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Stability Assessment and Composition of Tree Species in Nigerian University

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ABSTRACT

Wind remains a strong abiotic agent associated with damages of forest trees. The vulnerability of a tree to windthrow is highly influenced by the ratio of tree total height to its stem diameter (RHD). However, RHD has been identified as an index and measure of tree and stand stability. This study assessed the stability and composition of open grown tree species in the University of Ibadan, Nigeria. Diameter at breast height (Dbh) and total height (THt) of one hundred and thirty-nine (139) trees species with Dbh ≥5.0 cm found within three departments of the University were measured. A total of 36 species from 17 families were identified with Myrtaceae and Combretaceae families having highest (28.8% and 21.6%, respectively) numbers of tree. RHD was found to have negative correlation with all the tree growth variables investigated except THt. However, this study reveals that about 79 % of the trees found in the study area had RHD <80, indicating stable and low risk or susceptibility to windthrow, wind-induced bending and breakage. Hence, trees with RHD >80 (21%) were recommended for felling as they pose threat to human life and properties in the study area.

***Keywords*:** Tree stability, species composition, slenderness coefficient, windthrow

1. INTRODUCTION

Wind is one of the natural agents that influence environmental disaster, it is the perceptible natural movement of the air, especially in the form of a current of air blowing

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from a particular direction. Wind has been identified to be associated with damages to forest trees. Wind damage ranges from bending of wood, breakage of stems to uprooting of a live tree [1, 2]. However, wind has become a threat to the enormous benefits of forest trees. Benefits such as; food, recreation and job to man, habitat for plants and animals, stock for carbon and ecosystemic balance.

Conversely, the vulnerability of a tree to windthrow is highly influenced by the ratio of tree's height to its stem diameter [3]. Tree total Height/diameter at breast height has been demonstrated to be a fast and good proxy for mechanical stability of trees [3]. Previous research has also identified the ratio of total height to stem diameter (RHD) as an index and/or a measure of tree and stand stability [4, 5]. The ratio of height to diameter (RHD) of a tree also known as tree slenderness coefficient is computed as total height (Tht) divided by its diameter over bark at breast height (Dbh) [5-7].

However, [8] derived RHD classes from the French Forest Institute Revue Forestière Française, the classes were stated as: "Low" for RHD <80, "Moderate" for RHD = 80 – 100 and "High" for RHD > 100. In the same vein, [9] developed RHD categories for mature white spruce and Aspen regeneration in Boreal Mixed woods. The category follows: RHD > 99 as "High", RHD = 70 – 99 as "Moderate" and RHD <70 as "Low". Furthermore, [5] categorized RHD for tropical rain forests of Nigeria into three, namely; "Low" (RHD< 70), "Moderate" (RHD 70-80) and "High" (RHD > 80).

Thus, Lower RHD value indicates better developed root system, higher crown projection area, longer crown length and lower center of gravity of tree, thus high tree stability [5, 10]. On the other hand, High RHD value implies that the tree is much more susceptible to wind damage [11-14]. Therefore, knowledge of the relationship of tree and stand's RHD will help forest and wildlife managers in understanding the structure and stability status of a stand. Thus, aid decision making based on trees susceptibility to wind-related damages so as to boost stand productivity. This study therefore, aimed at assessing the stability status of the natural forest in Shasha Forest Reserve, Nigeria, with a view to providing baseline information for sustainable forest management.

2. MATERIALS AND METHODS

2. 1. Study area

This study was carried out on trees species within three departments in the Faculty of Renewable Natural Resources (RNR), University of Ibadan, Nigeria. The departments are; social and environmental forestry, Forest production and products and Wildlife and Ecotourisim Management. The area is situated between latitude 7.448° N and 7.450° N and longitude 3.896° E and 3.898° E. (Figure 1), with a total land area of 2.276 ha and mean elevation of 212.2 m. The study area is bounded by Department of Nursing in the east, Kashim Drive (road) in the west, Faculty of Agriculture road in the south and department of Agricultural Biology in the North.

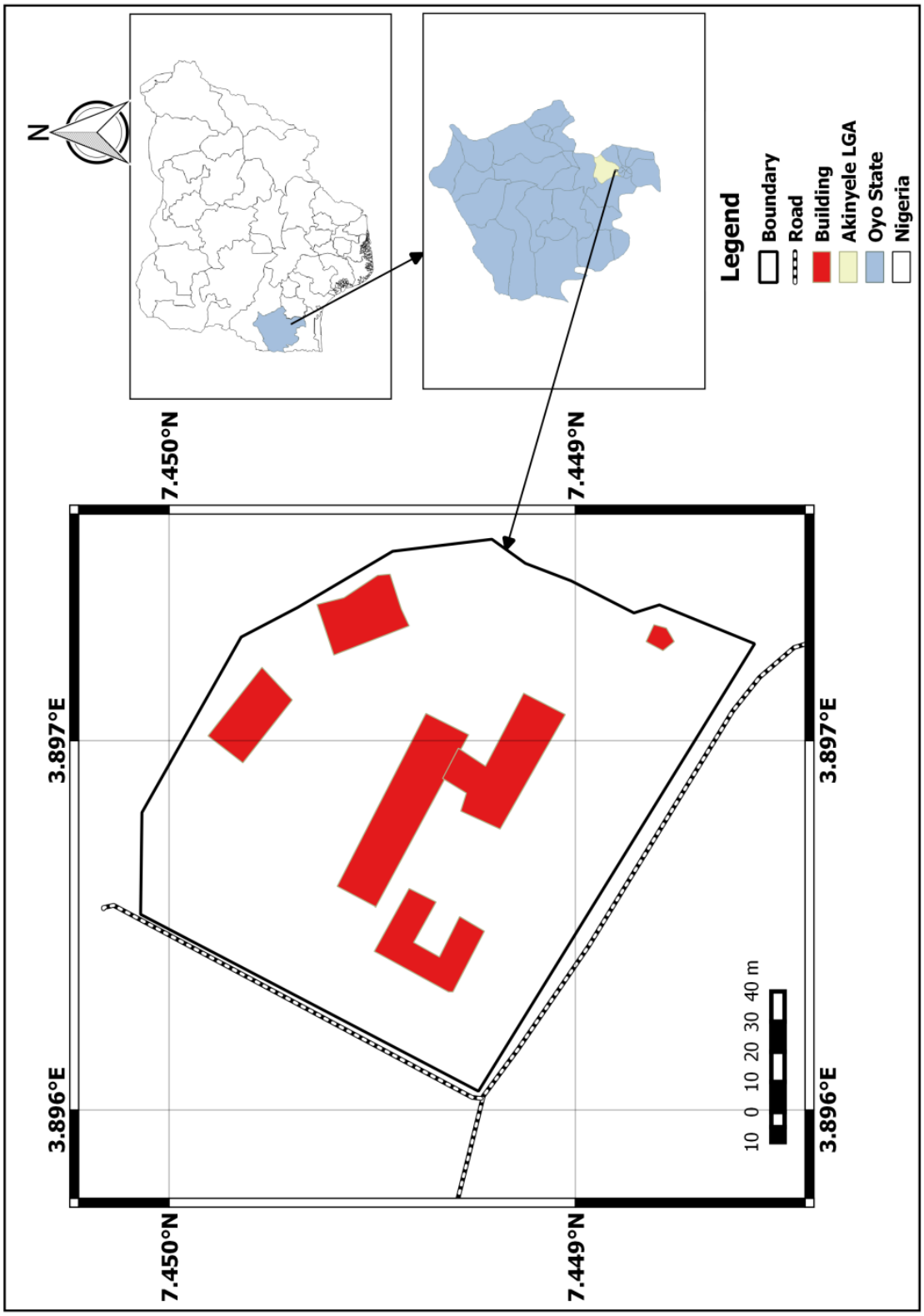

Figure 1. Map of Shasha Forest Reserve

2. 2. Sampling procedure and data collection

The data used for this study was collected all tree species with diameter at breast height (Dbh) ≥ 10 cm found within the departments of; Social and Environmental Forestry, Forest Production and Products and Wildlife and Ecotourisim Management, University of Ibadan, Nigeria. Diameter at breast height (Dbh) and Total height (THt) of one hundred and thirty-nine (139) found within the study area were measured.

Individual trees diameter over bark was measured using diameter tape calibrated in centimeter. The point of the measurement was recorded from the uphill sides of the trees and on the inside of the lean for leaning trees. For trees with deformations at 1.3 m, the measurement was made at the sound point on the stem above the abnormality. During the measurement, loose bark, climbers and epiphytes were lifted above the measuring tape.

Total height was measured using Spiegel relaskop, height from the ground to the tip of the tree was measured as the total height.

2. 3. Data processing and analysis

Basal area for each tree was computed using:

$$BA = \frac{\pi(Dbh)^2}{4} \quad (1)$$

where:

BA = Basal area (m^2); π = Pi is constant (3.143); Dbh = Diameter at breast height (cm)

$$RHD = \frac{Tht}{Dbh} \quad (2)$$

where:

RHD = Stability index; THt = Total height (m); Dbh = Diameter at breast height (m)

2. 4. Descriptive statistics and correlation analysis

The tree growth variables were described using measures of central tendency and measures of dispersion. Pearson's product moment coefficient of correlation was carried out to examine the relationship between the tree growth variables and RHD.

The correlation coefficient was computed as:

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{N}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{N}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{N}\right]}} \quad (3)$$

where:

r = correlation coefficient, X = variable (1) to be compared, Y = variable (2) to be compared, N = total numbers of observations or trees measured.

2. 5. RHD categorization

The ratio of height to diameter (RHD) of tree species found within the natural forest of Shasha Forest Reserve, Nigeria was calculated (equation 2) and further categorized into three stability categories according to [5] as follows:

Low (RHD < 70)
Moderate (RHD 70 – 80)
High (RHD > 80)

The frequencies of the observed numbers of tree in each category were further computed.

3. RESULTS

3. 1. Tree composition

This study enumerated a total of 139 trees consisting of 36 species distributed among 26 genera in 17 families. *Myrtaceae and Combretaceae* are the most dominant families in the study area, with the largest number of trees representing 28.8% and 21.6% of the total population trees, respectively (Table 1). However, *Combretaceae and Meliaceae* had the highest number of species with four (4) each (Figure 2). *Eucalyptus camaldulensis, Terminalia superba, Eucalyptus tereticornis* and *Nauclea diderichi* are the most dominant tree species in the study area.

Table 1. Family and species frequency of trees in the study area

Family	Species frequency	Trees frequency	Tree (%)
Anacardiaceae	2	2	1.4
Apocynaceae	3	5	3.6
Arecaceae	1	5	3.6
Caesalpiniaceae	1	2	1.4
Combretaceae	4	30	21.6
Fabaceae	3	5	3.6
Irvingiaceae	1	1	0.7
Leguminosae	2	3	2.2
Meliaceae	4	7	5.0
Moraceae	3	3	2.2

Moringaceae	1	1	0.7
Myrtaceae	3	40	28.8
Pinaceae	1	3	2.2
Rubiaceae	1	17	12.2
Sterculiaceae	3	5	3.6
Theaceae	1	1	0.7
Verbenaceae	2	9	6.5
Total	**36**	**139**	**100**

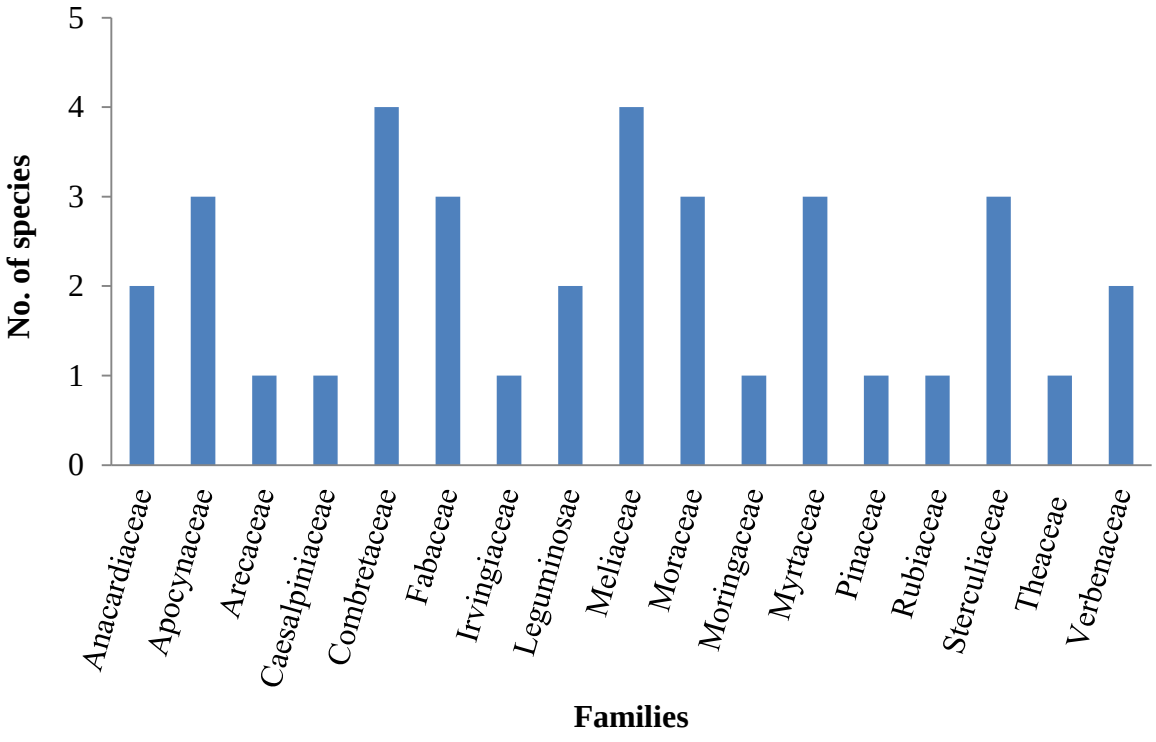

Figure 2. Distribution of tree species among families in the study area

3. 2. Summary statistics of tree variables

The minimum, maximum, mean and standard error of the measured and derived tree growth variables from the study area were presented in Table 2. The distribution of Dbh ranged from 10.19 to 143.22 cm, total height ranged from 3.40 to 26.60 m, RHD ranged from 13.11 to 154.80 and basal area ranged from 0.007 to 1.661 m^2.

Table 2. Summary statistics table for growth characteristics variables

Variable	Descriptive Statistics		
	Minimum	Maximum	Mean± Std. Error
Dbh (cm)	10.19	143.22	30.35± 2.245
THt (m)	3.40	26.60	13.67± 0.511
RHD	13.11	154.80	59.22± 2.338
BA (m^2)	0.007	1.611	0.126± 0.022

where: Dbh = diameter at breast height, THt = total height, BA = Basal area (m^2), RHD = ratio of height to diameter and SE = standard error.

Table 3 showed the result of Pearson's product-moment correlation analysis between Dbh, THt, BA and RHD. The result revealed that RHD is significant negatively correlated with all the tree growth variables investigated except THt. RHD had high correlation with Dbh and BA (r = -0.59 and -0.49, respectively) and low correlation with THt (r = -0.02).

Table 3. Bivariate correlation between RHD and tree growth variables

Growth Variables	Correlations			
	Dbh	THt	BA	RHD
RHD	-0.59*	0.02 ^{ns}	-0.49*	1

where: Dbh = diameter at breast height (cm), THt = total height (m), BA = basal area (m^2), * = Correlation is significant; ns = non-significant at the 0.05 level (2-tailed). Number of trees = 139.

The frequency result of the RHD categories (Figures 3 and 4) for the tree species in the study area revealed that 87 trees (63%) had high low ratio of height to diameter (RHD < 70). However, 23 trees (16%) and only 29 trees (21%) had moderate and high ratio of height to diameter (RHD 70-80 and RHD > 80, respectively).

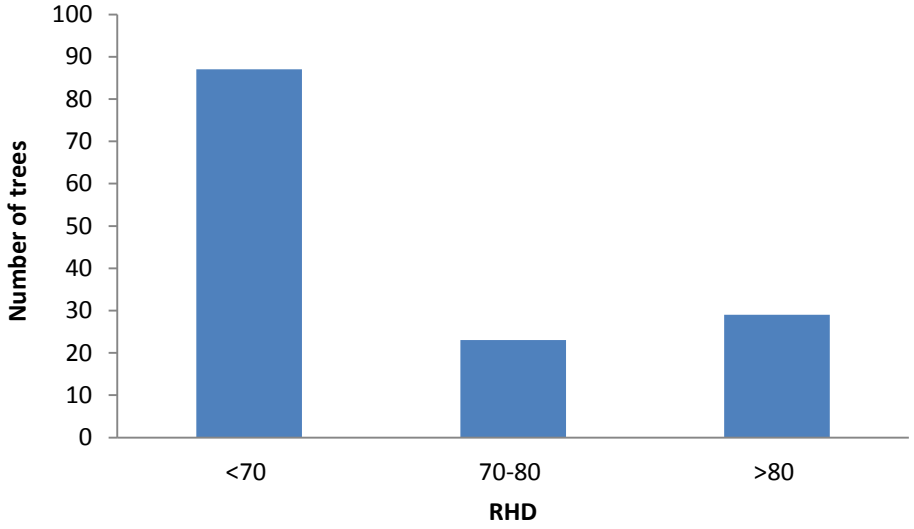

Figure 3. Graph showing RHD categories for the trees in the study area

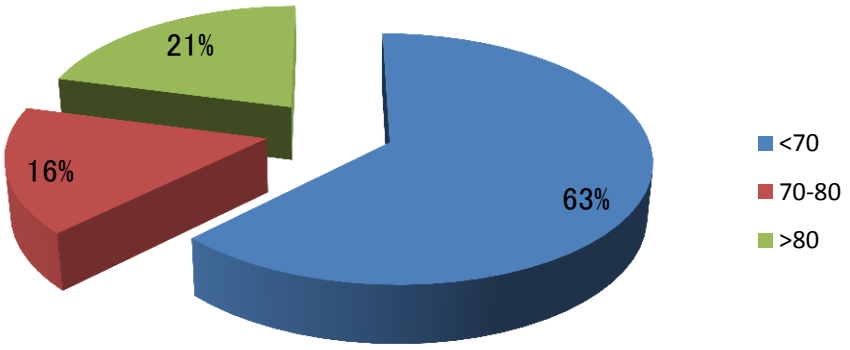

Figure 4. Chart showing tree percentage in RHD categories

4. DISCUSSION

A total of 139 trees were enumerated, Combretaceae and Meliaceae had the highest number of species represented in the mature tree population (Figure 1). However, the families Myrtaceae had the highest numbers of tree (density), followed by Combretaceae and Rubiaceae. This is similar with the findings of [15] that these families are highly represented within the Faculty of Agriculture and Forestry; now known as Faculty of Renewable Natural Resources and Faculty of Agriculture. Thus, forming a unique man-made ecosystem of indigenous and exotic tree species in the study area.

Correlation analysis carried out gave insight of the association between ratio of height to diameter (RHD) and other tree growth variables.

However, the result revealed that RHD had negative correlation with all the variables investigated in this study except total height. This implies that the stability index (proportion of trees prone to wind-throw) or RHD increases with decrease in tree diameter, basal area and increase with total height.

This result is in agreement with previous research that RHD had direct association with basal area [5], Dbh [16] and an inverse association with total height [7].

Therefore, high correlation of Dbh and BA with RHD as well as RHD low correlation with total height implies that the stability (increase or decrease in RHD) depends more on tree's circumferential increment than its vertical elongation. The is also confirmed by the non-significance displayed between RHD and THt. These statements are in agreement with the assertion of [4], that trees with high ratio of height to diameter (low taper) are much more susceptible to damage (low stability) than trees with low RHD (high taper). Hence, smaller ratio of height to diameter (RHD) is usually indicating higher resistance to windthrow (high stability). Lowest correlation coefficient was obtained for the relationship between RHD and total height. However, this result is comparable to the reports of [7] and [16].

According to [2] and [5], trees with RHD values over a threshold of 80 (RHD>80) are prone to wind-induced breakage. However, the frequency result of the three RHD classes considered in this study reveals that about 79% of the trees found within the Faculty of Renewable Natural Resources, University of Ibadan had either low (63%) or Moderate (16%) RHD. This implies high stability and low risk or susceptibility to windthrow, wind-induced bending and breakage.

This may be as a result low tree density which reduced competition for sunlight among the trees in the study area. Hence, causing more increase in stem diameter than the height of trees. These assertions were confirmed by [10] who affirmed that lower RHD connotes trees grown under the less influence of mutual support of their neighboring trees. Thus, [17] also reported that lower slenderness coefficient can be an indicator of larger crowns with lower centre of gravity and a better developed root system.

However, previous studies [5, 18-20] indicated that RHD below 80 depicts good stability for forest trees. Conversely, the result of this study generally shows that only few (21%) tree species within the study area are at risk of windthrow and breakage.

5. CONCLUSIONS

This study revealed the composition of tree species in the Faculty of Renewable Natural Resources, University of Ibadan. However, significant and inverse relationship was also revealed between tree height to diameter ratio and most tree growth variables. More than two-third of the tree species within the study area were found to be stable or not at the risk of wind damage. However, only but a few number of trees have possibility of windthrow effect. Thus, poses threat to human life and properties around the Faculty.

Furthermore, this study recommends that the management faculty should either fell those trees that were found to have RHD >80 or apply the appropriate silvicultural measures to improve the stability the affected of trees species.

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