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STABILITY ASSESSMENT OF TREE SPECIES IN THE UNIVERSITY OF ILORIN PERMANENT SITE, NIGERIA

[1] Moshood, F.J*, [2] Ibrahim, T.M. and [3] Salami, K.D.
[1] Department of Forest Production and Products, University of Ibadan, Oyo State, Nigeria
[2] Department of Surveying and Geoinformatics, University of Lagos, Lagos State, Nigeria
[3] Department of Forestry and Wildlife Management, Federal University Dutse, Jigawa State, Nigeria
*** Corresponding author's contact: +2348176771152, moshoodfarhan@gmail.com**

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ABSTRACT The contribution of trees to environmental, social, and economic wellbeing cannot be overestimated. Trees contribute significantly to human health, environmental quality, aesthetic quality, and the financial security of humankind. This study assessed the stability of tree species in the University of Ilorin permanent site, Nigeria, using slenderness coefficient as the stability index. A stratified random sampling technique was used by dividing the study areas into five different strata (academic area, administrative area, business area, student hall, and religious area). Diameter at breast height (Dbh) and the total height of living trees with Dbh ≥ 10cm were measured while basal area, slenderness coefficient, and relative density for trees in the study area were computed using relevant mathematical equations. The study observed one thousand four hundred and ninety (1490) tree species distributed across 18 taxonomic families in the study area. *Daniella oliveri* was the most abundant species with a relative density of 20.27%, while *Cumbretum erythrophyllum* was the least occurring species (0.07% relative density). The mean Dbh, height, and basal area for trees were 79.42 ± 13.564 cm, 18.66 ± 3.456 m, and 0.47 ± 0.165 m^2, respectively. About 77.85% of the trees were of low slenderness coefficient, 14.97% were of moderate slenderness coefficient, and 7.18% were of high slenderness coefficient. It implies that most of the trees were not susceptible to wind-induced damage. The study, therefore, recommends that tree species with high slenderness coefficient be removed and replaced with young trees at a ratio of 3:1.

Keywords: Slenderness coefficient; stability index; stratified random sampling; taxonomic families; wind-induced damage.

INTRODUCTION

The Food and Agricultura Organization (2013) defined a tree as "a woody perennial with a single main stem, or coppice with several branches, having a more or less definite crown.". Trees provide a multitude of benefits to humankind. The contribution of trees to humankind's environmental, social, and economic wellbeing cannot be overestimated. Trees are an essential constituent of the vegetation that requires monitoring and management to direct the process of succession towards maintaining the diversity of species and habitat (Turner, 1987). On the other hand, trees can create problems, especially when they are not adequately managed. Some of the common challenges with trees are branch and root conflicts with infrastructure and site use and accidental tree fall (Ajewole *et al*., 2013).

When tree stability is assessed, the structural firmness of tree roots that are unreachable and the maximum and stable height of trees is well understood (Omoro *et al*., 2010). One crucial growth parameter used to estimate tree stability is the slenderness coefficient. The slenderness coefficient is the ratio of the tree height to the diameter at 1.3 m above ground (diameter at breast height). Both growth parameters are measured in the same unit, usually in meters (Onilude and Adesoye, 2007). The tree slenderness coefficient is dimensionless, and it is computed based on the ratio of tree diameter at breast height and total height (Moravčik, 2007). The tree slenderness coefficient often serves as an index of tree stability or resistance to windthrow (Navratil, 1996; Ige, 2017). A low slenderness coefficient value usually indicates a more extended crown, lower centre of gravity, and a better-developed root system. Therefore, slender trees with high slenderness coefficient values are more susceptible to wind-induced damage. Because of the tree slenderness coefficient importance for indexing tree resistance to windthrown, it is crucial to know the slenderness of trees (Ige, 2017).

Despite the abundance of trees in the study area, there has been no study on the stability assessment of trees. This research, therefore, assessed the stability of tree species within the University of Ilorin permanent site using slenderness coefficient as an index of stability.

This is to provide baseline information that will be useful for the management of tree species.

MATERIALS AND METHOD

The Study Area

The University of Ilorin permanent site (Figure 1) is geographically situated between Latitudes 8°29'N and 8°27'N and Longitudes 4°38'E and 4°41'E and covers about 15,000 ha (http://www.unilorin.edu.ng/index.php/about-us). It is located in Ilorin, the state capital of Kwara State, Nigeria. The University of Ilorin was established in 1975 alongside six other institutions by the then military government of Nigeria. The university is notable for its stable academic calendar for more than 15 years, and it is presently the most sought-after University in Nigeria, with about 90 educational programmes distributed across about 15 faculties/colleges.

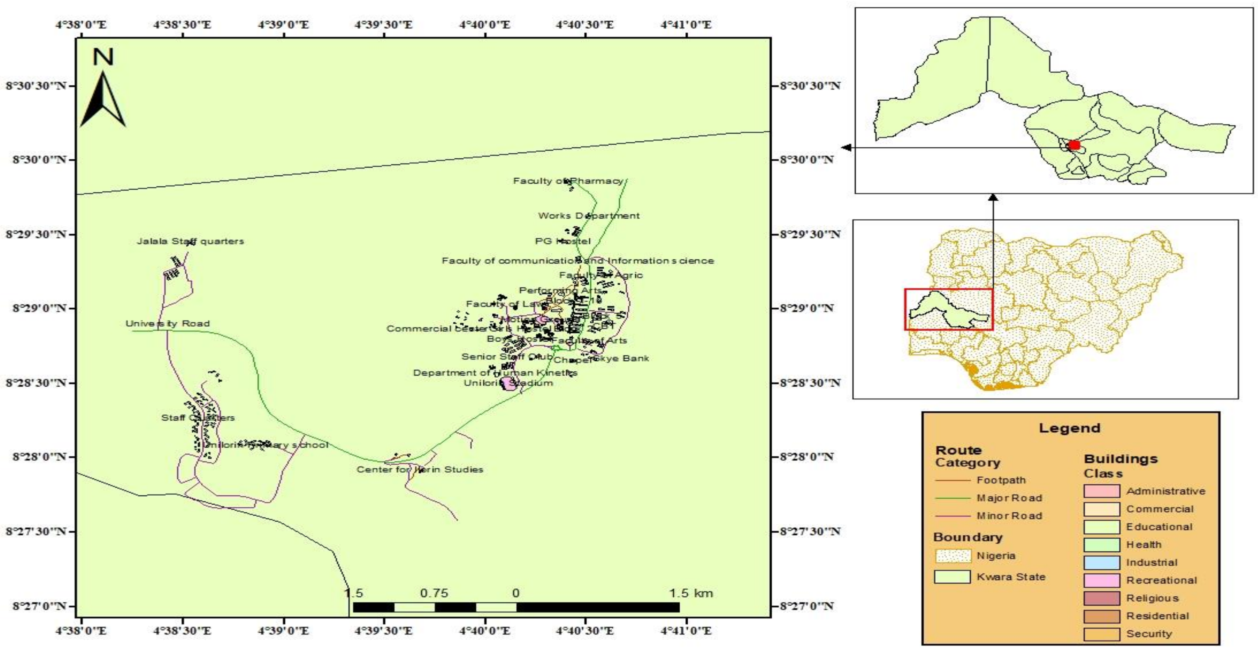

Figure 1: Map of the University of Ilorin permanent site

Sampling Procedure and Data Collection

A stratified random sampling technique was adopted for the study. The University of Ilorin permanent site was stratified into five strata based on the similarities of activities performed in the sub-strata (Table 1): academic area, administrative area, business area, student hall, and religious area (Raji and Babalola, 2018). Data collection involved a complete enumeration of all living trees with Dbh ≥ 10cm. This research employed the service of an experienced taxonomist to identify trees to species level

Table 1: Stratification of the University of Ilorin Permanent Site

S/N	Strata	Selected sub-strata in the study area
1	Academic Area	Faculties of Pharmacy, Communication and Information Sciences, Management Sciences, Environmental Sciences, Social Sciences and Agriculture, Block 1 to Block 10, Engineering Lecture Theater, Departments of Statistics, Geology and Chemistry, Old Faculty of Art Area, Faculty of Law and New Art building, Art Class Area, Faculty Education area and University Stadium and Faculty Veterinary Medicine
2	Administrative Area	Network Operating Center, Counseling and Student Affairs Units, Senate Building Area, Auditorium and Student Industrial Work Experience Unit, University Clinic Area, Student Union Building, Security Unit and Admission Office
3	Business Area	School Park, Motion Ground, School Market, and Cafeteria
4	Students'Hall	Post Graduate Student Hostels, Private Hostels Area, Female, and Male Lagos Hostels, Zamfara and Abuja Hostels
5	Religious Area	Church Area (Chapel and STAC Cathedral), Mosque Area (University Central Mosque)

Source: Raji and Babalola (2018), and slightly modified.

Data Analysis

Basal Area

The basal area of trees was computed using:

$$BA = \frac{\pi D^2}{4} \ldots \ldots (1)$$

Where D = diameter at breast height (m) and л = pie $(\frac{22}{7})$.

Slenderness Coefficient

Tree slenderness coefficient (SC) for all measured trees was computed using:

$$SC = \frac{THT}{D} \ldots \ldots (2)$$

Where THT = total height (m) and D = diameter at breast height (m).

The individual trees were grouped into slenderness coefficient classes as high (with SC > 80), moderate (with SC: 70-80), and low (with SC < 70) slenderness coefficients (Adeyemi and Adesoye, 2016).

Relative Density

Relative density was determined using:

$$RD\ (\%) = \frac{number\ of\ individual\ species}{total\ number of\ species} \times 100 \ldots (3)$$

Correlation Analysis

The linear statistical association between growth variables was examined using Pearson product-moment correlation coefficient. It is given as:

$$r = \frac{\sum ab - \frac{(\sum a)(\sum b)}{n}}{\sqrt{(\sum a^2 - \frac{(\sum a)^2}{n})(\sum b^2 - \frac{(\sum b)^2}{n})}} \ldots \ldots (4)$$

Where a and b = measurements of the growth variables considered and n = sample size.

RESULTS AND DISCUSSION

Tree Species Composition in the Study Area

A catalogue of the tree species, their families, frequency, and relative density in the study area are presented in Table 2. One thousand four hundred and ninety (1490) tree species distributed across eighteen (18) taxonomic families were encountered in the study area (Figure 2). *Daniella oliveri* was the most frequently occurring species in the area, having a relative density of 20.27%. The second most occurring species was *Gmelina arborea* , with a relative density of about 15.23%. *Cumbretum erythrophyllum*, *Blighia sapida*, and *Khaya senegalensis* were the least occurring species with 0.07%, 0.13%, and 0.13% relative densities, respectively. Fabaceae was the most occurring taxonomic family with 13 species (27.08%), followed by Combretaceae with six species (12.50%). However, six taxonomic families (Apocynaceae, Bombacaceae, Chrysobalanaceae, Rutaceae, Sapindaceae, and Sapotaceae) all had a species as their representatives.

Fabaceae, the most abundant family in the study area, agrees with Iheyen *et al.* (2009). Most members of the Fabaceae family are known to disperse their seeds by wind. Fabaceae are essentially found everywhere in the world except in Antarctica and the high Arctic (http://www.mobot.org/MOBOT/Research/APweb/orders/fabalesweb.htm#Fabaceae). Apocynaceae, Bombacaceae, Chrysobalanaceae, Rutaceae, Sapindaceae, and Sapotaceae are poorly established in the study area probably because the site condition does not support their growth as much as it supports that of Fabaceae members or anthropogenic activities such as the construction of roads, expansion of buildings, among others have accounted for their fewer occurrences.

Table 2: Tree Species Composition in the University of Ilorin Permanent Site

S/N	Scientific name	Family name	Freq	Relative Density
1	*Acacia auriculiformis*	Fabaceae	24	1.61
2	*Acacia spp*	Fabaceae	3	0.20
3	*Adansonia digitata*	Bombacaceae	5	0.34
4	*Afzelia africana*	Fabaceae	13	0.87
5	*Albezia lebbeck*	Fabaceae	16	1.07
6	*Anarcadium occidentale*	Anarcadiaceae	41	2.75
7	*Annona senegalensis*	Annonaceae	3	0.20
8	*Annona spp*	Annonaceae	3	0.20
9	*Annoigeissus leocarpus*	Combretaceae	3	0.20
10	*Azadirachta indica*	Meliaceae	72	4.83
11	*Bauhinia variegate*	Fabaceae	24	1.61
12	*Blighia sapida*	Sapindaceae	2	0.13
13	*Bridelia feruginea*	Euphorbiaceae	4	0.27
14	*Burkea africana*	Ceasalpinaceae	18	1.21
15	*Cassia spp*	Fabaceae	7	0.47
16	*Casuarina equisetifolia*	Casuarinaceae	10	0.67
17	*Citrus sinensis*	Rutaceae	14	0.94
18	*Cocos nucifera*	Arecaceae	16	1.07
19	*Cumbretum erythrophyllum*	Combretaceae	1	0.07
20	*Danielia oliverii*	Fabaceae	302	20.27
21	*Delonix regia*	Fabaceae	28	1.88

22	*Detarium microcarpum*	Ceasalpinaceae	13	0.87
23	*Elaeis guinensis*	Aracaceae	4	0.27
24	*Eucalyptus camaldulensis*	Myrtaceae	20	1.34
25	*Ficus spp*	Moraceae	4	0.27
26	*Ficus sycomorus*	Moraceae	10	0.67
27	*Ficus thonningii*	Moraceae	4	0.27
28	*Gmelina arborea*	Verbenaceae	227	15.23
29	*Hura crepitans*	Euphorbiaceae	6	0.40
30	*Khaya senegalensis*	Meliaceae	2	0.13
31	*Leucena leucocephala*	Ceasalpinaceae	5	0.34
32	*Mangifera indica*	Anarcadiaceae	58	3.89
33	*Millettita thonningii*	Fabaceae	3	0.20
34	*Parinari polyandra*	Chrysobalanaceae	40	2.68
35	*Parkia biglobossa*	Fabaceae	54	3.62
36	*Peltophorus pterocarpus*	Fabaceae	10	0.67
37	*Pinus equisetifolia*	Casuarinaceae	14	0.94
38	*Plumeri alba*	Apocynaceae	14	0.94
39	*Prosopis africana*	Fabaceae	134	8.99
40	*Psidum guajava*	Myrtaceae	4	0.27
41	*Pterocarpus erinaceous*	Fabaceae	15	1.01
42	*Tectona grandis*	Verbenaceae	5	0.34
43	*Terminalia catappa*	Combretaceae	61	4.09
44	*Terminalia glaucescens*	Combretaceae	23	1.54
45	*Terminalia ivorensis*	Combretaceae	7	0.47
46	*Terminalia mantaly*	Combretaceae	65	4.36
47	*Vitellaria paradoxa*	Sapotaceae	64	4.30
48	*Vitex doniana*	Verbenaceae	15	1.01
	TOTAL		**1490**	**100**

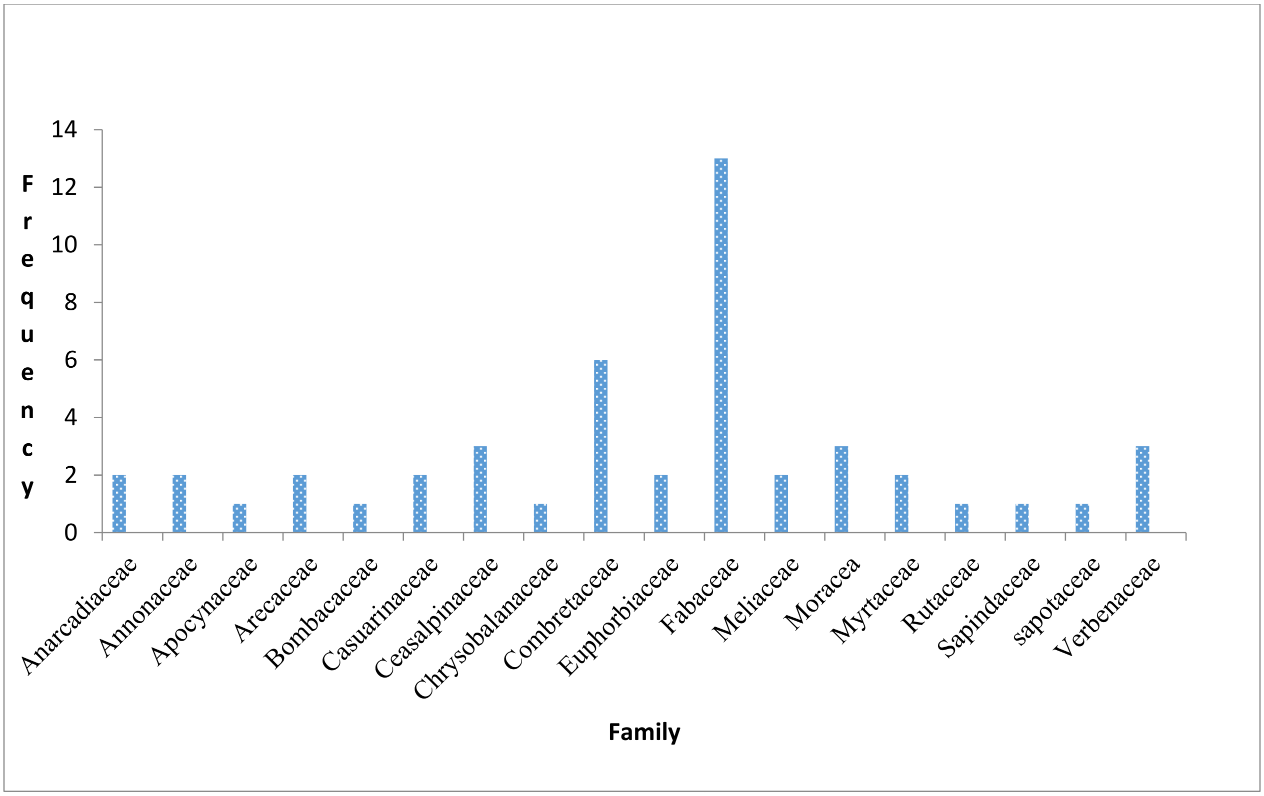

Figure 2: Taxonomic distribution of plant species into family classes in the University of Ilorin permanent site

Tree Growth Statistics

The descriptive statistics for tree growth parameters in the study area are presented in Table 3. The Dbh ranged between 11.42 cm and 105.35 cm, with a mean of 79.42$\pm$13.564 cm. The THT ranged between 5.78 m and 27.17 m, with a mean of 18.66$\pm$3.456 m. On the other hand, BA had a mean value of 0.47$\pm$0.165 m^2 with minimum and maximum values of 0.20 m^2 and 0.84 m^2, respectively. The slenderness coefficient value of tree species in the study area ranged between 7.00 and 102.00, and the mean was 22.40$\pm$8.430 (Table 3).

The correlation matrix for tree growth variables in the study area is shown in Table 4. Dbh had a strong positive correlation with THT (0.702; p> 0.05) and BA (0.856; p> 0.05) but a strong negative correlation with SC (-0.786; p> 0.05). THT had a positive correlation with BA and SC, while BA and SC had a negative but significant correlation (-0.345).

The overall mean Dbh for the study area was lower than 122.8 cm reported by Ezenwenyi*et al*. (2020). As for spacing increases between trees, tree diameter also tends to increase because trees at wider spacing utilize the advantage of having more growing space for crown and root development due to the reduced competition. Eliakimu *et al*. (2015) observed a significant increase in the diameter of a tree stand with an increase in spacing between the tree stands.

Table 3: Summary of Tree Growth Statistics in the University of Ilorin Permanent Site

S/N	Growth parameters	Minimum	Maximum	Mean± Std. deviation
1	Dbh(cm)	11.42	105.35	79.42±13.564
2	THT(m)	5.78	27.17	18.66±3.456
3	BA(m^2)	0.20	0.84	0.47±0.165
4	SC	7.00	102.00	22.40±8.430

Dbh = diameter at breast height; THT= tree total height; BA= basal area; SC = slenderness coefficient

Table 4: Correlation Matrix for Tree Growth Variables in the University of Ilorin Permanent Site

	Dbh(cm)	THT(m)	BA(m^2)	SC
Dbh(cm)	1			
THT(m)	0.702*	1		
BA(m^2)	0.856*	0.456	1	
SC	-0.786*	0.234*	-0.345*	1

* *Significant($P < 0.05$)*

Slenderness Coefficient Assessment

The tree slenderness coefficient assessment revealed that 1160 trees had low slenderness co-efficient, constituting about 77.85% of the trees. Two hundred twenty-three trees (14.97%) and 107 trees (7.18%) had moderate slenderness coefficient and high slenderness coefficient values, respectively (Figure 3). According to Ige (2017), trees with a higher slenderness coefficient are more susceptible to damage than trees with a low slenderness coefficient. Hence most of the trees in the study area are of low slenderness coefficient, which translates to high stability. This figure agrees with Adeyemi and Moshood (2019) and the findings of Adeyemi and Ugo-Mbonu (2017). It is, however, lower than the findings of Ezenwenyi *et al.* (2020), who observed that the majority (95.8%) of the trees in the Nnamdi Azikiwe University Campus had a low slenderness coefficient which may be attributed to the fact that the competition for resources by the trees is low because they are open-grown trees. According to Harja*et al*. (2020), trees in denser stands tend to be more slender than the less-dense ones because competition for light among trees in denser stands is high. The result further indicates that the tree slenderness coefficient values tend to decrease for more giant trees and the most significant slenderness coefficient values occur for the trees with small Dbh. This is supported by the strong negative correlation (-0.786) obtained between Dbh and the slenderness coefficient. This means that the higher the Dhb of trees in the study area, the lesser their susceptibility to wind damage and vice versa. The high slenderness coefficient is an indication of tree growth stress.

Therefore, it is safe to conclude that most of the trees in the study area do not belong to the high-risk category of wind-induced damage.

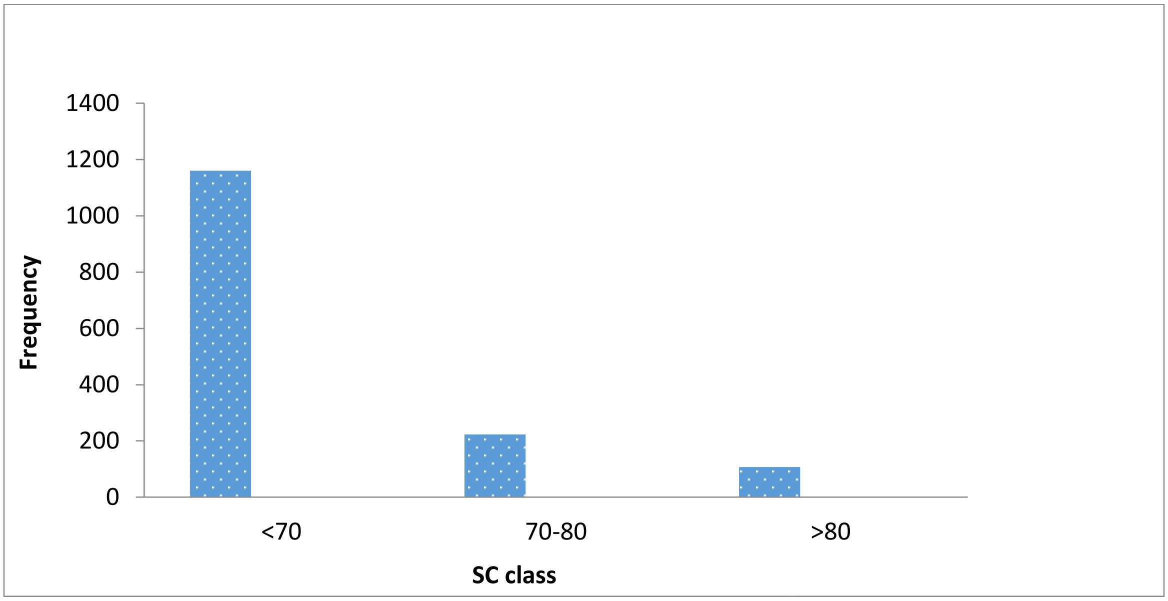

Figure 3: Tree slenderness coefficient distribution in University of Ilorin permanent site

CONCLUSION

This study reveals the stability of tree species in the University of Ilorin permanent site. Most trees had low and moderate slenderness coefficients, which means they are not susceptible to wind-induced breakage or damage. However, it is highly recommended that the school management identify and remove all the tree species (about 107 trees) with a high slenderness coefficient value (susceptible to damage). They are threats to life and properties within the campus. It is also recommended that more tree species be planted to replace the removed species at a ratio of 3:1 (for every tree removed, three should be planted in replacement).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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