Environmental Research Journal 2 (3): 115-121, 2008
ISSN: 1994-5396

Effects of Logging on Forest Regeneration in South-Eastern Nigeria

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Abstract: This research work was carried out in the tropical high forests of Iwuru community, in Cross River State; South Eastern Nigeria. The focus was to determine the effect of logging intensity on forest regeneration status. Twenty four plots of one hectare each were laid. The plots were classified as lightly logged, moderately logged, severely logged and unlogged (control) based on levels of canopy opening and number of tree stands per hectare. Each category had 6 plots. Data on the number of regenerating seedlings in each of the sample plots were enumerated. Mean differences and analysis of variance were the statistical models applied to the data set. A positive statistically significant correlation was observed between logging and forest regeneration as the number of seedlings increased with logging intensity. The long term implication of this for rainforest recovery is highlighted.

Key words: Logging intensity, forest regeneration, rain forest recovery, South Eastern Nigeria

INTRODUCTION

In spite of the great values of the tropical rain forests, the threats of mass elimination of irreplaceable species and resources inflicted through human activities which include logging continue to grow (Bisong, 1999; Akintoye, 2002). The rapid rate of deforestation of which commercial felling of economic trees known as "logging" is a very important contributor has continued worldwide. In Nigeria, Cross-River State (CRS) presently has over 40% of the remaining Tropical High Forests (THFs) of the entire nation. It is the most forested state in Nigeria with at least 75% of its population inhabiting rural communities (Balogun, 1994). These populations largely depend on the exploitation of the rich biodiversity of the THFs in their environment (Atte, 1994; Bisong, 1994; Ajake, 2000).

The rapid rate of forest degradation through logging operations and its possible contribution to biodiversity depletion has equally become a major source of concern. For instance forest degradation and fragmentation are reported to have increased by an astronomic 522% between 1991-2001 for the Cross River Region. Even the 4000 km^2 expanse of the Cross River National Park (CRNP) has become the operational theatre of local and International logging organizations (Non Governmental Organization Coalition on Environment, 1995).

There is therefore, a dire need to examine the impact of logging operations on the THFs of Cross River State, not only as it affects the regenerational status of the forest but as it relates to its long term recovery.

The key questions to guide the study include the following:

- What is the impact of logging operations on forest regeneration potentials in the region?
- What is the long term implication of the pattern of regeneration for rainforest recovery?
- What logging strategies are appropriate for the minimization of damage to forest vegetation structure and composition?

As such, the objective of this study is to:

Identify the effects of logging intensities on forest regeneration potentials in the study area and recommend approaches that may minimize the negative effects of logging.

Logging intensity and forest regeneration: Silvicultural Systems contrast in their ability to foster forest regeneration. Three systems identified to give different effects on forest regeneration status are natural regeneration, clearing and replacement systems. The relationship between clearing and replacement systems on

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forest regenerational status in dipterocarp forest (Mason, 1983; Riswan and Kartawinata, 1991) and rainforest (Maury-Lechon, 1991; Saldarriaga and Uhl, 1991; Saulei and Lamb, 1991) regimes has been studied under different forest production systems namely, clear felling, slash-and-burn agriculture and pulpwood logging.

In these systems, logging damage has sometimes been so severe that both advance growth and seedling regeneration of desirable species were virtually eliminated (Mason, 1983; Kemp *et al*., 1993). Regenerational processes are as a result stifled with attendant consequences on the high rate of loss in biodiversity of faunal and floral species.

In the Nigerian context, very little attention has been paid to the relationship between logging and forest regeneration in management systems characterized by natural regeneration. A study by Obot (2002) was however focussed on the question of why natural gaps in forest do recover while gaps from disturbance associated with timber exploitation fail to recover. Employing the sunflect model (Quigley, 1981 in Obot, 2002) to data from the Cross River forest, Obot insinuates a critical gap size from which the forest is not likely to recover.

In the global context however, the relationship between logging within natural regeneration systems and forest regeneration has generated substantial information. Dawkins (1958), Nicholas (1958) and Fox have noted that the observed high reduction in seedling stocking is caused by exploitation damage, while Liew and Wong (1973) and Mwoboshi (1982) indicated that post logging survival percentage was only 13.7% of the pre-exploitation seedling number. Studies by Verissimo *et al*. (1992) revealed that there were an abundance of seedlings and saplings greater or equal to 10 cm tall in the logged forest sites studied.

Low intensity logging helps in the maintenance of large and varied seed supply from residual trees. Large scale intensive logging on short felling cycles with poor harvesting control may alter the species composition; damage both forest structure and site quality. Logging impact is indiscriminate in its effect on genetic resources but intensive logging tends to enhance opportunity for pioneer species (Kemp *et al*., 1993).

The key challenge is the effective management of logging sites to attain reduced impact logging in ways that minimize damage to residual stand and enhance the regeneration of native species. Studies that delineate the effects of logging on the regenerative status of forest in South-eastern Nigeria, a zone of intense logging activities are non-existent. This study fills this gap by investigating the effects of logging intensity on forest regeneration.

MATERIALS AND METHODS

Study area: The study area selected for this study is Iwuru a tropical rainforest community located at Latitude 05° 24' 03'' and longitude 08° 13' 19'' in the Akamkpa local government area of Cross River State, South-eastern Nigeria. It is approximately 65 km north of Calabar (Latitude 4°50'0" north and Longitude 8°15'00' east), the state capital of Cross River State.

Data collection method: This research depended on primary data collection, obtained from field measurements carried out in the tropical high forests of the study area.

Stock inventory method: The field measurement adopted for this study is the Stock Inventory Method (SIM). Field observations and measurements were carried out on 24 sample plots classified into sites with different logging intensities. This ranged from the unlogged plot for control, to the lightly, moderately and severely logged plots. Measurements on each of these plots were the number of forest trees felled and the number of trees and seedlings (natural regeneration) affected in logged and unlogged plots. The numbers of regenerating seedlings (trees below 16 cm height) were enumerated in each of the sampled plots.

Sampling technique: The stratified random sampling technique was employed for the collection of data in order to ensure that relevant areas with different logging activities were sampled. A total of 24 sample plots were laid with unlogged, lightly logged, moderately logged and severely logged plots having six each. Figure 1 shows a schematic diagram of the layout of the plots. Each plot was 1 ha (100×100 m). Trees from 30 cm dbh (diameter at breast height) and above were measured while seedlings not above 15 cm in height were enumerated. The ceiling of 15 cm was placed so that saplings will not be counted and most studies use seedling height between 10 and 15 cm (Verissimo *et al*., 1992). Forestry Commission of the Cross River State government approves the harvesting of transmission poles at the dbh of 30 cm. This explains why this is adopted in this study to conform to the minimum harvesting diameter.

Classification of plots: Plots were classified into unlogged, lightly logged, moderately logged and severely logged. The level of canopy cover and the number of trees (30 cm and above) per hectare influenced this classification. For instance, a plot was classified as unlogged when there was 90-100% canopy cover and the availability of about 150 trees with dbh 30 cm and above.

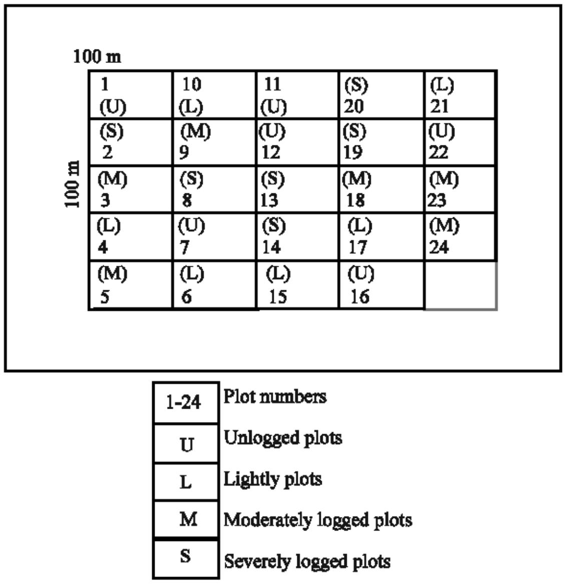

Fig. 1: Layout of sample plots (One hectare each), Source: Researcher's Field Work (2002)

Lightly logged plots had about 70% canopy cover with about 120 trees with dbh 30cm and above. For moderately logged plots, the canopy cover was about 50% with about 70 trees of the prescribed dbh per hectare. Severely logged plot had about 40% canopy cover with about 35 trees of the said dbh ha^{-1}.

Analysis of Variance (ANOVA) was employed to determine statistically significant differences in the regenerative status of the plots under different logging intensities.

RESULTS AND DISCUSSION

Table 1 presents the data obtained from the enumeration of regenerating seedlings in the sample plots. Table 1 shows a progressive increase in the number of seedlings from unlogged through lightly logged, moderately logged to severely logged plots.

The result of the one way Analysis of Variance (ANOVA) in Table 2 indicates that the f-value of the relationship between logging intensity and regeneration is relatively high at 89.122 and the p-value is 0.000, where the f-value is large and the significance level (p-value) is small (typically smaller than 0.05 or 0.01). The relationship is highly significant, confirming the direct relationship between logging intensity and the occurrence of forest regenerating species in Iwuru.

Table 3 shows the result of the multiple comparison of mean difference of logging intensities and forest regeneration in the sampled plots. It may be observed that

Table 1: Logging intensity and forest regeneration in sample plots in the study area

Plot No.	Description of sample plot	Forest regeneration (Number of species less than or equal to 15 cm in height)
1	Unlogged	129
7	Unlogged	139
11	Unlogged	116
12	Unlogged	150
16	Unlogged	112
22	Unlogged	120
	Mean	129
4	Lightly logged	175
6	Lightly logged	150
10	Lightly logged	200
15	Lightly logged	190
17	Lightly logged	163
21	Lightly logged	193
	Mean	179
3	Moderately logged	250
5	Moderately logged	275
9	Moderately logged	213
18	Moderately logged	200
23	Moderately logged	252
24	Moderately logged	218
	Mean	235
2	Severely logged	322
8	Severely logged	348
13	Severely logged	360
14	Severely logged	341
19	Severely logged	400
20	Severely logged	312
	Mean	347

Source: Researcher's Forest Survey (2002)

the mean differences for each of the 4 sample plots systematically compared with the other three sample plots in rotation. This is significant at the 0.05 level and also corroborates the existence of significant direct relationship between logging intensity and occurrence of regenerating species.

In Table 4, a Pearson Correlation is obtained from the regression analysis carried out on data in Table 1. The analysis reveals a very high R-value of 0.944, which indicate a very high significant relationship between logging intensity as represented in the different sample plots and forest regeneration. The model summary of the same regression analysis shows an R-value of 0.944 and R^2-value of 0.891. The very high R-value shows that there is a very high positive significant relationship between logging intensity and forest regeneration as already observed from other analysis using different statistical approaches.

The observed trends depicting a highly positive statistically significant relationship between logging intensity under natural regeneration systems and the occurrence of regenerating species is consistent with some earlier studies conducted elsewhere (Kemp *et al*., 1993; Verissimo *et al*., 1992). The explanation of the observed trend has been well documented in the literature

Table 2: Analysis of variance considering logging intensity and forest regeneration

	N	Mean	Std. deviation	Std. error	95% Confidence interval of mean Lower bond	Upper bond	Minimum	Maximum
Unlogged Plot	6	12883	14.16	5.78	113.97	14370	117	150
Lightly Logged	6	178.50	19.34	7.89	158.21	198.79	150	200
Moderately Logged	6	234.67	28.68	11.71	204.57	264.76	200	275
Severely Logged	6	347.17	31.19	12.73	314.43	379.90	312	400
Total	24	222.29	86.03	17.65	185.96	258.62	112	400

	Sum of square	df	Mean square	F-value	Sig.
Between groups	158394.460	3	52798.153	89.122	0.000
Within groups	11848.500	20	592.425		
Total	170242.960	23			

Table 3: Multiple comparisons of mean difference on logging intensities and forest regeneration

Plot description (I)	Plot description (J)	Mean difference (F-J)	Std. error	Sig.	95% Confidence interval Lower bound	Upper bound
Unlogged plot	Lightly logged	-49.67*	14.05	0.019	-92.51	-6.82
	Moderately logged	-105.83*	14.05	0.000	-148.68	-62.99
	Severely logged	-218.33*	14.05	0.000	-261.18	-175.49
Lightly logged	Unlogged plot	49.67*	14.05	0.019	6.82	92.51
	Moderately logged	-56.17*	14.05	0.007	-99.01	-13.32
	Severely logged	-168.67*	14.05	0.000	-211.51	-125.82
Moderately logged	Unlogged plot	105.83*	14.05	0.000	62.99	148.68
	Lightly logged	56.17*	14.05	0.007	13.32	99.01
	Severely logged	-112.50*	14.05	0.000	-155.34	-69.66
Severely logged	Unlogged plot	218.33*	14.05	0.000	175.49	261.18
	Lightly logged	168.67*	14.05	0.000	125.82	211.51
	Moderately logged	112.50*	14.05	0.000	69.66	155.34

*The mean difference is significant at the 0.05 level

Table 4: Descriptive statistical of data on logging intensity and forest regeneration

	Mean	Std. deviation	N
Qty. Forest regenerating Sp. (<15cm ht)	222.29	86.03	24
Plot description	2.50	1.14	24
Correlations			
		Qty. Forest regenerating sp. (<15cm ht)	Plot description
Pearson correlation	Qty. of forest regenerating sp. (<15cm ht)	1.000	0.944
	Plot description	0.944	1.000
Sig. (1-tailed)	Qty. of forest regenerating sp. (<155cm ht)		0.000
	Plot description	0.000	
N	Qty. of forest regenerating sp. (<15cm ht)	24	24
	Plot description	24	24

and is partially explained by the fact that during logging, canopy is opened leading to the penetration of sunlight in the forest floor which stimulates the growth of latent species in the seed bank of the top soil and other tree seedlings (Mwoboshi, 1982; Park, 1992; Withmore, 1991; Théry, 2001).

Figure 2 graphically shows the distribution of regeneration species in sample plots with different logging intensities. This shows a significantly high level of regenerating species population (40%) in the severely logged sample plots while the lowest population (14%) is found in the unlogged sample plots. This suggests also that, the canopy gaps created by logging activities tends to allow sunlight to reach ungeminated seedlings and retarded regenerating species and thus stimulate growth and development, as has been pointed out earlier.

The more fundamental question however is the implication of the observed trends for longer term rainforest restoration. While, intensive logging is associated with the availability of numerous seedlings, most of these eventually die as a result of competition between themselves and also with other species. Very few of these eventually grow to timber size which takes a period of about 80 years in the West African environment (Mwoboshi, 1982). This has tremendous implication for silvicultural management under natural regeneration regimes if the recovery of native hardwood species is in the management objective.

To identify the seedlings most likely to survive in logged sites, a table of the distribution of tree seedlings in the severely logged sites is provided (Table 5). This

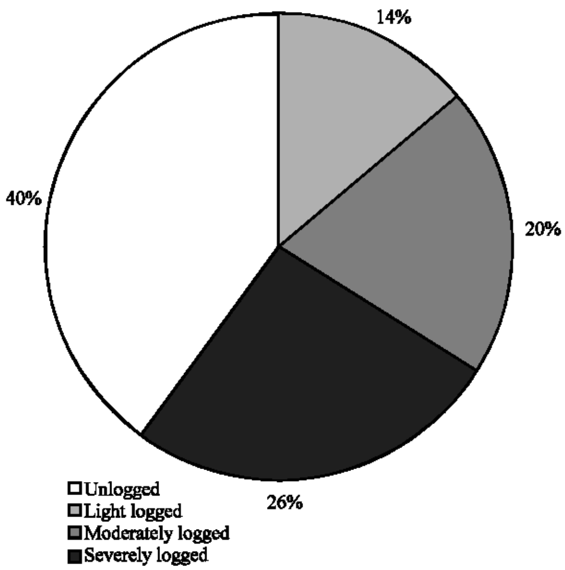

Fig. 2: Distribution of regenerating species in sample plots with different logging intensties

Table 5: Distribution of seedlings species in intensively logged plots (qualitative assessement)

Species	Stage in succession	Abundance class
Musanga cecrepioides	Early colonizers	Abundant
Trema guineensis	Early colonizers	Frequent
Anstocleista nobilis	Early colonizers	Frequent
Nauclea sp.	Early colonizers	Common
Harungana madagascariensis	Early colonizers	Common
Brachystegia sp.	Late colonizers	Occasional
Entandroporagma sp.	Late colonizers	Rare
Milecia excelsa	Late colonizers	Rare
Canarium schweinfurthii	Late colonizers	Rare
Lovoa trichilioides	Late colonizers	Rare
Pycnanthus angolensis	Late colonizers	Occasional
Pterocarpus sp.	Late colonizers	Occasional

Abundant>30%; Common 10-20%; Frequent 5-<10%; Occasional > 1% -< 5%; Rare 1%

was derived through a qualitative estimate of the regenerating species and reported to reflect their abundance class.

The most common of the regenerating seedling species is *Musanga cecrepioides*, which combines to make up a little over 50% of the encountered population in the sample plots. Other early colonising species of significant occurrence are, *Trema guineensis*, *Anstocleista nobilis*, *Nauclea* sp. and *Harungana madagascariensis*. Species in the category of late colonizers are seedlings of the tropical hardwoods such *Brachystegia* sp., *Entandrophragma* sp., *Milicia excelsa*, *Canarium Schweinfurthii*, *Lovoa trichilioides*, *Pycnanthus angolensis* and *Pterocarpus* sp.

The dominant species in the logged sites are evidently the early colonizers. This quickly take advantage of the favourable light and temperature regimes due to canopy openings and the associated gaps created through tree removal and damage of residual stands. The hardier species are at this stage rare or occasional in occurrence on the logged sites. As shade lovers, they for a while benefit from the favourable shade environment provided for their growth by the early colonizers. These species soon become more successful in the struggle and ultimately eliminate the early colonizers and ascend to dominance as late colonizers.

Under intensive and excessive timber exploitation characterized by shorter rotation cycles, the succeeding ecosystems will be dominated by the early colonizers, the most common of which is *Musanga cecrepioides* as early mentioned. The musanga species belong to the family MORACEAE and is also referred to as the Umbrella tree. Trees of this family have exudates, alternate leaves and paired stipules. The flowers are minute and crowded in highly specialised inflorescences. The flowers do not have petals and always unisexual. The species is confined to West and Central Africa and therefore indigenous to the region. It is the only species within the genus Musanga (Keay, 1989). It has a very rapid growth but with a short lifespan. This species is known to inhabit forest clearings. Within the high forest, Musanga gets to a height of about 20 m and a girth of 2 m with an open crown of widely spreading branches hence the name Umbrella tree. The bark is smooth with grey to greenish brown colouration with straight bole anchored on stilt roots. When slashed a copious clear liquid is found and not latex. This exudate is used by local people as medicine. The wood is soft and very light and good for pulping when the corky pith is removed. Since the tree does well in natural regeneration, it may not be too difficult to raise it on nurseries and plantations should this become a management objective.

CONCLUSION AND RECOMMENDATIONS

The research outcome clearly revealed that logging intensity significantly influences forest flora diversity and that the higher the logging intensity, the greater the damage to the forest flora population. Consequently, these could have dire effect on the general forest ecosystem and severe implications on the availability of socio-economic, industrial and medical (health) dependent natural resources obtainable from this highly precious type of vegetation.

To ameliorate or totally eradicate these problems, the following recommendations have been made. A deliberate effort needs to be made towards applying the principles of Reduced Impact Logging (RIL). This entails a series of decisions and procedures to meet given objectives. Strategies and procedures for undertaking RIL have been detailed out in many reports and studies (Higman *et al*., 1999; Pinard and Putz, 1996) to suite various management contexts. Pinard and Putz (1996) reports that RIL performed significantly better than conventional logging methods with respect to minimizing damage to residual stands and promoting future increments and yields in forest biomass.

Two key approaches to achieve impact reduction during logging that are of critical relevance to the study results are minimizing wood uptake and adopting ecofriendly harvesting and extraction methods. To reduce the number of trees logged for minimal damage to residual trees and regenerating species, an increase in the minimum girth of trees to be exploited is recommended. The present girth size of trees extracted range from 2.5-3 m. This may be increased to the range of 3-3.5 m to ensure that only the very mature stands are removed. The implication of this is a reduction in exploitation frequency and an increase in the rotation cycle of trees harvested to ensure maximal post harvest recovery of the rainforest ecosystem.

Ecofriendly harvesting and extraction methods will serve towards reducing the gaps created by canopy openings and destruction of residual stands. The aerial lifting of logs through helicopters, balloons and pulleys are the greatest ecofriendly extraction strategies to minimize damage and wide gap creation. The cost of these operations however makes them unattractive. Introducing mobile or walkabout sawmills are the ready alternatives to damage reduction. Logs are converted insitu right within the forest which avoids ecological damage to seeds in top soil and seedlings arising from skidding.

Pre-harvest planning should be carried out and should include pre-harvest inventory to determine the species type and size of trees to be harvested, which direction to fell the trees and the mode of extraction (Higman *et al*., 1999). Influencing the direction where logged trees fall will serve to reduce the destruction of seedlings and saplings from harvested trees which saves the gene pool from which longer term rainforest recovery will emanate from.

There should be a compulsory system of replacement of at least three seedlings for every one tree logged in order to ensure survival of one of the seedlings. Emphasis should be given to indigenous species over exotic ones in order to maintain the food chain. Fortunately most of the seedling pool comprise of native species. Minimum and maximum logging intensities for all logging concession areas should be stipulated and highly destructive machines and vehicles discouraged from the area in order to enhance the long term potential of the forest for recovery. However, the increase in the number of seedlings could be misleading as it takes about 80 years for the seedlings to mature to commercial timber and most of them will not survive unless they are properly nurtured.

The importance of forest disturbance and canopy openings to regeneration of certain commercially favoured timber species and NNTP's should be identified and such moderate processes should not be totally discouraged. There should be pre-logging environmental impact assessments, which culminates in the submission of environmental impact assessment reports on which logging operations can be adjustably executed.

Research should be carried out to develop fast growing trees as well as those resistant to fire and pathogenic attack. Environmental Laws should be revised and fully implemented to carry severe jail terms and fines. At present, very few if any defaulter had ever been prosecuted under those laws.

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