a species, but the trees are large compared with others in the area. The calculated importance value of the trees in the study area (Table 3) was revealed to be low, with only 1.32 for paper tree and 1.68 for mahogany. This signifies that both of these tree species in the area have a very close number of individuals, and since they are relatively young, they have low canopy coverage and are generally undersized.

Table 3. Calculated importance value of the tree species in the study area.

Parameters	Paper tree *(Gmelina arborea)*	Mahogany *(Swietenia macrophylla)*
Relative Density (m^2)	0.46	0.53
Relative Frequency	0.46	0.53
Relative Coverage (m^2)	0.38	0.61
Importance Value	1.31	1.68

Diversity

Table 4 shows that the diversity of the trees in the study area was calculated through the Shannon-Wiener diversity index and Simpson's diversity index.

The Shannon-Wiener diversity index incorporates the richness and evenness of the plants as its components. The higher the value, the higher the diversity, and the lower the value, the lower low diversity. The value of *H* of 0.69

Table 4. Calculated the diversity of the trees in the study area.

	Scientific name	Common name	Count
Plot 1	*Gmelina arborea*	Paper tree	2
	Swietenia macrophylla	Mahogany	2
Plot 2	*Gmelina arborea*	Paper tree	4
	Swietenia macrophylla	Mahogany	1
Plot 3	*Gmelina arborea*	Paper tree	1
	Swietenia macrophylla	Mahogany	6
	Total		15
	Shannon-Weiner diversity index		0.69
	Simpson's diversity index		0.46

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signifies low tree diversity. The Simpson's diversity index, on the other hand, is a measure of diversity whose values range from 0 to 1, with increasing values corresponding to a higher diversity of plants. The calculated value of 0.47 signifies low tree species diversity.

DISCUSSION

There were two species of trees found and identified in the study area. These were paper tree (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*). There were only seven paper tree and eight mahogany trees in the three plots examined. The low number of tree species in the study area could be attributed to the fact that it was man-made. Hence, the species were already selected prior to planting and thus have been subject to human intervention and not a result of natural phenomena. This relatively low number of tree species resulted in the low diversity of trees in the study area (0.69) on the Shannon-Wiener diversity index and 0.47 on Simpson's diversity index, both indicating low species diversity. Since the forest was man-made, this had a significant effect on the density and frequency of the trees pecies in the study area. The calculations of the density and frequency of the trees showed very close and similar results, with paper tree having 0.47 and mahogany having 0.53. It could be inferredthat the almost even distribution and interval of trees planted in the study area affected the overall density and frequency of trees. In nature, the distribution of trees is influenced by variation in community composition among sites that vary in topography, and parent material is often clearly related to differences in water and nutrient availability. If competition was mainly for light and therefore one-sided or asymmetric (Ford and Sorrensen, 1992; Cannell and Grace, 1993; Schwinning and Fox 1995), strong local regular patterns of surviving individuals develop from initially random or clumped patterns. There is general agreement that such pattern formation is driven by resource competition and subsequent density-dependent mortality e.g. due to competition (Powell, 1990; Kenkel et al. 1997).

SUMMARY AND CONCLUSION

There were two (2) tree species present in the study area: paper tree (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*). The trees were observed to have been only introduced and not naturally present in the area. The trees were also relatively young, estimated to not exceed 20 years. The analysis of the data revealed that mahogany had the highest density, with 0.53, followed by paper tree with 0.47, although they were relatively close. Mahogany also had the highest frequency, with 0.53 while paper tree only had 0.47. A similar trend was observed in the circumference at breast height (CBH) and canopy coverage, which were both dominated by paper tree, attributed to its fast-growing nature.

The calculation of the importance value has revealed a low value for both tree species, with paper tree having only 1.32 and mahogany having 1.68. The diversity of the tree species has yielded a low value, with 0.69 on the Shannon-Wiener diversity index and 0.47 on Simpson's diversity index. The low values in importance and diversity are attributed to the young age of the trees and the low number of tree species in the study area, respectively.

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