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Logging Effect on Forest Regeneration in a Tropical Rainforest, Etung, South South, Nigeria

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Abstract: The role of forest in preserving biodiversity and providing ecosystem services is threatened by commercial logging activities carried out without efficient plan. This unsustainable activity usually results in loss of growing stock, sensitive species and ecosystem equilibrium, coupled with heavy duty equipment that destroy several plants and compact soils during logging. The implication of constant logging activities is the impact on forest regeneration capacity. This study assessed the effect of logging on forest regeneration in tropical rainforest, Etung, South- South, Nigeria. The objective was to run a comparative assessment of forest regeneration condition of logged sites and unlogged sites. The experimental research design was adopted in carrying out the study. Data was obtained from forest inventory of 42 stratified sampled sites (21 logged sites and 21 unlogged sites). The null hypothesis (Ho) states that there is no significant differences between means of forest regeneration of which X (logged site) and Y (unlogged site) are samples. The result obtained from the statistical analysis showed that at t (8.67) = 10.3, the level of significance (p) = 0.033<0.05 for the levene's test of equality, while the independent statistical result availed a level of significance (p) = 0.024 <0.05. Hence, the null hypothesis was rejected against the alternative hypothesis that there is a significant difference in forest regeneration in the logged and the unlogged sites of the forest. The field survey recorded an average of 326.43 seedlings and samplings ≥ 10cm in height per logged plots as against 194.3 for the unlogged plots. The study recommends strengthening of weak policies and programs to reduce illegal logging in the study area.

Keywords: Forest Regeneration; Logged Sites; Logging; Tropical Rainforest; unlogged sites.

Introduction:

Logging is a common practice in forest regions and contributes to the economies of most tropical countries (Proudyaletal.,2018) but almost always causes degradation of the sites (Brunig 1977; Qin *etal.,* 2024) leaving the people depending on the forest to suffer. It is usually selective and carried out at intervals (CazzollaGattietal,.2015) but quite often no plans or maps are prepared when several commercial tree species are felled and this directly affects species composition and growing stock of the forest ecosystem. Consequently, the unplanned and unmapped logging affects the forest's seed in the subsequent year (Souza, de Ávila, Araújo, et al 2021).Regeneration refers to processes that add new seedlings to a population in terms of flowering , seed production, germination and seedling survival (Luu*etal.*, 2024) and these are all the influenced by a variety of biotic and abiotic factors.

Although the logging impact may encourage a new balance of regeneration, most of the vegetation present before logging is often destroyed, particularly where large gaps are formed (Brown & Lugo 1990, Mwima, 2018). Logging induced disturbance favours the sporadic emergence of pioneer species which may later be replaced by non-pioneer light-demanding or shade-tolerant species as light become limiting in the understory (Dampteyetal., 2021).This natural process of regeneration is critical for colonization and establishment of native tree species as well as recovery and stabilization of forest ecosystems (Hammond etal., 2021; Chazdonetal., 2020; Dyderski & Jagodzinski, 2020; Crouzeillesetal.,2017).

Decomposition of debris from remains of the felled trees release nutrients for the development of the residual stand while extraction of timber using heavy equipment destroys several plants and compact soils (Sh & Jourgholami, 2013). The end results are reflected in limited regeneration, change in vegetation composition and implications on soil as well as other ecological processes (Picchioetal., 2020). Extents of logging impacts are different for different tree size classes. Small trees are much more vulnerable to destruction as they suffer severe injury than larger ones (Fargeon, et al. 2017). The damage caused tends to be confined around the tree felled, where the regeneration is affected most. Disturbance due to logging or gap creation by natural fall has been shown to have a positive impact on the forest by stimulating species regeneration (Bowd, Mc Burney, & David, 2021). Similarly Kao and Jiao (2022) observed that artificial vegetation only improved soil nutrients but caused soil desiccation which is difficult to recover but natural vegetation restoration model of sparse forest grassland was better than artificial vegetation model.

Factors responsible for variations in forest regeneration and spatial distribution are changes in temperature, humidity, rainfall, altitude and soil type (Snell, 2017). If any environmental factor is less than ideal, it can limit a plant growth. Variation in vegetation is partly the result of adaptations of plants to the physical and chemical conditions of a site. The key factor of any site is the soil which varies with elevation and associated climate and vegetation (Sanjeewanietal.,2024). In line with this position, Connell (2018) noted that niche subdivisions are also found along gradients of light, water nutrients and heat and explains forest composition in terms of variation in elevation, slope, aspect, soil type, under-storey composition and impacts of previous or current management. Species occurrence in natural forests has been described in different ways. For example, Huntley (2018) reported that in some forests species occur in clumps. He gives three possible reasons for such occurrence namely, accumulation of seeds by animals or birds depositing them in one place, seed dispersal occurring over a very limited distance or presence of suitable microclimates for successful regeneration at that site. Similar reasons were also given by Wenny (2016) about seed dispersal mechanisms in natural forest ecosystems.

In summary, it can be said that species diversity, structure and distribution pattern are dictated by physical, chemical, biological and environmental factors. A combination of these factors on population dynamics means that no particular species can dominate the forest. Species abundance, therefore, depends on fecundity, seed dispersal, establishment within a variety of environments, microclimatic characteristics, and natural competition (Connell, 2018; Mackereth, 2017). Forest regeneration dynamics has been studied by foresters for long though rarely in the concept of gap-phase dynamics (White more, 1990) by which it begins with creation of gaps, proceed by colonization of gaps, and growing of colonizers in a building phase until forest attains maturity to begin the cycle again. Appreciable as it was, details were not effectively investigated, largely because of the neglect of non-commercial members of the forest (Okali and Dike, 1996). The importance of those details is even more today with the tropical rainforest still under pressure from logging. Though rich in global biodiversity but not as resilient as temperate forests because of the limited and scattered distribution of most species and their adaptation to specific ecological niches (WWF, 2017). Information about regeneration on gaps created by logging is not only crucial in generating data but management of the status of rainforest ecosystem in Etung, South-South Nigeria which is in dire need of stability. Accordingly the objective of this work is to assess the effect of logging on forest regeneration in a tropical rainforest, south-South, Nigeria. A hypothesis was formulated to test the difference in means of the two sampled sites.

Site Description:

The study area is Etung Local Government Area of Cross River State, South- South Nigeria. The area is chosen because it is one of the three areas of significant Tropical Rainforest in the State (Balogun, 1994). Etung has a total land area of 903.22 km² (CR-SEEDS, 2005). The area lies roughly between longitudes 8° 55′ and 9° 02′ East of

Greenwich and between latitudes 5° 42′ and 6° 01′ North of the equator. It is bordered on the South by Akamkpa Local Government Area, Ikom and Boki local Government Areas lies to the North (all in Cross River State), Republic of Cameroon to the East and on the West is Ikom Local Government Area. It belongs to the Bantu group of languages, which is itself a division of the Benue - Congo sub family which has the Niger Congo at its apex (Onor, 1994).

The land is generally undulating, rising north-east-wards towards the Cameroon Mountains. There are extensive lowland plains (30m in height approximately), especially in the northern part of Etung. These lowland plains extend northwards into Boki Local Government Area, terminating at the foothills of Obudu Plateau area. The Obudu plateau rising to a height of 1,765 meters on the average (Udo, 1978) are an extension of the Cameroon Mountains. The summit of the hills forms the water shed of the country between Cross River and the sea. In Southern Etung, the land is undulating (with much higher plains above 30m) and rises precipitously towards Etara/Onughi highlands of the Oban hills. The Oban massif attains an elevation of 1500m.

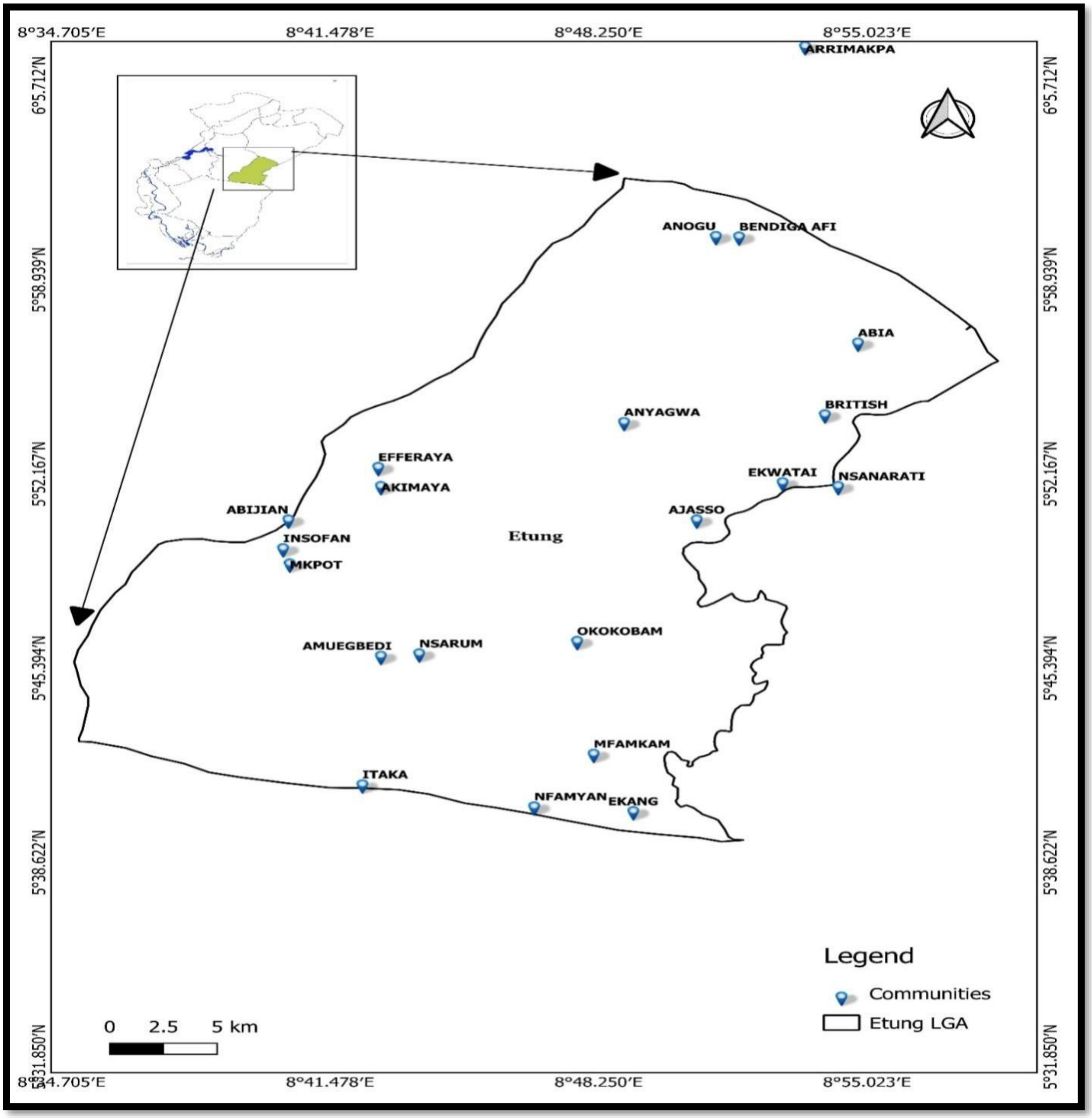

Figure 1: Map of Etung LGA, Cross River State inset
Source: Diva GIS, 2023.

Materials and Methods:
Experimental research design was employed for this study. The stratified random sampling was used for primary data collection so that samples were distributed to the various strata based on the proportion of each stratum in relation to the total. Thus, the samples were well spread to cover the logged areas and unlogged areas. Twenty-one (21) plots on either side of logged and unlogged areas of the forest were laid. Hence, a total of

Forty-two (42) plots of 5m x 5m were laid for the study. The unlogged area served as control plots. The advantage of 5m x 5msubquadrat is the provision of practical means for mapping large number of trees in small diameter classes (Dallmeier etal, 1992)
Field work aided the observations and measurements of the number of tree seedlings (natural regeneration) affected in logged and unlogged areas. All seedlings ≥ 10cm in height were enumerated and computed for natural regeneration. Questionnaires were also designed and administered in the State forestry Commission, Calabar, and the Zonal Offices in Akamkpa, Ikom, and Etung. Information extracted was combined with secondary sources of data to design strategies that minimize forest disturbance.

Result and general discussion of findings:

An inferential statistic was employed to observe forest regeneration in logged and unlogged sites of theforest in Etung Local Government Area.Regeneration in different sites of the forest, particularly the logged sites and unlogged sites were examined for uniformity or variation (Table 1 and 2). This is by means of testing the hypothesis formulated to guide the study. The hypothesis states that forest regeneration is higher on the logged sites than the unlogged sites. The null and alternate hypotheses are stated below:
H_0: There is no significant difference between means of forest regeneration of which X (logged sites) and Y (unlogged sites) are samples.
H_1: There is a significant difference in between means of forest regeneration of which X (logged sites) and Y (unlogged sites) are samples.

Table 1: Independent Sample Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	T	Df
Forest regeneration (logged and unlogged site)	Equal variances assumed	9.013	.0467	7.23	9
	Equal variances not assumed			8.67	10.2

Source: Author Field Report

Table 2: Independent Sample Test

		t-test for Equality of Means				
		Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	95% Confidence Interval of the Difference
					Lower	Upper
Forest regeneration (logged and unlogged site)	Equal variances assumed	.0024	-6.57758	8.13500	13.09172	-13.09172
	Equal variances not assumed	.0026	-5.87858	8.2545	-13.44973	-13.44973

Source: Author field Report

The result obtained from the statistical test showed that at t (8.67) = 10.2, the level of significance (*p*) = *0.046*<0.05 for the levene's test of equality, while the independent statistical result availed a level of significance (*p*) = *0.024 <0.05*. Hence, the null hypothesis was rejected against the alternative hypothesis that there is a significant difference in forest regeneration in the logged and the unlogged sites of the forest. It showed that the observed difference is not due to chance but a result of gaps created by logging which have now been colonized by seedlings and saplings. The field survey recorded an average of 326.43 seedlings and samplings ≥ 10cm in height per logged plots as against 194.3 for the unlogged plot (Fig 1)

This implies that logged plots have higher number of regenerating seedlings and saplings than unlogged plots. This is attributed to sunlight infiltration which enhances seedling germination and growth in the logged plots. Close to this finding is that of Mfon and Bisong (2008) who noted that all seedlings fewer than 15cm in height increased progressively from unlogged through lightly logged, moderately logged to severely logged plots. Accordingly, he recorded average population of regenerating species of 129 in unlogged plots, 179 in lightly logged plots, 235 in moderately logged Plots and 347 in severely logged plots. Kane and Pokorny (2020) noted that gap regeneration remains all-important nature promoting silviculture practice and ecosystem-based strategy for improving diversity and conservation of native species in tropical African forests.

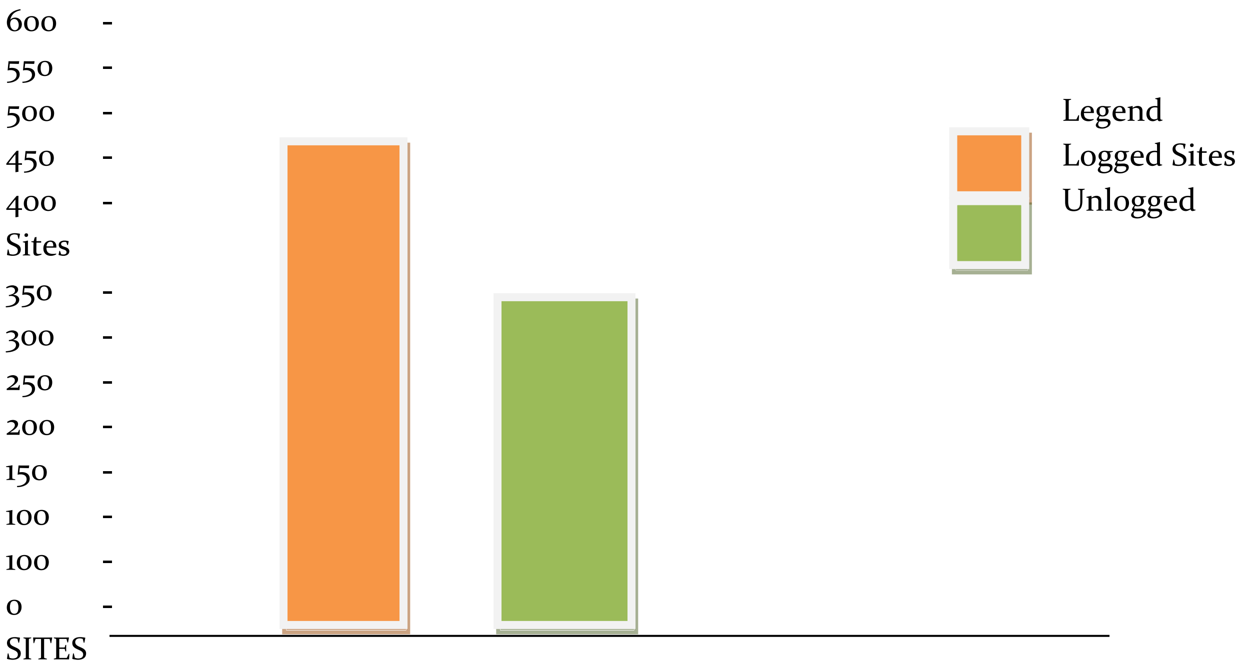

Fig 2: Graph Showing Mean Regeneration ≥ 10cm in Height for the 21 Logged Sites and 21 unlogged Sites.

This is in consonance with Verissimo et al., (1992) that worked on several logged sites in South America and observed that natural regeneration was abundant in logged sites and discovered 4,300 seedlings and samplings of economic species per hectare. Accordingly Steege (2003) noted that high intensity logging operations lead to strongly increase diversity in the first logging cycle. This is due to the fact that frequent disturbance allows previously absent, fast growing species to colonize and maintain themselves in the community. In Nigeria, Okali and Dike (1996) studied regeneration of Tropical moist forests in terms of gap phase dynamics and observed that climax and pioneer species simultaneously re-invade gaps. This according to them has implications for succession theory as they are consistent 'with the Competitive hierarchy model of Horn (1981), by which all colonizing species arrive simultaneously and some out-compete others to become initially dominant.

Thus forest regeneration is influenced by creation of gaps in the Canopy. At the same time, the disruption of the forest structure by logging alters ecosystem processes and the microclimate of the forest floor, which in turn influence the natural regeneration and growth of climbers. From author's field observation, the three main phases of Whitmore's, (2009) forest development example gap phase, building phase and mature phase were represented in the study sites.

Conclusion:

The tropical rainforest in Etung like all natural ecosystems has the capability to run and maintain itself in a state of dynamic equilibrium automatically without any assistance from outside as long as it continues to receive sunshine. This natural process of adjustment is rather hindered from without via logging. These disturbances result in an average of 326.43, seedlings and saplings greater than or equal to 10cm in height found per logged plot as against 194.3, for the unlogged plots. Higher forest regeneration on the logged sites than the unlogged sites promises a higher regeneration capacity if there is longer logging interval in the study area. This again shows the role of gaps created by logging and the attendant'sinsolation which has gingered colonization of seedlings and saplings. The incidence of sunlight in gaps is a factor for the higher number of regenerated plants in the logged sites.

Conclusively, logging involves two distinct processes; "cutting" and "removal" The effect of "cutting" is local in the sense that damage to trees and non-timber forest products is within extraction site. While the impact of removal" is felt throughout the "Ecosystem". Invasive species are fast in growing and occupying space and it can easily dominate in the succession, and this is made possible as a result of excessive logging in the forest area. Intensive logging, especially on short felling circles alters forest composition and damages forest Structure and site quality, thereby resulting in rapid lost of nutrient capital, and consequently, very slows recovery. Some of the negative environment implications of forest loss or shrinkage include more soil exposure to the full impact of heavy rain and sunshine thereby leaving it baked hard for weeds and grasses to colonize. Without roots and humus there is nothing to bind the soil and is easily washed away leading to gulling of slopes and eventually landslide, especially without the stabilizing effect of trees.

Recommendations:

The study recommends, that there should reduction on the illegal cutting down of trees in the study area. The policies and programmes meant to prevent illegal cutting down of trees should be fully implemented and enforced to the later in the study area to boost sustainability.

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