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Logging impacts on volume yield of tropical rainforest ecosystem in Ondo State, Nigeria

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Abstract

The increasing demand of each person for resources from the forest has put the forest under great threat. This research focused on the impacts of logging on volumes of tropical rainforest ecosystem in Ondo State, Nigeria. This was achieved by comparing volume yield in an undisturbed forest and a disturbed forest of Akure Forest Reserve located in Ondo State, Nigeria. Data collection took place in the disturbed and undisturbed forest of Akure Forest Reserve. Systematic line transect method was used in plot layout, where tree growth variables were collected for volume estimation. Two parallel transects of 200m apart were laid and two equal sample plots (50mx50m) were laid in alternate direction of each transect. All trees with dbh ≥10cm were tagged and tree growth variables such as the Db, Dbh Dm, Dt and height of all trees encountered on the plots were measured for volume estimation. The undisturbed plots of Akure Forest Reserve had 168 stems per hectare when compared to the disturbed plots with 98 stems per hectare. A volume per hectare of 177.58$m^3$was recorded in the undisturbed plots of the reserve and 22.25$m^3$was recorded in the disturbed plots. The results of t-test revealed that there were significant differences (P<.05) in the tree growth variables measured in the disturbed and undisturbed sites of the Forest Reserve. The low stand volume recorded in the disturbed forest was attributed to the logging and logging activities that had occurred in the site. This study has revealed the importance of conservation in forest management and sustainability. The study therefore recommends that logging should be carried out on sustainable basis and degraded forests should be allowed to recover.

Keywords: Logging impacts, volume yield, conservation, forest management.

Introduction

The knowledge of various processes that occur in the forest ecosystem and estimates of the growing stock are vital in managing the forest in a sustainable way. Such Information will help forest managers in making important management decision about the forest[1]. For timber production, volume is usually used to determine the quantity of the trees. Tree volume is an important parameter that can be used to determine the size and quantity of trees in the forest. Kebede and Soromessa[2] also reported that appropriate assessment of timber stock (volume and biomass), yield regulation and assessment of forest productivity are integral parts of forest management.

Presently, despite the increase in global unease and increase in awareness, tropical rainforests continue to disappear at an alarming rate. According to Primack[3] and Geomatics[4], logging causes canopy opening, this results to alteration in microclimate which have negative effects on the residual trees, detrimental to biodiversity conservation, soil properties and tree growth and development. In Nigeria, majority of the rural dwellers depend on forest for their sustenance. The increased rate of exploitation of natural resources in Nigeria is a result of rapid population growth[5].

Omiyale[6] pointed out that about 5.2% of Nigeria's forest is lost annually. In the past 20 years, a high percentage of the forest has been lost through anthropogenic activities. This result in the destruction of faultless forests and other ecosystem leading to loss of biodiversity and decrease in tree volume yield[7]. The removal of large, old trees and woody debris during clear-cutting affects the population of soil microbes.

Fuwape[8] stated that majority of industries that make us of wood in Nigeria is dominated by Sawmills. The method used in the conversion of log in the mills is partly responsible for the frequent demand for timbers in the forest and the damage to the forest ecosystem. Forest deforestation, especially logging has resulted into extinction of many important flora and fauna[9]. Wilcox[10] also noted that Forest degradation causes reduction in forest productivity and regeneration potential. This pressure results into destruction of faultless forest. This work therefore assesses logging impacts on volume of tropical rainforest ecosystems in Ondo State.

Methodology

The study area: This study was carried out in Akure Forest Reserve in Ondo State, Nigeria. Two sites where logging is active and undisturbed forest were selected, (degraded and the

Strict Nature Reserve). Akure Forest Reserve is a tropical rainforest ecosystem located in Ondo State. It has an undisturbed segment popularly known as 'Queen's plot that covers an area of about 32 hectares and lies between latitude 06.59718^0N and longitude 004.49199^0E with a mean annual rainfall around 1700mm and temperature range from about 20.6^0C to 33.5^0. The map of Akure Forest Reserveis presented in Figure-1.

Method of data collection: Sampling technique and selection of sample plots: The laying of the plot was carried out using systematic line transect (Figure-2). Two parallel transects of 200m apart were laid in the study area (disturbed and undisturbed) after a 50m off set had been measured out. Thereafter, four sample plots of equal size (50mx50m) were alternately laid on each transect.

Enumeration of Tree growth variables in the disturbed and undisturbed sites: All living trees encountered on the sampled plots with dbh ≥10cm were measured. The tree growth variables measured are db, dbh, dm, dt and total height.

Data Analysis: Basal Area Calculation: The basal area for all trees encountered in the study area was calculated using:

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

Where: BA = Basal area, D = Diameter at breast height and π = Pie (3.142).

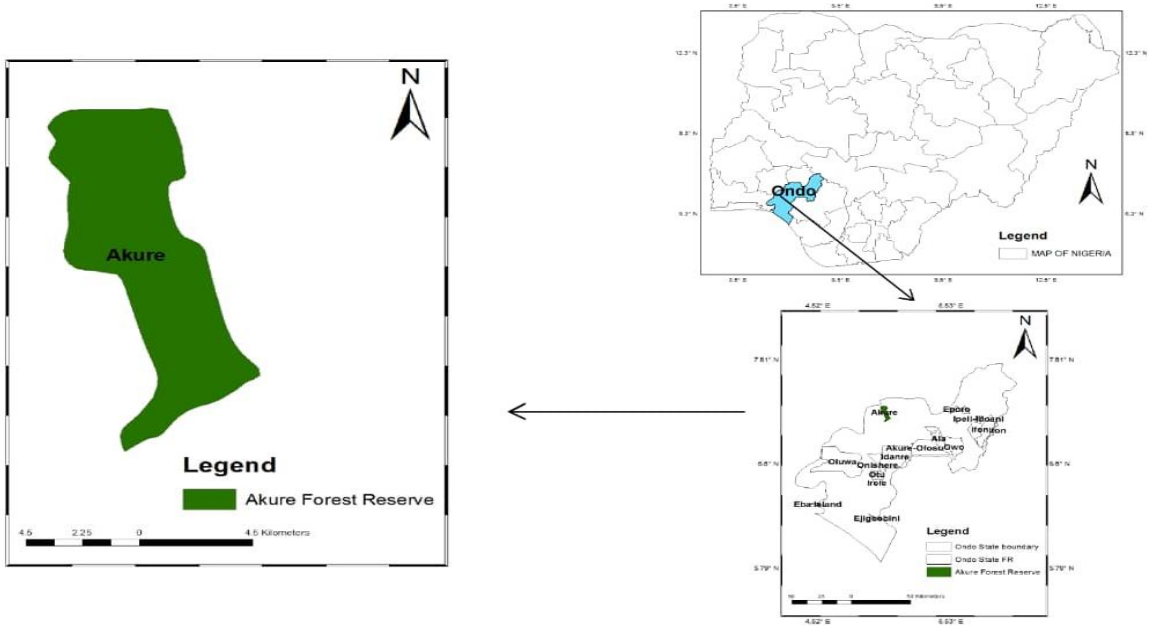

Figure-1: Map of Akure Forest Reserve[11].

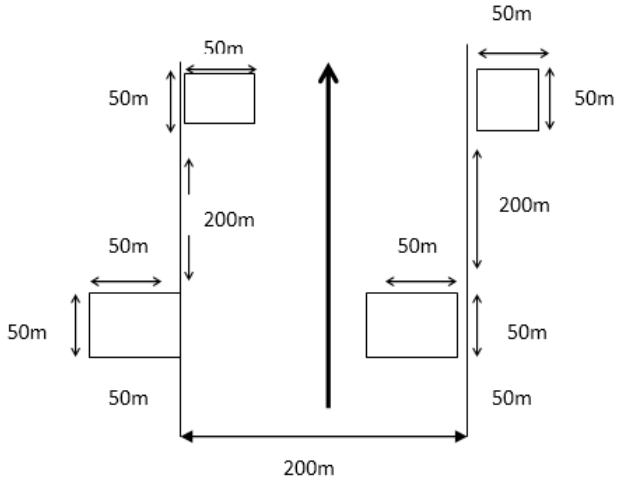

Figure-2: Systematic line transect.

Volume Estimation: The volumes of trees in the study were computed using the formula below

$$V = \frac{\pi h}{24}\left(D_b^{\,2} + 4D_m^{\,2} + D_t^{\,2}\right) \quad (2)$$

Where: V= Volume, D_b= Diameter at the base, D_m = Diameter at the middle, D_t = Diameter at the top (m), H = Total height (m).

Statistical Analysis: Spearman correlation coefficient was used to show the strength of relationship between growth variables recorded in the study sites (disturbed an undisturbed) and test for significant difference was carried out using the student t-test.

Results and discussion

Table-1 shows that a total of 168 stems per hectare were recorded in the undisturbed forest of the Forest Reserve, which is higher than the 98 stems per hectare recorded in the disturbed forest. A high volume per hectare was recorded in undisturbed forest of the study area ($177.58m^3$) when compared to the value recorded for disturbed site ($22.25m^3$). A dominant dbh of 102.55cm was observed in the undisturbed plots of Akure Forest Reserve, which ranks higher than what was recorded in the disturbed site (65.04cm). The undisturbed and disturbed forest had abasal area per hectare of 17.54m^2 and 5.83m^2 respectively. The values of all tree growth variables rank higher in the undisturbed site of the Forest Reserve. The results obtained revealed that the basal area increases as the diameter classes increases. The distribution of number of stems into different diameter classes is presented in Table-2 and Figure-3. In undisturbed forest, the distribution of each of the trees encountered in this study according to diameter size classes ranged from 10–20cm to >100cm. The diameter distribution of stems encountered in both sites indicated that the number of trees decreases as the dbh increases. About 48% of stems encountered in the undisturbed plots of the reserve fell in the height class of 11-20m. Only 1% of them fell below 5m. The disturbed plots of the Forest Reserve are dominated by trees that fell in the height class of 5-10m which accounted for about 56% of the population (Table-3 and Figure-4). A strong positive relationship of 0.98 was found between the BA and the volume of trees in the disturbed forest while a moderate positive relationship with a correlation of 0.52 was observed between the dbh and height of trees in the undisturbed forest (Table-4). The results of t-test for comparing the tree growths variables (BA, Volume, Height and dbh.) in the disturbed and undisturbed locations revealed that there were significant differences (Table-5).

Table-1: Summary of Tree growth variables for the two sites.

Growth Variables	Akure FR (Disturbed)	Akure FR (Undisturbed)
No of stems per hectare	98	168
Basal area per hectare (m^2)	5.83	17.54
Volume per hectare (m^3)	22.25	177.58
Mean tree dbh (cm)	24.08	31.25
Dominant dbh (cm)	65.04	102.55

FR-Forest Reserve.

Table-2: Basal Area/Vol. per hectare and distribution of stems according to Dbh classes.

Forest Reserve	DBH class	Number of individual	Number of species	No of family	Basal Area /ha(m^2)	Volume /ha(m^3)
Undisturbed Forest	10.0-20.0	51	17	13	1.08	8.61
	21.0-30.0	46	17	10	2.19	20.21
	31.0-40.0	39	19	8	2.76	34.13
	41.0-50-0	17	12	9	1.6	28.51
	51.0-60.0	4	4	3	0.9	17.55
	61.0-70.0	1	1	1	0.3	4.1
	71.0-80.0	1	1	1	0.4	1.59
	81.0-90.0	6	4	5	3.35	26.22
	101.0-110.0	1	1	1	0.8	5.24
	111.0-120.0	2	2	2	4.15	31.42
	Total	168			17.54	177.58
Disturbed Forest	10.0-20.0	56	20	12	1.14	5.24
	21.0-30.0	21	12	7	1.08	3.99
	31.0-40.0	8	7	6	0.71	2.69
	41.0-50-0	8	5	3	1.2	4.16
	51.0-60.0	1	1	1	0.2	0.7
	61.0-70.0	2	2	2	0.59	2.04
	71.0-80.0	2	2	2	0.91	3.43
	Total	98			5.83	22.25

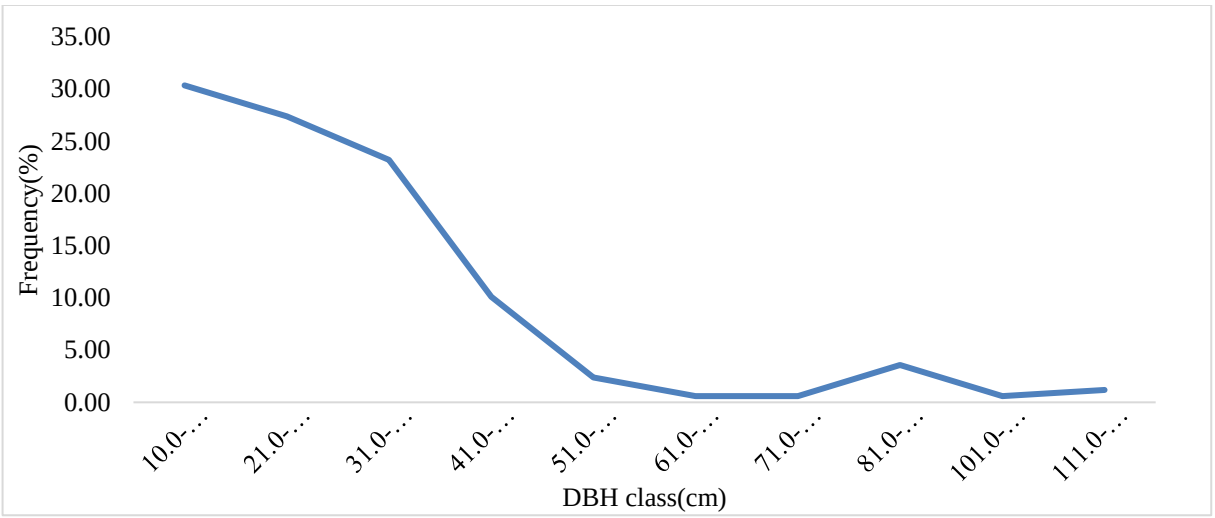

Figure-3a: Undisturbed forest

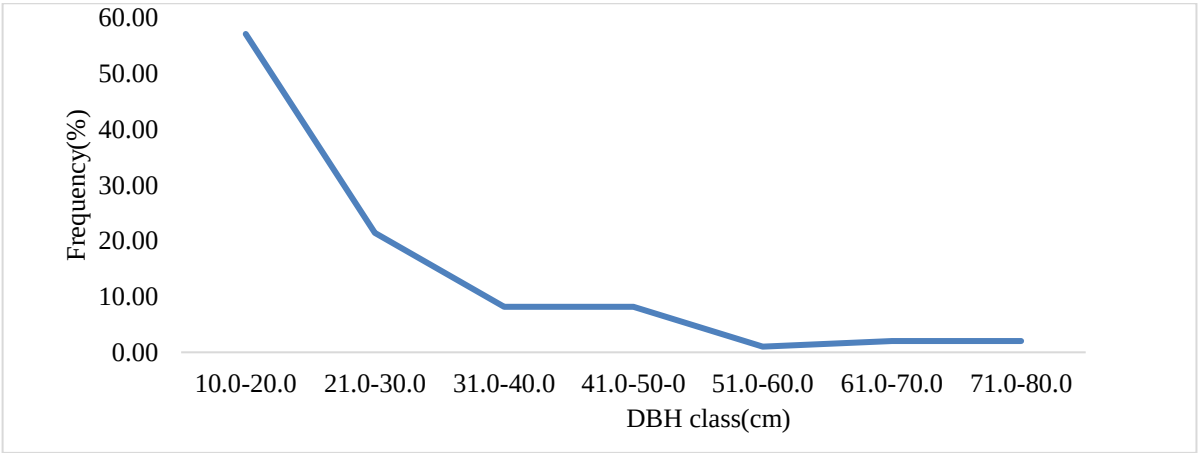

Figure-3b: disturbed forest

Figure-3a&b: Stems distribution according to Dbh classes.

Table-3: Basal Area/Vol. per hectare and distribution of stems according to height classes.

Forest Reserve	Height	Number of individual	Number of species	No of family	Basal Area /ha(m^2)	Volume /ha(m^3)
Undisturbed Forest	<5	2	1	1	0.04	0.14
	5.0-10.0	49	10	9	3.28	12.67
	11.0-20.0	80	28	10	5.57	50.73
	21.0-30.0	33	19	9	5.68	72.8
	31.0-40.0	4	4	3	2.97	41.23
	Total	168			17.54	177.58
Disturbed Forest	5.0-10.0	55	19	12	2.09	7.31
	11.0-20.0	43	15	13	3.74	14.94
	Total	98			5.83	22.25

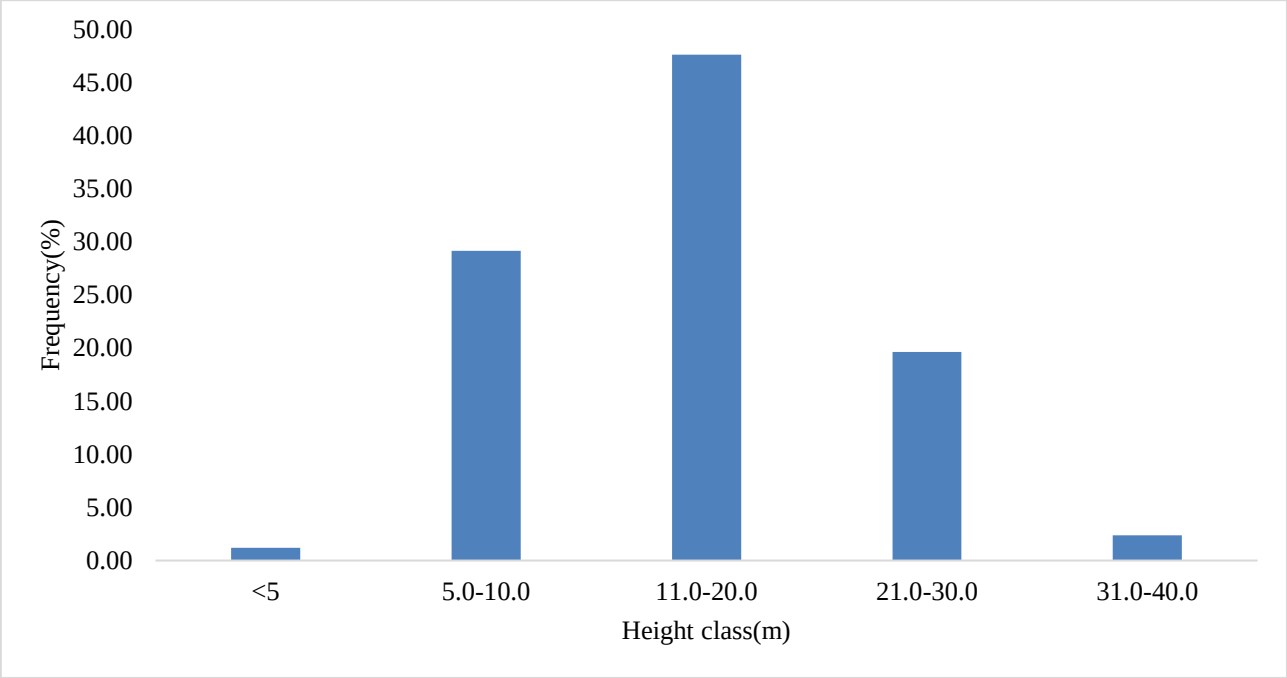

Figure-4a: Undisturbed Forest.

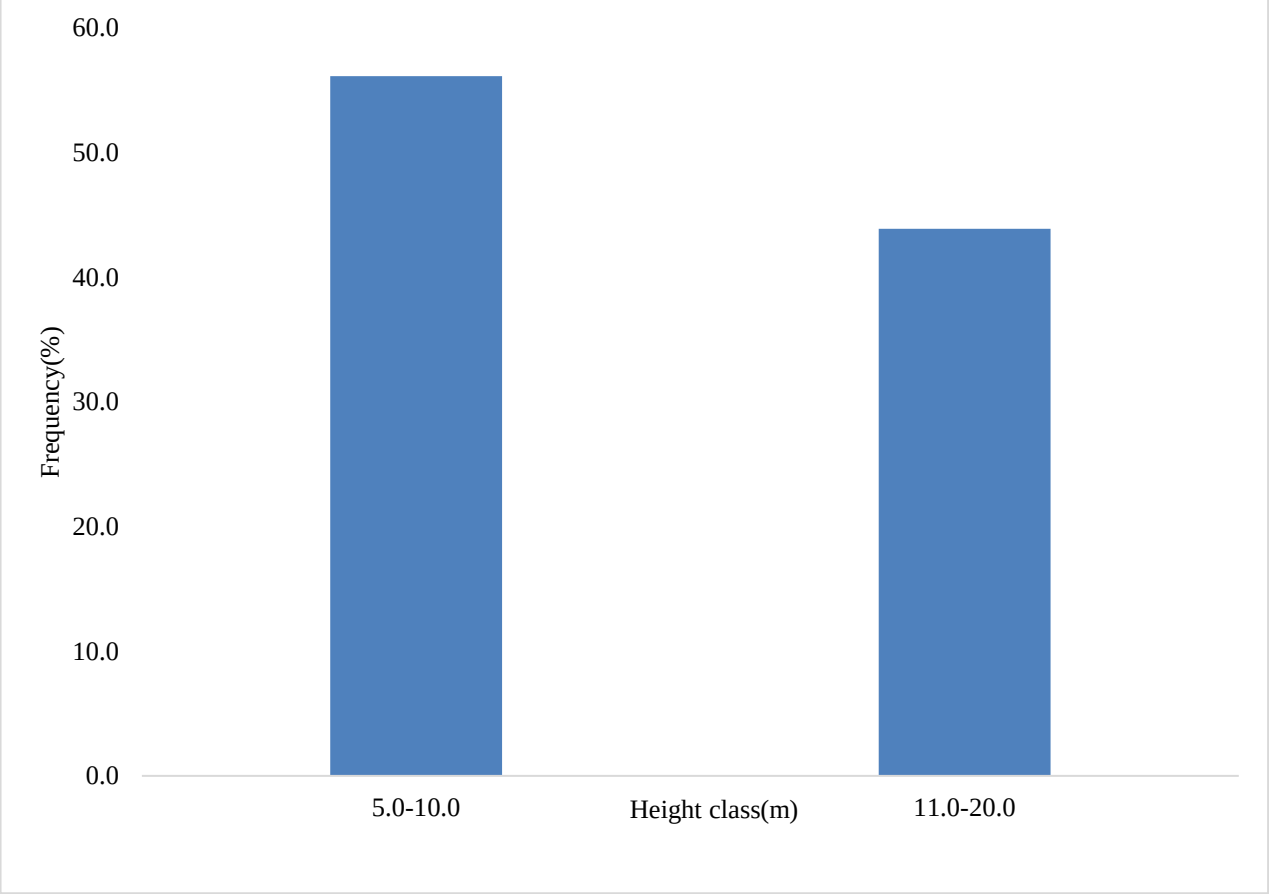

Figure-4b: Disturbed Forest.
Figure-4a &b: Stems distribution according to Height classes.

Table-4: Correlation Matrix for growth variables in the study sites.

Forest Reserve	Growth Variables	Correlation coefficient
Disturbed	Height *Dbh	0.32
	BA*Height	0.31
	Volume*Dbh	0.93
	Volume*BA	0.98
Undisturbed	Height *Dbh	0.52
	BA*Height	0.47
	Volume*Dbh	0.84
	Volume*BA	0.88

Table-5: Growth variables comparison using t-test for the study sites.

Growth Variables	t-stat	t-critical	P value
Vol.(m^3)	5.65	1.97	0.00*
Ht.(m)	8.5	1.97	0.00*
BA(m^2)	3.03	1.97	0.00*
DBH(cm)	3.61	1.97	0.00*

**-significant*

Discussion: Availability of a reliable data that provides sufficient information about the extent, potentials and present status of the forest and its resources is one of the basic requirements for a sound forest management strategy[12]. The high number of stems/ha recorded in the undisturbed location when compared to the disturbed forest agrees with the work of Brown and Gurevitch[13] who reported that regardless of how trees are removed, either through clear-cut or selective logging, logging reduces the number of economic trees.

According to Tonolli[14] tree stem volume at stand level is a key parameter in forest management, it is costly and time consuming because it requires data obtained from field surveys. The high stand volume and basal area obtained in the undisturbed plots of the study area were as a result of conservation, indicating that no exploitation has taken place in the forest[15]. Uncontrolled logging that has taken place in the disturbed forest over the years could be responsible for the low values recorded for the growth variables when compared to the unlogged forest. Rao[16] found out that diameter distribution is one of the parameters that is use to indicate how a forest regenerates and make use of the available resources in the forest. The distribution of trees into diameter class in this work follows an inverse-J shaped curve expected for a healthy forest[17] and the presence of trees with large diameter trees has been reported to be a sign of matured tropical forest[18]. Significant differences were obtained when the tree growth variables from the disturbed and undisturbed sites were compared with t-test.

Conclusion

The results of the study revealed that continuous and excessive exploitation could result to reduction in tree volume yield. Since the rate of logging has significant impacts on tree volume, and destruction of trees is always comparative to the volume of woody plants removed, frequency of logging must be significantly reduced and be planned on sustainable basis. This is to ensure post-logging condition permit continued survival of the forest eco-system. Forests that have been degraded as a result of logging should be allowed to recuperate from its present condition.

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