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EVALUATION OF TIMBER HARVESTING AND ITS IMPACT ON RESIDUAL TREE SPECIES IN EDO STATE NIGERIA

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Abstract
The study was carried out to evaluate and examine the impact of timber harvesting on residual tree species in Edo State, Nigeria. The reconnaissance survey of the forest reserve was used to identify logging activities in the study. Furthermore, questionnaire was used to retrieve information from fifty (50) professional tree loggers to collect information on the demographic characteristics of the loggers and to know the major causes of damages to the trees and seedlings during felling operations and precautions taken to mitigate such damages. Findings showed that *Bosquieaangolensis* had the highest frequency among the damaged species. The total volume of damaged trees per hectares was 711.04m^3. Results also showed that among the loggers, 7.6% had no formal education, while, 23.7% had over ten years of working experience. It also revealed that the majority of the operators 92.4% still required additional training on effective felling operation. The timber industry has grown beyond the forest regeneration capacity with poor conventional harvesting practices, and unabated degradation of the forest ecosystems during logging operations. The study revealed that major damage is done to the residual trees during the felling and transportation of the targeted tree species. There is need therefore, for adequate training and or retraining, monitoring, and supervision of effective felling operations to improve their competencies and further decrease the destruction of the ecosystem during logging activities.

Keywords: Harvesting, Loggers, Residual, Species, Timber

Introduction

The term logging is the sum of all processes, operations, and activities that make it possible for mature trees to be extracted for onward transmission to factories or places of secondary conversion (Ogbonnaya, 2002). It encompasses tree felling, de-branching, cross-cutting, skidding, loading, and primary transportation. It is a very lucrative business in Nigeria and provides employment for many. Timber harvesting is the most important intervention factor in forest operations and management practices on the environment. Conventional timber harvesting, which has been practiced until now in Nigeria, often is considered to be a major cause of degradation; however, shifting cultivation and forest fires frequently are also responsible for forest decrease. In the government reserves, logging is controlled by policies and laws enforced by the State Department of Forestry, and these must be strictly adhered to by both loggers and concessionaires. However, government control on logging in the free areas is limited to the issuance of permits or licenses to loggers after payment of all necessary fees (Adetula, 2008). Currently, the removal of timber occurs in an uncontrolled manner, without strict adherence to the laws or payment of appropriate fees and levies. Such illegal operations are termed 'illegal logging' (Pfeil *et al.,* 2007). Furthermore, logging operations are responsible for forest destruction in Nigeria. These processes are primitive and tedious and have the potential to disrupt the ecosystem (Olajide and Udo, 2005). Because forest operations neglect the principle of sustainable forest management, proper harvesting, well-planned logging techniques, review, execution, and enforcement of logging policies and adoption of reduced impact logging are neglected in Nigeria, which leads to decline in forest production. There is a high need to evaluate the extent of logging damages and its impact on other residual plants species to help promulgate and enforce operational and appropriate logging policies in Nigeria. Hence, the aim for which the study was carried out was to examine the damage to non-targeted neighbouring tree species and the forest ecosystem by logging operation, intending to proffer precautionary measures that would encourage sustainable forest management. The specific objectives were to (i) assess the volume of damaged trees and abandoned logs; (ii) identify and enumerate damaged tree species during timber harvesting and evacuation; (iii) determine the types and level of damage and (iv) evaluate the level of compliance of operators to low impact logging.

Methodology

This study was carried out in Sakponba Forest Area in Orhionmwon Local Government Area of Edo state. Edo State is located between latitude 5°5 N – 7°33 N and longitudes 5°E – 6°40'E. It shares common boundaries with Ondo state in the west, Delta State in the east, and Kogi state in the north. The vegetation of the state is a moist rain forest in the south and derived savanna in the north. Sakpoba Forest Reserve lies between latitudes 4° - 4° 30'and longitudes 6°-6° 5'E. It is located in Orhionmwon Local Government Area, about 30 kilometers South-East of Benin City. The reconnaissance survey of the reserve was carried out physically to familiarize myself with the terrain and to be able to identify possible logging activities that are prevalent in the study area. It was observed that massive timber exploitation was currently ongoing in the reserve, farming activities are on the rise along the boundaries.

Data collection

Economic, indigenous, and high-value timber species on two different compartments of 20ha each allocated to different loggers for exploitation was selected. Sixteen sample plots of 25m x 25m were randomly mapped out in each of the selected compartments. The damaged trees and abandoned logs in each plot were marked and enumerated. Total heights and diameters at the base, middle, top, and breast height (DBH) of the selected plants were measured. The surrounding residual plant species and the condition of the environment were observed closely and noted. Broken tree branches with a diameter > 10cm were also measured and their frequencies were noted.

Tree stems damage assessment

The three damage assessments used by Eroglu*et al.,* (2009) and Weimin*et al.,* (2008) were employed to quantify stand-level damage severity. These are the percentage of stems damaged, percentage of the basal area lost, and a "stand-level damage index'. As tree stems often suffer multiple damage types and events, an 'integrated stem damage code' which combines all information/indices of uprooting, breakage, leaning, and leaned-on into a single code ranging from 0 to 3 was used. A damaged stem is defined as code 3 (if the tree sustained severe damage i.e. completely uprooted, >90% canopy loss or leaning towards the ground); code 2 if a tree sustained substantial damage (i.e. partially uprooted, 35 – 90% canopy loss, leaning but supported by other trees or pined on the ground by fallen neighbours); and code 1 if a tree sustained modest damage (i.e. 10 – 35% canopy loss, leaning > 10% or bent with > 10% crown displacement). Code 0 was used for minor or no damage. The integrated stem damage code reflects multiple damage attributes for a stem and therefore should more accurately reflect tree damage status than the individual components assessed.

Logger's experience and reports on causes of logging damage to non-targeted plants

A questionnaire survey of 50 professional tree loggers, popularly referred to in Nigeria as 'operators', was designed to collect information on the demographic characteristics of the loggers, major causes of damage to other trees, and seedlings during felling operations, and precautions to mitigate such damage. The questionnaire was filled by the loggers and retrieved on the spot. An intensive interaction was carried out with key informants such as forest guards and government officials involved in loggings activities.

Results and Discussion

Results

There were 33 timber species exploited in the forest reserve (Table 1). Among these; *Ceiba pentandra* had the highest frequency (6), followed by *Cordial milleni, Khaya ivorensis,Terminalia ivorensis, and Triplochiton scleroxylon* (3 each) with a minimum of one tree each of *Alzelia Africana, Albizia lebbeck, Alstonia boonei, Celtis zenkeri, Piptadenistrum africanum, Pycantus angolensis and Ricinodendron heudelotti*felled by the allottees. The study identified 2 species of Caesalpinioidea, Mimosoideae, Combretaceae, and Sterculiaceae, while for 8 other families (*Apocynaceae, Bombacaceae, Ulmaceae, Bignoniaceae, Meliaceae, Moraceae, Myristicaceae, and Euphorbiaceae*) only 1 species was exploited. In the past, a good number of the exploited species were not valued by timber contractors and plank marketers. The growth variables of damaged tree species during logging activities are presented in Table 2. The observation recorded during the study revealed that 54 standing stems belonging to 21 tree species were damaged in the process of logging. *Bosqueia angolensis* had the highest frequency among the damaged species (8 trees), followed by *Albizia lebbeck, Entandrophragma angolense, and Triplochiton scleroxylon* (5 trees each). Apart from *Terminalia superb, Pycnanthus angolensis, and Cordial milleni i*with a frequency of 4, other damaged species had a frequency less than 3. The total volume of damaged trees per ha is 711.04m^3 (Table 3). This is a huge loss in monetary terms since the species composition cut across all the exploited trees.

Loggers experience and logging impact

The loggers suggested some measures for reducing logging damage to untargeted trees and the entire forest ecosystem (Table 4). It was observed that 82% of respondents identified proper determination of felling direction, particularly in areas with sparse tree population, as the most important damage-reducing measure during tree felling. The second proposal was the use of competent and well-trained tree fellers (72.0%) and suspension of felling activities when the wind is strong and weather conditions are not favourable (66.0%). The remaining 48.0% considered that engaging experienced skidding operators and prohibition of the use of heavy log evacuation equipment (32.0%) were other common measures that could be used to minimize logging damage. The demographic characteristics of the loggers (Table 5) indicate that majority (74.2%) were married, younger workers (between 25 – 34 years old) were most common (44.4%), with a wider age group range (15 to 60 years) involved in logging activities (Table 5). Only 7.6% of the loggers did not have formal education. Among loggers, 23.7% had over ten years of working experience while 71.6% were skilled in timber felling. The remaining loggers came to the profession through wood-based industries (10.4%) and friends (18%). However, findings revealed that the majority of the operators (92.4%) still require additional training on effective felling operation. This supported the assertion by Adekunle and Olagoke (2010) that the majority of the operators had no training and their skills increased according to the time spent on the job.

Discussion

The thriving timber industry has grown beyond the forests' regeneration capacity, with poor conventional harvesting practices, colossal destruction, and unabated degradation of forest ecosystems during logging operations. These are detrimental to the sustainability of forest resources and their management. Conventional timber harvesting which has been practiced until now often is considered to be a major cause of forest degradation; however, shifting cultivation and forest fires frequently are also responsible for forest decrease. The concession holders or timber contractors usually carry out their timber harvesting operations in the easiest way, often without sufficiently detailed harvesting plans and work instructions for timber harvesting operations. Consequently, most of the seedlings and saplings are severely damaged (when cut, trampled, or uprooted) during logging operations, reducing their natural ability to successfully replace the harvested trees in the future. This study revealed that major damage is done to the residual trees during the felling and transportation of the targeted tree species. Clatterbuck (2006) substantiated the occurrence of such damage and stressed that residual tree species are devalued and may not recover to become better-graded timber. Also, Limbeck (2003) observed that fungal infections and decay are common when trees are wounded. Thus, logging damage especially bole-breakage, stem splitting, and de-branching could lead to fungi infections and decay of damaged tree species and expose the trees to pathogens infestation. Tree species that are mildly injured could recover from the stress inflicted during logging activities. Elias (1996) found that the degree of residual stand damages caused by conventional timber harvesting ranged between 28 – 45% and the incidence of damage to small trees was greater than to larger trees (80%). Most of the damaged trees were seriously injured (85%) and had little chance to recover because the degree of damage did not permit their survival. As tree stems often suffered multiple damage types and events, the integrated stem damage code was used by combining all information/indices of crown damage, total fall, breakage, de-branching, splitting of stem, and leaning (as shown in Plates 1 – 5). The results show that the highest proportion (60.5%) of total damage was on scale 3, followed by 16.1% on scale 2 and 23.4% on scale 1 as shown in Figure 1. Although, the demographic characteristics of the loggers show that majority had sound experience, education and were mature, attributes that have contributed immensely to their expertise. Notwithstanding, adequate training and/or re-training on effective felling operations could improve their competency and further reduce the destruction of the ecosystem during logging activities. The results of this study also revealed that the loggers are aware of the damage caused to the forest ecosystem during logging but their overzealousness to meet targets in terms of daily returns nonchalant attitude to instruction would not enable them to take cognizance of the dangers associated with unregulated felling. This is in agreement with reports of Ogbonnaya (2002); Eroglu and Acar (2007); Eroglu *et al*. (2009), who indicated that damage to residual stands due to timber harvesting involves tree felling, hauling of logs, road construction, and log transportation. However, now that timber harvesting has become a very lucrativebusiness enterprise considering the ever-rising demand for timber products, damage can only be abated by taking safety measures and through sufficient training of loggers. The working practices and experience of chainsaw operators and skidders can considerably reduce logging damage. In addition, proper forest harvesting, especially well-planned logging techniques are required to maintain site quality and productivity and maintain sustainable management of forest resources (Dykstra and Heinrich, 1996). Eltz and Buhl (2001) confirmed that reduced impact logging causes less direct damage to the environment compared to conventional practices and this should be inculcated into forest harvesting practices in Nigeria.

Conclusion

In conclusion, logging activities are causing large damages to residual tree species and these damages were recorded during felling operation, preparation of gantry, and road construction. Considerable timber harvesting damage was attributed to excessive and indiscriminate logging, inexperienced chainsaw operators and skidders, and lack of adequate training. Forest clear-felling during road construction causes more damage to the forest ecosystem than the fallen trees. Bole breakages, crown damage, stem splitting, de-branching, stem leaning, and soil compaction are the main types of damage to untargeted tree species and ecosystems during logging. Loggers are not ignorant of the adverse impacts of incessant logging activities on the ecosystem. However, sufficient planning, proper operational techniques control of the operation, and supervision during logging operations could retard the quantum damage associated with conventional timber harvesting. Reduced impact timber harvesting operations and other eco-friendly harvesting techniques, as practiced in the developed world, are feasible methods to reduce the impact of logging activities on the ecosystem. Training of loggers and in-service training for forestry workers in all categories on the need for sustainable logging practices and where necessary, imposition of heavy fines on loggers or concession holders commensurate with the level of damage incurred at each compartment are therefore recommended as a way of curbing the damage and promoting sustainable forest management. Based on this study, the following are hereby recommended for effective reduction in the impact of timber harvesting on untargeted tree species:

i. There is a need to promote the implementation of reduced-impact timber harvesting in all the forest reserves in Edo state.
ii. Proper topography and tree location map be prepared before the allocation of forest reserves.
iii. Training of power chain saw operators, felling, and skidding foremen is highly necessary.
iv. Forestry officers who are responsible for the supervision of timber harvesting operations should undergo periodic in-service training on sustainable forest management.
v. Imposition of fines on loggers who contravene forestry laws guiding forest allocation and timber harvesting in the forest reserves as a veritable means of curtailing damage.
vi. Developing local codes of practice of reduced impact timber harvesting operations.

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Table 1: Harvested tree species in the two compartments assessed at Sakponba Forest Reserve

Tree Species	Family	Frequency	Total DBH (cm)	Total Basal Area (m^3)	Relative Density
Afzelia Africana	Caesalpinioideae	1	154	1.86	2.7
Albizia lebbeck	Mimosoideae	1	438	15.07	2.7
Alstonia boonei	Apocynaceae	1	132	1.37	2.7
Brachystegia eurycoma	Caesalpinioideae	2	526	10.87	5.4
Ceiba pentandra	Bombacaceae	6	1274	21.25	16.2
Celtis zenkeri	Ulmaceae	1	146	1.67	2.7
Cordial millenii	Bignoniaceae	3	130	0.44	8.1
Khaya ivorensis	Meliaceae	3	473	5.86	8.1
Mansonia altissima	Sterculiaceae	2	112	0.49	5.4
Milicia excels	Moraceae	2	493	9.55	5.4
Piptadeniastrum africanum	Mimosoideae	1	366	10.52	2.7
Pycnanthus angolensis	Myristicaceae	1	118	1.09	2.7
Ricinodendron heudelotii	Euphorbiaceae	1	214	3.60	2.7
Terminalia superb	Combretaceae	2	285	3.19	5.4
Terminalia ivorensis	Combretaceae	3	274	1.97	8.1
Triplochiton scleroxylon	Sterculiaceae	3	422	4.66	8.1
Total 16	**12**	**33**	**5557**	**93.46**	**89.1**
Mean			**168.39**	**2.83**	**2.7**

Source: Data generated from a fieldwork, 2021

Table 2: Relative dominance and density of damaged trees in two compartments at Sakponba Forest Reserve

Compartment	Species	Basal area (m^2)	Frequency	Relative density (%)	Relative dominance (%)
1	*Albizia lebbeck*	2.45	3	7.89	10.34
1	*Blighia sapida*	0.61	1	2.63	2.57
1	*Bosquiea angolensis*	3.18	6	15.78	13.4
1	*Brachystegia eurycoma*	1.47	2	5.26	6.19
1	*Ceiba pentandra*	3.27	2	5.26	13.79
1	*Celtis zenkeri*	2.7	1	2.63	11.38
1	*Chrysophyllum albidum*	0.42	1	2.63	1.77
1	*Entandrophragma angolense*	1.56	5	13.15	6.57
1	*Khaya ivorensis*	0.20	1	2.63	0.86
1	*Mansonia altissima*	0.20	2	5.26	0.86
1	*Pycnanthus angolensis*	0.69	4	10.52	2.89
1	*Ricinodendron heudelotii*	0.66	1	2.63	2.8
1	*Terminalia superb*	0.39	2	5.26	1.66
1	*Triplochiton scleroxylon*	2.41	3	7.89	10.15
1	*Vitex grandiflora*	0.40	1	2.63	1.67
2	*Afzelia Africana*	0.05	1	2.63	0.49
2	*Albizia lebbeck*	0.78	2	5.26	7.78
2	*Alstonia boonei*	0.31	1	2.63	3.11
2	*Bosquiea angolensis*	1.39	2	5.26	13.87
2	*Celtis zenkeri*	0.18	1	2.63	1.81
2	*Cordial millenii*	0.41	4	10.52	4.06
2	*Pachystela brevipes*	0.55	1	2.63	5.53
2	*Pterygota macrocarpa*	0.92	2	5.26	9.2
2	*Sterculia rhinopetala*	0.30	1	2.63	3.01
2	*Terminalia superb*	0.42	2	5.26	4.2
2	*Triplochiton scleroxylon*	0.78	2	5.26	7.79

Source: Data generated from a fieldwork, 2021

Table 3: Damaged residual tree volume distribution (per plot) two compartments at Sakponba Forest Reserve

	Compartment (m^3)	
Plot	**Comp 1**	**Comp 2**
1	46.09	29.21
2	82.66	5.72
3	40.03	5.50
4	39.54	8.64
5	3.69	6.03
6	12.47	7.96
7	31.33	
8	15.63	
Mean/plot (m^2/25m by 25m plots	33.93	10.51
Standard error	8.77	3.78
Vol/ha (m^3/ha)	**542.87**	**168.16**

Source: Data generated from a fieldwork, 2021

Table 4: Various damage reduction measures suggested by logging operators

Operation	Logging damage reduction measure	Number of respondents	Percentage (%)
During felling	Use of appropriate felling machine	27	52.0
	Employment of competent operator with adequate training	36	72.0
	Proper determination of felling direction	41	82.0
	Felling operation should discontinue during high wind	33	66.0
During log evacuation	Skidding and transportation should be done by an experienced skidding operator	24	48.0
	Proper construction of timber evacuation route in an area with low vegetation	11	22.0
	Prohibition of the use of heavy log evacuation equipment	16	32.0

Source: Data generated from fieldwork, 2021

Table 5: Demographic characteristics of the logging operators in Sakponba Forest Reserve

Characteristics	Group	Percentage (%)
Gender	Male	100
	Female	0
	Total	**100**
Marital status	Single	25.8
	Married	74.2
	Total	**100**
Age (years)	15 – 24	15.2
	25 – 34	44.4
	35 – 44	22.3
	45 – 54	9.4
	≥ 55	8.7
	Total	**100**
Educational background	None	7.6
	Primary	21.0
	Secondary	62.8
	Tertiary	8.6
	Total	**100**
Logging experience (years)	0 – 5	16.1
	6 – 10	60.2
	11 – 15	10.3
	16 – 20	8.8
	≥ 21	4.6
	Total	**100**
Route into this job	Learning	71.6
	Employed by a wood industry	10.4
	Through a friend	18.0
	Total	**100**

Source: Data generated from a fieldwork, 2021

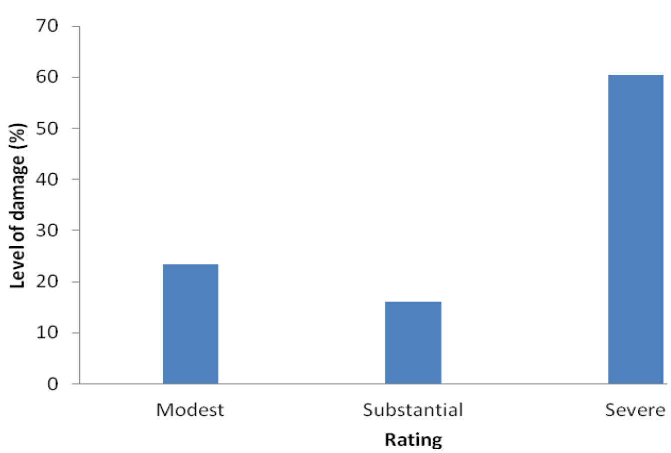

Figure 1: Type of tree damage caused by logging operation in the study area