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Stability assessment of open grown forest tree species in Nnamdi Azikiwe University Awka, Nigeria

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Abstract

The objective of this study was to assess the stability of open grown forest trees in Nnamdi Azikiwe University, Awka, Nigeria, for sustainable management. The stability of a tree is very important for understanding the structural firmness of a tree. Tree stability can be assessed using tree slenderness coefficient (TSC) and crown ratio (CR). The study area lies between latitude 6.245º and 6.283ºN and longitude 7.115º and 7.1219ºE in the Tropics. Total enumeration of open grown tree species with D ≥ 10cm found within the investigated site was done and the following growth variables; diameter at height of 1.3m (D), total height and crown length were measured. The data collected were analysed using descriptive statistics. The study discovered that about 95.8% and 68.9% of the trees enumerated had TSC<70 and CR>0.50, respectively; indicating high stability and vigour respectively. This implied that most of the open grown forest trees in the site studied remain stable and have low risk or not susceptible to wind throw, wind-induced bending and breakage. Hence, trees with TSC values >99 (1.7%) and CR<0.30 (18.0) were recommended for felling as they pose threat to human lives and properties in the study area.

Keywords: Crown ratio, tree slenderness coefficient, structural firmness, sustainable management, tree species.

Introduction

The stability of a tree is very important when studying trees and its environment. Assessing tree stability gives an understanding of the structural firmness of tree roots which are inaccessible and also gives guidance on the maximum and stable height of a tree[1]. The global use and exploitation of trees therefore, creates a wide range of ecological problems. Hence, there is growing concern over the stability of trees especially open grown trees in the urban environment. Many authors have based stability of tree species on influence of root morphology[2,3]. The assessment of tree stability has not been investigated in Nnamdi Azikiwe University, Awka campus, Nigeria.

Tree stability can be assessed using tree growth characteristics such as tree slenderness coefficient (TSC) and crown ratio (CR). TSC has remained as one of the vital guides extensively used for assessing the opposition of trees to wind throws[4]. According to Navratil[5], TSC habitually functions as a directory of tree stability and classified TSC into 3 categories, as: "Low" for TSC values <70, "Moderate" for TSC =70-99 and "High" for TSC>99. Trees with higher TSC are more vulnerable to wind mutilation while trees with low TSC values have a lesser center of solemnity and healthier established root structure[6,7]. Becquley and Nivert[8] proposed the three stability zones which are stable, moderately stable and unstable in pure even-aged stand of conifers species. Chukwu and Chenge[7] adopted the same stability zones to classify trees species found within the three (3) Departments in a Nigerian University.

Tree crown ratio (CR) on the other hand, has been found to be an important predictor of tree diameter growth[9,10]. It is also an indicator of tree's resistance to wind[11] and stand density[12]. Thus, the less dense the trees in an area, the higher the crown spread area, as a result of lower competition rate leading to stable trees. CR has also been used as an indicator of tree vigour and a useful variable for assessing forest health condition[7]. Tree crown anchors the leaves which allow photosynthetic processes and it is used to describe crown size. The measurement of the crown of trees is often done to assist in the quantification of the growth of tree in a stand. Crown ratios of open grown trees were classified into the following three vigour classes modified by Schütz[13] as: Low vigour for CR <0.30, Moderate vigour for CR = 0.30-0.50 and High vigour for CR >0.50.

This study was aimed at assessing the stability of open grown forest trees which has rarely been investigated in Nnamdi Azikiwe University (NAU), Awka, Nigeria to provide baseline information for silvi cultural practices and management of open grown trees in the considered site.

Materials and Methods

Study area: The study site **(**6.245º and 6.283ºN, 7.115º and 7.1219ºE) is a Nigerian University established in the southeastern zonein 1991 with mean elevation of 136 meters above sea level. The climate of the area is tropical indicating that it is basically within the tropical rainforest ecological zone with mean temperature of 26.3°C. Awka has seasonal climatic

conditions; the rainy and the dry seasons with a short spell of harmattan as well as precipitation array of 1828mm-2002mm[14]. Figure 1 displayed the map of Awka South showing the location of the study area.

Sampling design: A complete enumeration of open grown forest trees (≥10cm diameter at 1.3m (D)) growing within the NAU was employed. Total height of tree (THT), crown length (CL) and diameter at 1.3m (D) of each open grown forest trees in the study area were measured. A total number of four hundred and seventy-nine (479) trees encountered and recorded.

Data handling and analysis: Data collected were cautiously handled thus, analysed following the objective of the study. The following tree growth variables were computed.

Tree slenderness coefficient was computed using:

$$TSC = \frac{THT}{D} \quad (1)$$

Where; TSC = Tree slenderness coefficient; THT: Total height of tree (m); D = Diameter at 1.3m (m).
Crown ratio was computed using:

$$CR = \frac{CL}{THT} \quad (2)$$

Where: CR = Crown ratio; CL = Crown length (m); THT = Total height of tree (m).

Exploratory analysis: Descriptive statistics and correlation analysis were used to investigate and summarize the tree growth variables information. Pearson's correlation matrix was used to examine linear associations among the tree growth variables.

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 considered; Y= variable 2 considered; N= total number of trees measured.

TSC categorization: According to Navratil[5], TSC values were categorized into 3 classes. There are; TSC values >99 = High SC, 70< TSC >99 = Moderate SC, TSC values <70 = Low SC

CR categorization: Crown ratio of open grown trees is classified into the following three vigour classes modified from Schütz[13]: i. Low vigour (CR<0.30), ii. Moderate vigour (CR 0.30-0.50), iii. High vigour (CR> 0.50).

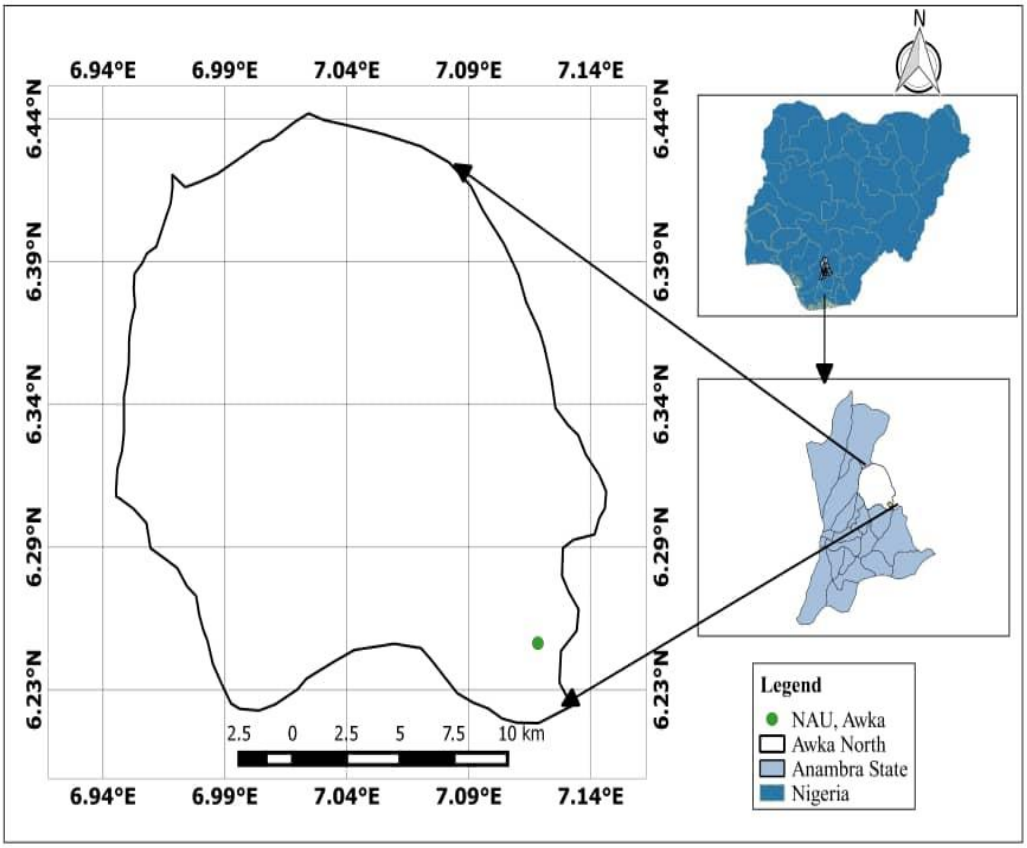

Figure-1: Map of Awka showing NAU.

Results and discussion

Results: Descriptive statistics results revealed the distribution of D to range from a minimum of 10.0cm to a maximum of 342.9cm with mean ± standard deviation values of 122.8±63.587cm (Table-1). TSC ranged from 5–193 with mean ± standard deviation values of 21.28±20.441 and CR ranges from 0.04 to 0.98 with mean ± standard deviation values of 0.55±0.182. THT ranges from 7.1m – 36.3m with mean and standard deviation values of 18.4±3.625. CL ranges from 0.7m - 21.3m with mean and standard deviation values of 10.20±3.812 (Table-1).

The result of rectangular correlation analysis between CR, TSC and other tree growth variables showed that TSC was negatively correlated with D (-0.60) and other tree growth variables. CR had a high positive correlation with CL (0.84) and low negative correlation with D at -0.06 (Table-2).

The frequency result of TSC categories for open grown tree species revealed that 459 trees (95.8%) have low slenderness coefficient (TSC<70). However, 8 trees (1.7%) have high slenderness (TSC>99) (Figure-2). The frequency result of CR categories for open grown tree species showed that 46 trees (9.6%) have low vigour(CR<0.30). However, 330 trees (68.9%) have high vigour (CR>0.50) (Figure-3).

Discussion: The result of the descriptive statistics indicated that stem diameter of trees in the study area decreases upward along the stem. This proves the biological validity of the data set. This result is in disagreement with the result of Sumida et al.[15] who reported that tree trunk growing rates at altered heights tend to upsurge marginally from breast height (1.3m) aloft. The summary of growth variables for the measured trees showed relatively high variations which are due to uneven age tree stands.

Correlation analysis carried out gave understanding of the link amongst TSC, CR and other tree growth characteristics. The result of correlation analysis indicates that TSC was negatively correlated with D and total height which indicated that TSC value tends to decrease for larger trees. This implied that the proportion of trees prone to wind throw or damage in the study area decreases with increase in stem diameter and vice versa. This agrees with the findings of Ezenwenyi and Chukwu[4]who reported that the proportion of wind-throw and damaged trees in a stand decreases strongly as the D increases for a given slenderness ratio. This is an indication that the bigger the D of a tree, the more stables the tree and can withstand wind throw. The study also revealed low and negative association between D and CR. This implied that horizontal increment affects tree vigour. This corroborates the report of Popoola and Adesoye[16] that crown ratio decreases with increasing tree size.

The frequency result of the three TSC classes considered in this study implied high stability and low risk or susceptibility to wind throw and breakage. This may be as a result of low tree densities; since the trees were open grown with reduced competition. These assertions were confirmed by Sharma et al.[17] who affirmed that lower slenderness connotes trees grown beneath the less effect of communal sustenance of their neighbouring trees. The result of classification of the crown ratio in the studied site also revealed that the larger percentages (21.5% and 68.9%) of the species are within the moderate and high vigour classes respectively. Generally, crown ratios are expected to be larger for area with lower density of trees[12,18].

The frequencies of the tree slenderness coefficient and crown ratio categories showed an indirect relationship; most trees with high slenderness coefficients had low crown ratios. This is in line with Faber[19] who reported that relationship between crown dimensions and slenderness coefficient (SC) is incidental; lower SC could be a pointer of bigger crowns with lesser centre of solemnity and a well-developed root structure. The result of this study generally showed that only few (TSC=1.7% and CR=9.6%) tree species within the study area are at risk of wind throw and breakage.

Table-1: Summary statistics of Tree Variables.

Variables	Minimum	Maximum	Mean	Std. Error	Std. D
D (cm)	10.0	342.5	122.8	2.905	63.587
THT (m)	7.1	36.3	18.4	0.166	3.625
CL (m)	0.7	21.3	10.20	0.174	3.812
TSC	5	193	21.28	0.934	20.441
CR	0.04	0.98	0.55	0.008	0.182

N= 479, D= diameter at height of 1.3m (cm), THT= total height of tree (m), CL= crown length (m), TSC= tree slenderness coefficient, CR= crown ratio.

Table-2: Rectangular correlation matrix.

Growth variable	CL (m)	D (cm)	THT (m)	TSC
TSC	-0.04	-0.60*	-0.08*	
CR	0.84	-0.06	0.01	0.01

*= significant at 5% (2-tailed), CL= crown length (m), TSC= tree slenderness coefficient, CR= crown ratio, D= diameter at height of 1.3 m (cm), THT= total height of tree (m).

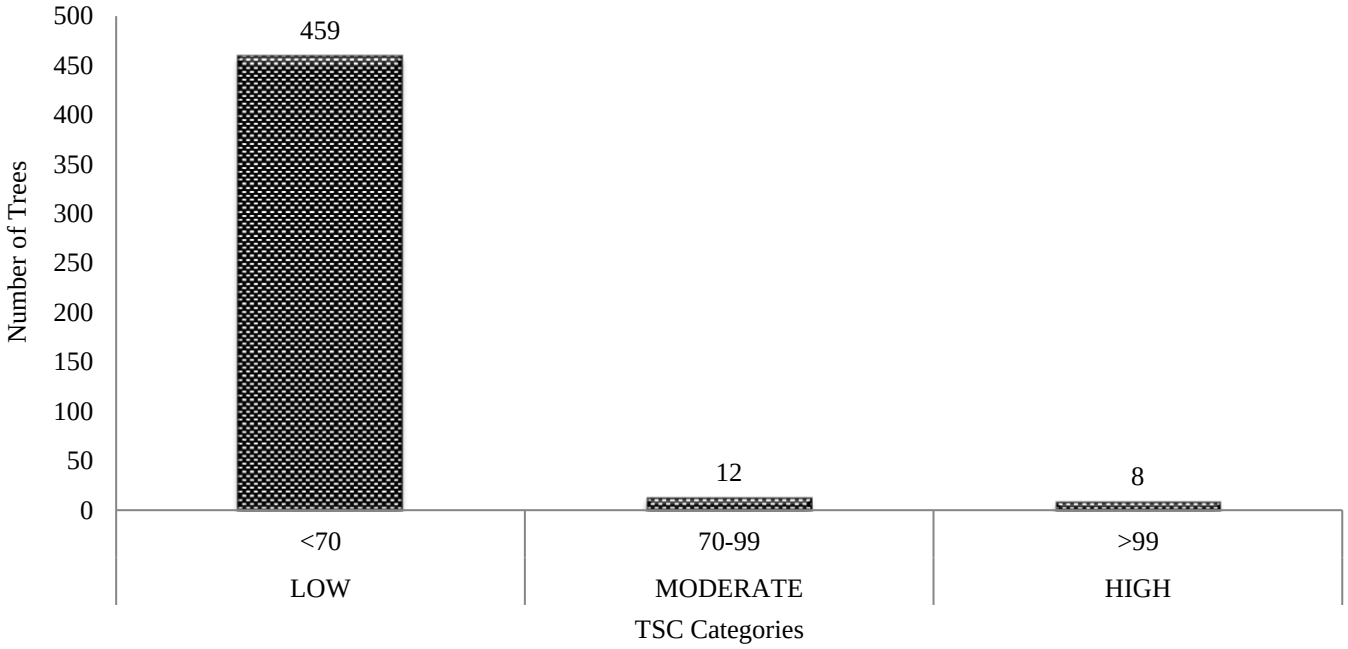

Figure-2: Frequency of trees and their slenderness coefficient categories.

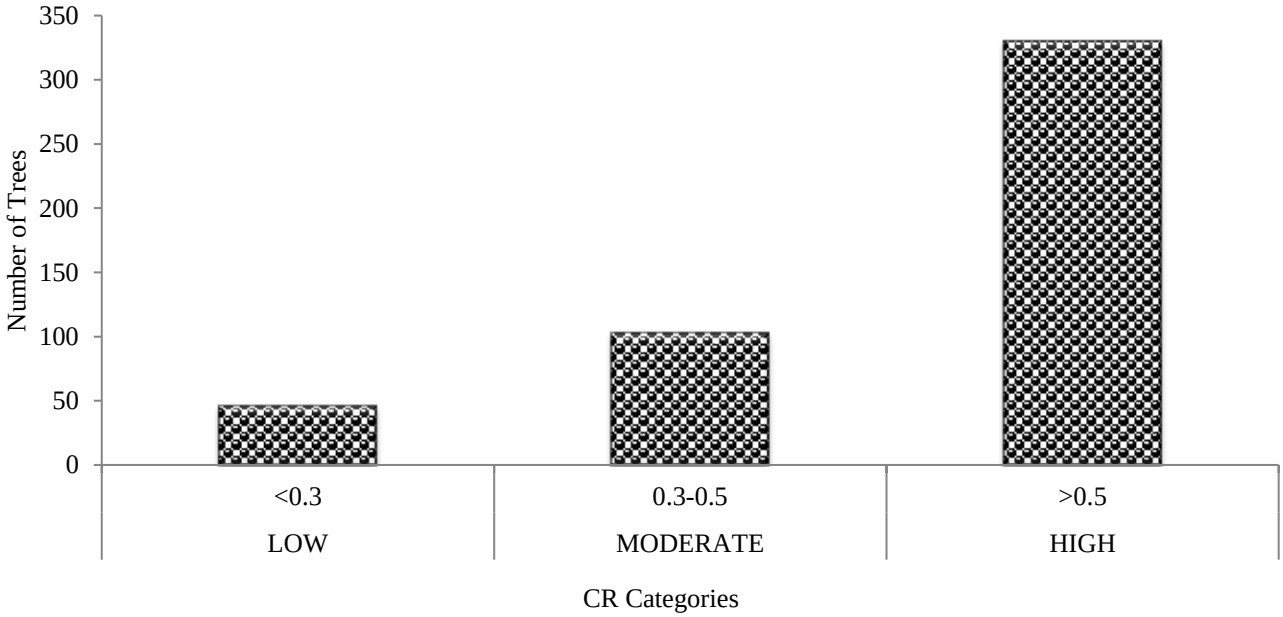

Figure-3: Frequency of trees and their crown ratio categories.

Conclusion

This study revealed the stability status of forest trees grown in the open in a Nigerian University. Majority of the forest trees investigated were found to be stable and are of low risk or not susceptible to wind throw, wind-induced bending and breakage. However, only but a few number of trees have possibility of wind throw effect. Thus, poses threat to human life and properties within the University campus and therefore were recommended for felling.

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References

1. Omoro L.M.A., Pellika P.K.E. and Rogers P.C. (2010). Tree species diversity, richness, and similarity between exotic and indigenous forests in the cloud forests of eastern Arc Mountains, Taita Hills, Kenya. *Journal of forestry Research*, 21(3), 255-264.

2. Mickovski S.B. (2007). Material stiffness, branching pattern and soil potential affect the pullout resistance of model root system. *European journal of soil science*, 58, 1471-1481.

3. Fourcaud T., Zhang Z.Q., Ji J. and Stokes A. (2008). Understanding the impact of root morphology on overturning mechanism. *A modeling approach, annuals of botany*, 101, 1267-1280.

4. Ezenwenyi J.U. and Chukwu O. (2017). Effects of slenderness coefficient in crown area prediction for *Tectonia grandis* Linn. f. in Omo Forest Reserve, Nigeria. *Journal of Current life science*, (3), 356-363.

5. Navratil S. (1996). Silvicultural system for managing deciduous and mixed wood stands with white spruce understory in silviculture of temperate and boreal broadleaf –conical mixture. Edited by Comeau, P.G. and Thomas, K.D. B.C. Ministry of Forests, Victoria, 35-46.

6. Eguakun F.S. and Oyebade B.A. (2015). Linear and non-linear slenderness model for *Pinus carribeae* stands in southwestern Nigeria. *IOSR journal of Agriculture and Vertinary science*, 8(3), Vversion 11, 26-30.

7. Chukwu O. and Chenge I.B. (2018). Stability assessment and composition of tree species in Nigerian University. *World scientific news*, 95, 235-245.

8. Becquley J. and Nivert J.R. (1987). *The existence of stability zones of stands*. Consequences on the management. Revue (les Chablis*: l'existence de zones de stabilite des peuplements*. Consequences suv la gestation. Revue). Forestierefranchaise, 4, fascicule thematique.

9. Hahn J.T. and Leary R.A. (1979). Potential diameter growth functions in a generalized forest growth projection system applied to the lake states region. USDA For. Serv. Gen. Tech. Rep. NC- 49. pp. 22-26.

10. Wykoff W.R., Crookstoon N.L. and Stage A.R. (1982). User's guide to stand prognosis model. USDA For. Serv. Gen. tech. rep. INT-133:122.

11. Navratil S. (1997). Wind Damage in Thinned Stands. In Proceedings of a Commercial Thinning Workshop. October 17-18. Whitecourt, pp 29-36.

12. Clutter J.L., Bailey R.L., Brister G.H. and Foster J.C. (1983). Timber management; a quality approach. John Wiley and sons, New york. 34-39.

13. Schütz J.P. (2001). The selection of forest and other forms of structured and mixed forests. *Parey Buchverlag*. Berlin. pp 207.

14. Ezenwaji E.E., Phil-eze P.O., Otti V.I. and Eduputa B.M. (2013). Household water demand in the pen-urban communities of Awka, Capital of Anambra State, Nigeria. *Journal of Geography and Regional Planning*, 6, 237-243.

15. Sumida A., Miyaura T., Hitoshi T.H. (2013). Relationships of tree height and diameter at breast height revisited: analyses of stem growth using 20-year data of an even-aged *Chamaecyparis obtusa* stand. *Tree Physiology*, 33, 106-118.

16. Popoola F.S. and Adesoye P.O. (2012). Crown ratio models for *Tectonia grandis* (Linn. f.) stands in Osho Forest Reserve, Oyo State, Nigeria. *Journal of forest science*, 28(2), 63-67.

17. Sharma R.P., Vacek Z. and Vacek S. (2016). Modeling individual tree height to diameter ratio for Norway spruce and European beech in Czech Republic. *Trees*, 30(6), DOI: 10.1007/s00468-016-1425-2.

18. Oliver C.O. and Larson B.C. (1996). Forest stands dynamics. John Wiley and sons, Toronto, 544P.

19. Faber P.J. (2008). Stability of stands to wind: a theoretical approach. *Ned. Bosbouwtijdschr*, 47, 179-193.