INTERNATIONAL JOURNAL OF APPLIED BIOLOGY AND PHARMACEUTICAL TECHNOLOGY
www.ijabpt.com ISSN : 0976-4550
Volume-9, Issue-3, July-Sept 2018 Coden IJABFP-CAS-USA

Received: 8th July-2018 *Revised: 24th July- 2018* *Accepted: 25th July-2018*
DOI: 10.21276/Ijabpt, http://dx.doi.org/10.21276/ijabpt ***Research article***

"EVALUATION OF THE IMPACT OF LOGGING OPERATIONS ON VEGETATION IN THE CONTEXT OF SLAUGHTERING AND SKIDDING IN THE SICOFOR FORESTRY BUSINESS UNIT"

Mbete Pierre[1,2], Nzila Jean de Dieu[3], Oko Clement Sosthène[1,2] and Obvala Ruth Raphaëlle [1, 2,3]

[1]National School of Agronomy and Forestry (ENSAF)
[2]Laboratory of Applied Ecology and Environment (LEAE) of ENSAF.
[3]National Forest Research Institute (IRF)

ABSTRACT: The study on the assessment of the impact of forest operations on vegetation is carried out in the Gouongo Forest Exploitation Unit (UFE) located in Komono District, Lekoumou Department, part of the Southern Forest Sector. The whole of the UFE is covered by the dense rain forest of the Guineo-Congolese region, except for a few rare non-forest areas: savannas, cultural complex, anthropised zones, stream beds and bare ground. The hydrographic network is relatively dense. Unfortunately, harvesting of forest products for the benefit of loggers is often accompanied by direct or indirect environmental impacts, resulting in the modification or disappearance of biodiversity. The methodology recalls the evaluation of the measures of the destroyed areas by counting the number of damaged stems compared to the two operations, in particular the felling and skidding of the woods in the forest. The results of this assessment show that there are differences in the average areas affected by the felling of trees, which is 2383.08m2, resulting in a number of damaged young stems of: 990 broken stems, 112 uprooted stems and 168 debarked trees, ie a total of from 1270 feet. For the skidding operation, the average area destroyed was 33329 m2 with a number of damaged stems of: 372 including 82 uprooted stems, 140 broken stems and 150 stems with bark. It can be seen that the harvest rate at the level of the slaughter is 1.84 feet per hectare in this 2017 Annual AAC. It is thought that if this rate had reached or exceeded the Exploitation standard. Reduced Impact Forest (EFIR) estimated at 2.5 feet per hectare, then damage to vegetation and the number of damaged young stems would still be enormous.

Key words: logging, slaughter, skidding, vegetation, areas, damaged stems

*Corresponding author: Pierre MBETE, [1]National School of Agronomy and Forestry (ENSAF)
[2]Laboratory of Applied Ecology and Environment (LEAE) of ENSAF. dr_oko@yahoo.fr

INTRODUCTION

Central Africa is home to the forest and hydrological ecosystems of the Congo Basin which constitute the largest tropical forest massif in the world after that of the Amazon. At 204 million hectares, these ecosystems cover 26% of the world's tropical rainforests and 70% of Africa's forest cover (FAO, 2011). This area is full of biomes, ecosystems and habitats including evergreen forests, semi-deciduous forests, floodplain forests, mangroves and more. (Mbete, 2010). These formations play an important role in the major ecological balances and contribute to the socio-economic development of the countries of Central Africa (FAO, 2003).

The Republic of Congo has an estimated forest cover of 22,471,271 ha divided between the Mayombe, the Chaillu and Nord-Congo massifs, which together occupy 65% of the national territory. Most Congolese forests are dense and wet, and nearly 37% are inundated almost continuously (FAO, 2011).

Since the 1990s and 2000s, the Congolese Government has embarked on an intensification of logging activities that has opened up all the massifs to multifaceted human pressures (Mbete, 2014).

Currently, logging gaps are steadily expanding and all onshore forests are home to logging concessions, while serving as Eucalyptus, pine, oil palm and traditional slash-and-burn farms and urban development of nascent and old urban cities.

For example, large tracts of forest are currently showing signs of dismantling woody and wildlife resources in several accessible places. The forest is increasingly considered as a provider of multiple resources (the tree and its products, the path, the soil usable for agriculture, hunting, gathering, landscape etc ...) at the origin of several economic sectors (Mbete, 2014).

In the face of continued population growth, recent economic forecasts increasingly reflect the natural resource regeneration capacity that could be displaced by the irrational rate of anthropogenic harvest (FAO, 2003).

To reconcile the use and conservation of natural resources, FAO has initiated the principle of reduced impact logging (RILF) with a view to promoting the regeneration of the stems of the future (FAO, 2011) and to other subsequent resources in the forest massifs.

The present work, which is part of the Government's priority axis, focuses on the impact of logging and logging on the environment in the forestry concession of Sino Congo Forêt (SICOFOR).

Operations in a logging operation cause several environmental impacts, particularly logging and logging, which are the focus of our study. These impacts can be negative or positive. The general objective of this work is to show if in forestry operations the incidence is high, and the damage is enormous on the forest stand. The specific objectives that have been set, namely:

- Evaluate the number of species exploited by SICOFOR;
- Determine areas (gaps) that were impacted during felling;
- Determine the number of injured, broken and uprooted stems of future during slaughter;
- Evaluate the areas of skid trails,
- Evaluate the number of wounded, broken and uprooted stems of the future

MATERIAL AND METHODS

Equipment used to assess incidence during slaughter:

- Exploitation monitoring maps, which were used for the identification of species;
- GPS (Geographic Positioning System) map 60Cx;
- A 20 meter and a flex meter for taking measurements;
- A machete for the opening of the roads during the prospection;
- A camera for taking pictures.

Equipment used to assess the impact on the skid trail:

- A prospecting map;
- A GPS map 60Cx;
- A decameter of 20m;
- A machete. Were used for evaluation on the skidding trail.

METHODS

The strategy of the methodological research used in this study is as follows:

- The bibliography search: it allowed us to collect information, to analyze the documents put at our disposal on the management of natural resources in Congo.
- Field surveys: they are conducted on the basis of a research protocol, data collection sheets.

Data Collection Methods

This study is carried out in the 2017 Annual AAC (Cutting Year) of the said logging unit where the data are collected. The area mapped on GIS using a UTM projection is 239,577 ha with a usable area of 228,614 ha (Figure 1). To determine the felling hole (which represents the area affected by the damage caused by the fall of the tree), we measured the length and the width of the crown (in meters) by a 20 m dekameter according to the its shape and extent between the forest stand (intact) and the branches (leaves) of the fallen tree and then added to the area affected by the barrel on the vegetation.

We counted trees felled of different species with their forest number marked at the strain by the slaughter team and the taking of their geographical position. All felled trees (Figure 2) encountered were botanically identified and the following measures were performed:

- Cross-section at the base of the drum or large end (m), determined by cutting (bucking) at the abutment;
- The cross-shaped diameter at the top of the barrel or small end (m), determined by the cutting at the head;
- The length of the barrel (m), determined by these cuts and corresponds to the ball skate;

The volume of the ball (m3) was calculated from the previous variables. The volume by the formula of Hubert: Volume (V) = [π (Dm) ² × L] / 4 (m³);

With π = 3.14 Dm: average diameter;

L: Length (Forester's Memento, 1978)
Area affected on the vegetation by the barrel: length (m) x width of the diameter in (m)

Method of assessing impact on skid trails

We conducted GPS surveys on a random sample of a skid trail network on five parcels (N = 5). The length and width of each runway are measured within the 200 meter range.
Along the skid trails, all injured or broken rods with a diameter greater than or equal to 5 cm are also raised.
The materialization of skid trails on prospecting maps is done by trial and error, by the tracking team. In the field, we followed its tracks which are opened by the tractor bulldozer, while comparing them with the theoretical tracks (found on the map). Any track open (Figure 3) on the field, not shown on the map is noted as a track off track.
The area degraded by logging in each parcel is calculated by multiplying the average width of all open tracks by the total length of all tracks.

Data processing

We used two software for the processing of our data:

- Word 2013, which allowed us to capture and edit our document;
- Excel 2013, which served us in the data processing.

PRESENTATION OF THE RESULTS

Assessment of incidence during slaughter

Five (5) species were the subject of our study, the previously mentioned parameters (base diameter, top diameter, log volume, length of the drum) were recorded and allowed us to obtain the data presented in Table 1. We measured a total of 148 trees (N = 148).
We note in the table above that the dominant species is Okoumé (aucoumea klaineana) with 41% followed by Tchitola (Oxystigma oxyphyllum): 17% and Okan (Cylicodiscus gabonensis): 16%. Aiele (Canarium schweinfurthii): 14% and Tali (Erythrophleum ivorense): 13% are the least measured species. Table 2 shows the average values (efective, felling gaps with measurement characteristics) of the main species used by the company.
This table indicates that the largest average area is that of Okoumé (Aucoumea klaineina) with 1196.7m2 and the smallest is that of Aielé (Canarium schweinfurthii) with 222.45m2; the highest average volume was that of Tchitola (Oxystigma oxyphyllum) with 29.92m3 and the smallest with 5.67 m3 is that of Tali (Erythrophleum ivorensis); the average length of the largest ball is that of Tchitola (Oxystigma oxyphyllum) with 15.96m and with 12.02m the Tali (Erythrophleum ivorensis) is the species with the smallest average length of the ball.
The information in the figure above tells us about the damage caused by the felling of the species that were the subject of our study. They are explained by the fact that the species with the largest average size are those with the largest average diameter and a very spread crown. The comparison of the area of the felling gap with that of the tree crown is shown in Table 3. The area of a felling gap depends on its crown. The damage to the stands is enormous when the crown is very tall.
As shown in the table above; the Okoumé (Aucoumea klaineana) causes more damage compared to other species causing an average gap of 1196.7 m² with a crown area of 600.8 m2 followed by Tchitola (Oxystigma oxyphyllum): 324.76m2 which despite its the average area of felling hole is lower than that of Tali (Erythrophleum ivorensis): 351.52m2, it has a larger crown area than the latter, which causes it to cause more damage than this one.
Comes after the Okan (Cylicodiscus gabonensis) with an average crown area of 275.2m2 causing an average gap of 287.75m2, in the end comes the Aiele (Canarium schweinfurthii) which causes him less damage than the others with a gap average of 222.45m2 and an average crown area of 212.35m2. The ratio between the stem and the crown of the tree is a function of diameter, height, species, but also tree crown spread (Figure 4).
The previous figure 4 shows that the percentage of Okoumé (Aucoumea klaineana) seed: 50% and that of its crown (38%) are larger than that of the other species, which makes it have more impact overall caused by its fall.
Many damage is caused by the fall of a tree, the tree falling uprooted, breaks and injures other trees as well as the stems of future. Of the 148 trees felled, we recorded a total of 1270 stems (Table 5) with a diameter greater than or equal to 10 cm having undergone various damage including 112 uprooted stems, 990 broken stems and 168 stems with bark, the data can be found in Table 4 Figure 5 shows the percentage of stem damage caused by falling trees.
This figure shows that 77.95% of the stems are broken, 13.22% are debarked and 8.81% are uprooted during the fall of the trees.

Evaluation of impact during skidding

Skidding is a logging operation that occurs after logging. It causes a visible impact on the forest stand, especially on the stems of the future by creating openings (Figure 6).

The disturbances caused in the forest environment during the opening of the skid trails are generally a function of the frequency of passage of the machines, the type of machines used and the skill of the operators. The results obtained in the skidding are summarized in Table 5 and illustrated in Figure 6.

Table 5 shows us the length, the width of the skid trails and the degraded area. On all the skid trails in the different parks, the maximum length of open slopes is 700 m, while the minimum is 320 m, with an average of 510 m.

The maximum and minimum length of skid trails differ by park, this is due to the fact that not all fleets have the same number of usable feet. The average width of open skid trails is 9.5 m, while the maximum width is 12.5 m and the minimum width is 9.5 m.

All tracks do not have the same width because of the different bulldozers used during the skidding in each parcel. The maximum degraded area is 7749 m2, the minimum area is 3520 m2 and the average of all areas is 5634.5 m2. The parameters that contribute significantly to the increase in skidding damage are: The length and number of tracks within a plot.

Damage to skid trails on the forest stand

In total we have 372 damaged stems including 82 uprooted, 140 broken and 150 wounded. Figure 7 illustrates some stems damaged by the skidding operation.

The nature of the damage to the stems during skidding is shown in Table 6.

This table shows that they are small diameter stems that are more damaged than those of large diameter. These small stems are easily uprooted or broken, while large diameter stems suffer a lot of abrasions (Figure 8).

Figure 8 shows us that the most common damage is breakage and uprooting. Of the 372 trees or shrubs damaged, there are some species that are often protected but suffer damage. These trees are affected by the bulldozer or logs because they are right on the edges of skid trails. In this case, the tracking team at this level did not respect the EFIR rules because it is planned to move the track at least 4 m from the protected or future tree. It should be noted that there are also some that are unnoticed in the eyes of the sorters, and therefore exposed during the actual operation.

Consequences on the environment

Many negative impacts on ecosystems are caused by industrial logging. As an example, we have wood extraction that results in a net loss of biomass, disturbs wildlife, and opens the forest canopy. These impacts, direct or indirect, can be distinguished according to their "avoidable" or "unavoidable" nature (Table 7).

Some impacts such as the opening of forest roads, the felling of trees, the construction of life bases, are inevitable. But the erosion caused by the construction of the various infrastructures can be avoided.

Consequences on the ground

Mechanized and intensified logging operations can cause superficial horizons compaction and qualitative physical soil degradation (Ntoumi, 2013).

Skidding negatively affects the soil from several points of view:

- By indirect impacts (soil compaction, artificialization or degradation of the hydrographic network, disturbance, construction of roads, tracks and work and skidding areas)
- The waterproofing which can cause runoff, erosions. These areas (stagnation of rainwater) can become places of over-population for animals disturbing the regeneration of pioneer species.

Comparison of the results of logging and logging carried out in SICOFOR LEU with EFIR standards (Table 8)

- Skidding

The EFIR standards require that the width of a skid trail be between 3.5 and 4 meters. In our case study, the average width of the tracks is 9.5 m, which is higher than the EFIR standards.

- Slaughter

With regard to slaughter, the EFIR standards allow a harvest rate of 2.5 stems / ha. Our study shows that in the annual base of harvest (AAC 2015), the harvest rate is 1 to 2 stems per ha, which is lower than the EFIR standards.

DISCUSSION OF THE RESULTS

Slaughtering

According to a study conducted by Mampassi (2013), logging and logging are the operations that generate the most direct impacts on the forest ecosystem. According to Sist (1998), slaughter damage directly depends on the number of stems taken per hectare and, generally, the size of the felled tree. This statement is not confirmed in its entirety by the study conducted by (Mirko Méoli, 2005).

The results obtained from our study do not confirm this affirmative sentence as a whole, the quotation from the latter is not an absolute because the variables studied are too relative and could not highlight a relationship between the size the tree felled (variables measured at the trunk level) and the impacts caused by its fall. We confirm our results.

Probably, other variables such as crown shape and size significantly affect the determination of canopy opening by increasing sunshine. This study demonstrates that this is valid.

The majority of felled trees are Okoumé. This is due to the fact that this species is the most abundant in the study area. Moreover, it is the most exploited by SICOFOR. In fact, in 100% of the impact caused by the fall of the tree, the crown causes more damage with respect to the cask (Mampassi, 2013). The damage caused by slaughter depends on the structure of the stand. Our study shows that there are more peeled and / or broken stems with a diameter of less than 50cm.

Our results go hand in hand with a study in East Kalimantan, Indonesia, which shows that the probability of being destroyed is higher for small trees than for large trees and that slaughter mainly causes breakage injuries on trees. trees 30 to 50 cm in diameter (Bertault & Sist, 1995).

The harvest rate of about 1.84 stems / ha results in an area affected by slaughter of about 11.0% in the study area. A study conducted in the Central African Republic (FAO, 2003) is used as a reference, it is presented in Table 9. We can deduce from this table that damage can be variable within a single forest.

It is difficult to significantly limit the impact of logging on the stand (Sist, 1998). To avoid or limit damage to the stems of the future, it is better to practice directional felling, however, this The technique can not reduce overall damage and is not or is very difficult to apply to large trees. To facilitate directional felling and to ensure high safety of the feller, slicing before slaughter is recommended (De Chatelperron G., & al 1986. Cedergen 1996 in Sist 1998).

Skidding:

Two forms of skidding are currently applied:

- The first skidding that is usually done by the bulldozer to listen remote skidding, it consists of storing logs at the intermediate park, usually in the forest to be relayed by the gear tire,
- The second skidding is done by tires, which take the logs at the intermediate yard and deposit them at the roadside storage yard.

Based on our observations in the field, what causes an increase in the degraded area is the fact that the machine operators make off-track tracks. If the driver notices that the tracking on the prospecting map indicates a longer track, then the track takes a shortcut to make a shorter track to save time. To avoid these errors, it is better to review the survey maps.

The skid trail causes the opening of a strip of forest, but unlike the opening of roads, the largest stems are spared. Coverage is poorly achieved over most of the network (Durrieu de Madron et al, 1998). Skidding causes the breaking of small diameter stems, usually between 10 and 20 cm, more rarely stems with a diameter greater than 40 cm (Bertault & Sist 1995). The skidding trails materialized in the field have an average width of 9.5 m; they are above the norm (3.50 - 4 m). This is proof that skid trails do not meet EFIR standards.

An improvement of the skidding method would limit damage to the forest stand, this is demonstrated in this study. When there are a lot of tracks open in a parcel, the damage is also huge. Reducing the number of open tracks in a parcel will limit the damage. Indeed, a planned layout of the track network reduces their length by about 30%.

This reduction results in a saving of time, a better profitability of the machines (for the same number of hours of operation, a bulldozer extracts on average a number of logs 30% higher when the tracks are planned in advance) and especially a reduction in the damage caused to the forest ecosystem (mainly on the soil and the undergrowth) (Mirko Méoli, 2005).

Depending on the frequency of passage of the machine, drawing or not a log, the soil can be deeply disturbed and packed (Durrieu de Madron et al, 1998). After a bad weather, the soils are often very compacted when passing a tank top. It is better to decompact these soils using a plowing tool after the end of logging activities to reduce this impact and to help regenerate the forest.

The results of this study allow us to affirm that in the end, it is possible to limit the damage associated with long shoring operations. First of all, a good establishment of the routes established on GIS for each parcel in the wake of raising the awareness of the operators of machines and encouraging them to a quality work that could considerably limit the impact on the skid trails.

The GOUONGO Forest Exploitation Unit (UFE) is located in the southern part of the Congo and is limited by others (UFE) and located between Komono and Zanaga districts.

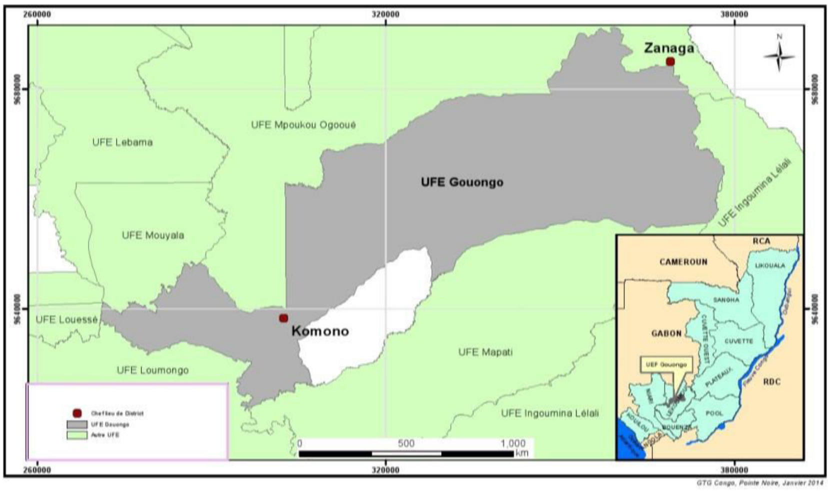

Figure 1: Location of the UFE Gouongo (UFE Gouongo development plan, 2006)

In Congo, a tree before the cut should have a diameter of exploitability admitted by the forest administration. At the time of slaughter, while falling, it tears everything in its path, which is why it creates an important felling hole illustrated in Figure 2.

Figure 2: Hole created by the fall of a tree

When skidding trees are cut down, skidding tractors create breakthroughs in the forest so that the areas impacted in its operations are important, which is why measurements of impacted areas illustrated in Figure 3.

Figure 3: Measuring the width of a skid trail

Figure 4 shows five species of the sample including (Okoumé, Tali, Okan, Tchitola and Aielé) followed by this study. It highlights the ratio of the area impacted by the felled tree that is a function of gasoline, crown and keg.

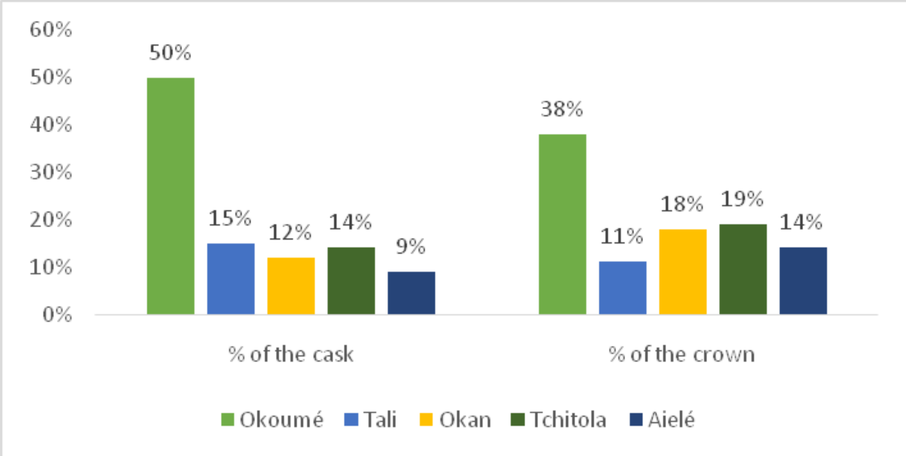

Figure 4: Contribution of cask and crown in impact

Figure 5 shows the type of damage to young stems during the fall of the felled tree. This figure shows that 77.95% of the stems are broken, 13.22% are debarked and 8.81% are uprooted during the fall of the trees.

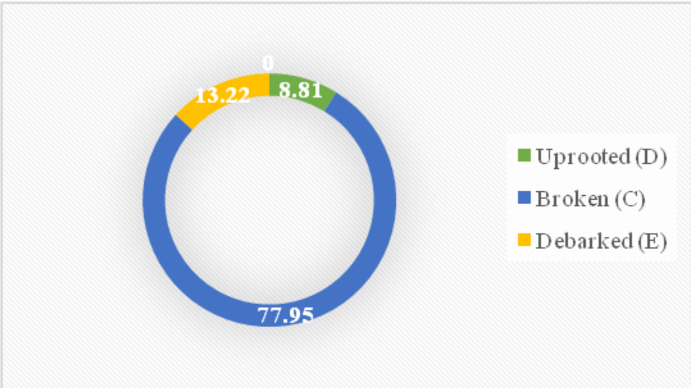

Figure 5: Percentage of stems damaged during slaughter

Skidding causes a visible impact on the soil and the forest stand, especially on the stems of the future by creating openings.

The disturbances caused in the forest environment during the opening of the skid trails are generally a function of the frequency of passage of the machines, the type of machines used and the skill of the operators. The result of opening logging roads and impaction of soils to logging is shown in Figure 6.

Figure 6: Skid way

Figure 7 shows the type of damage caused by the logging operation, especially when the standards of reduced-impact logging are not respected: there is a large number of stems peeled, broken and torn off.

Figure 7: Broken stem and debarked stem during skidding

These small stems are easily uprooted or broken, while large diameter stems suffer a lot of abrasions (Figure 8). It shows that the most common damage is breakage and uprooting.

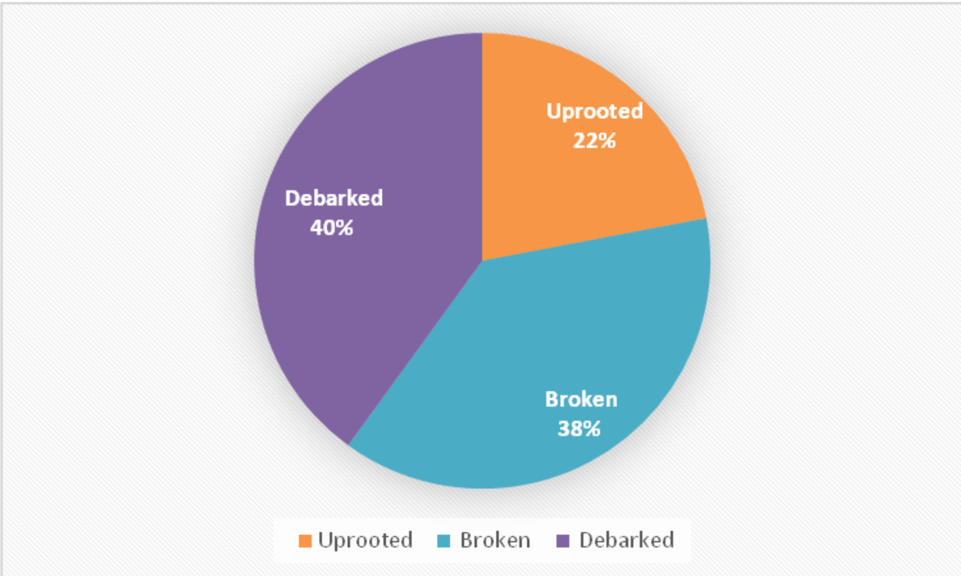

Figure 8: Proportion of stems damaged during skidding

Table 1: Number of trees measured

Species	Scientific names	Number of trees measured
Okoumé	*Aucoumea klaineana*	**60**
Tali	*Erythrophleum ivorense*	**19**
Okan	*Cylicodiscus gabonensis*	**20**
Tchitola	*Oxystigma oxyphyllum*	**24**
Aielé	*Canarium schweinfurthii*	**25**
Total		**148**

Table 2: Mean Values of Key Variables Measured

Species	**Effective**	**Average area of slaughter hole, (m^2)**	**Sum of slaughter hole areas, (m^2)**	**Average cask volume (m^3)**	**Average length of log (m)**
Okoumé *(Aucoumea klaineana)*	60	1196,7	71802	5,86	13,61
Tali *(Erythrophleum ivorensis)*	19	351,42	6677	5,67	12,02
Okan (*Cylicodiscus gabonensis)*	24	287,75	6906	8	15,46
Tchitola (*Oxystigma oxyphyllum)*	25	324,76	8119	29,92	15,96
Aielé (*Canarium schweinfurthii*)	20	222,45	4449	6,48	13,41
Total	**148**	**2383,08**	**97953**	**55,93**	**70,46**

Table 3: Average area of felling gaps/crown

Species	**Average area of felling gap, (m^2)**	**Average crown area, (m^2)**
Okoumé *(Aucoumea klaineana)*	1196,7	600,8
Tali *(Erythrophleum ivorensis)*	351,52	174,36
Okan *(Cylicodiscus gabonensis)*	287,75	275,2
Tchitola *(Oxystigma oxyphyllum)*	324,76	300,28
Aielé *(Canarium schweinfurthii)*	222,45	212,35

Table 4: Number and nature of stem damage by diameter

Class D (cm)	Number of damaged stems			
	Uprooted (D)	Broken (C)	Ecorcated (E)	Total stems damaged
10-30	80	800	100	980
30-50	22	100	28	150
> 50	10	90	40	140
TOTAL	**112**	**990**	**168**	**1270**

Table 5: Variation measured on skid trails

Variable	High	Low	Average	Total
Length of runways, (m)	700	320	510	2980
Width of runways, (m)	12,5	9,5	9,5	67,8
Area of degraded runways, (m^2)	7749	3520	2383,08	33329

Table 6: Number and nature of stem damage

Class D (cm)	Number of damaged stems			
	Uprooted (D)	Broken (C)	Ecorcated (E)	Total stems damaged
oct-30	40	80	90	210
30-50	30	20	25	75
> 50	12	40	35	87
TOTAL	**82**	**140**	**150**	**372**

Table 7: Impact of logging on the environment

Impacts	Direct	Indirect
Inevitable	Decrease in biomass Habitat fragmentation Damage to the residual stand Seed loss	Increase in human population density
Avoidable	Soil erosion and pollution	Increased access to isolated forests and means of transport. Increased deforestation for agriculture. Increased hunting of wildlife as a source of food

(ATIBT, 2006)

Table 8: Summary of results with EFIR standards

- Skidding trails

Average field width (m)	Average EFIR width (m)	Differential between the average width obtained in the field and that of the EFIR standard
9,5	3,5 – 4	5,75

- Slaughter

Number of stems shot per ha on most plots in the field.	Number of stems felled per ha in a plot according to the EFIR (OAB) standard	Difference between the number of stalks cut per ha on most plots in the field and the EFIR standard
1 – 2 stems / ha	2,5 – 3 stems / ha	1-1,5 stems/ ha

Table 9: Estimation of slaughter damage according to the number of stems exploited

Number of stems slaughtered/ha	0,44	0,88	1,4	1,84	2,4	3,3
Affected area (%)	3,79	6,11	9,27	11,0	15,7	20

(FAO, 2003)

CONCLUSION AND OUTLOOK

The objective of this study was to evaluate the impact in felling gaps of the species exploited by SICOFOR, to evaluate the impact on the network of skid trails. Generally, logging causes many disturbances of the ecosystem.
Indeed, the ecological management of natural resources organized on the pressure (local population, private managers ...) is without respect for the rules of the forest management consequently it brings about the change of the forest environment. Today these changes are manifested by climatic changes due to the pollution of the atmosphere, following the suppression of large quantities of plants that absorb certain greenhouse gases (GHG). Normally, in certified concessions, logging is subject to and planned according to the planning rules.
Our study shows that the slaughter levy rate is 1.84 feet per hectare in the 2015 AAC. It was found that if this rate had met or exceeded the EFIR standard of 2.5 feet per hectare, then, the damage to the forest would have resulted in a greater area of impact by felling the trees.
To reduce the impact of falling trees, directional felling is an effective solution. Setting a maximum tree harvest per hectare can also limit the number of gaps. A major tool for reducing the impact of slaughter is the training of slaughterers, because a well-trained slaughterer can also avoid causing more damage by slaughtering the tree.
When skidding, the average width obtained is 9.5 m; which exceeds the EFIR standard (3.5-4m). With a width so large, it is obvious that the damage is enormous because the larger the tracks, the more the damage is numerous. Skidding causes several very negative impacts because of the damage to the ground and the destruction of the forest stand. These impacts can nevertheless be reduced. A good establishment of the routes established on the Geographical Information System (GIS) will prevent several openings of the tracks by the drivers and too tight turns.

REFERENCES

ATIBT. (2006). Reduced Impact Logging (Module 6), 53p

Bertaul. T. J. G. & Sist. P. (1995). Impact of exploitation in natural forest. Tropical Woods and Forests 245: 5 - 20p.

From Chatelperron. G, Commerçon. R. (1986). Exploitation of the Natural Forest Research Facility in the Boukoko and La Lolé Forests in the Central African Republic Project F.A.C. A.R.R.F. C.T.F.T., 58 p.

Durrieu of Madron. L, Fornie. E, and Makok. M. (1998): low-impact logging techniques in Cameroon's dense rainforest. FORAFRI series, document 17. CIRAD-Foret, Montpellier, 28p.

Durrieu of Madron. L, Forni. E, Karsenty. A, Loffeir. E, Pierre. J.M. (1998). The integrated pilot project of Dimako (Cameroon) (1992 - 1996). FORAFRI project, 160p.

FAO. (2003). African Forests: A Vision for 2020. Rome: FAO.91p

FAO. (2003). Regional Code of Low-Impact Logging in the Tropical Rainforests of Central and West Africa. 131p.

FAO, IUCN. (2003). Assessment of training needs in the forest sector in Central Africa. Congo: FAO. 1, 19p

FAO, (2011). Forest situation in the Amazon Basin, Congo Basin and Southeast Asia.80p

FAO. (2017). Impacts of logging on the environment [online] .28 April 2017 at 13h06.Www. Google.Com

Mampassi, J. (2013). Evaluation of the environmental impacts related to the logging of the Ngombé UFA annual harvest (AAC, 2013), Department of Sangha. Master thesis Research in Forest Science and Environment. National School of Agronomy and Forestry: Marien Ngouabi University.36p

Mbete, P. (2014): Assessment of the impact of logging operations on vegetation and wildlife in the Mokabi-Dzanga Forest Management Unit. PhD thesis for the degree of Doctor of Natural Sciences-Agronomy, Specialty: Sustainable Forest Management 217p.

Mbete. P, Ngokaka. C, Akouango. F, Inkamba-Nkulu, Pandi Kaya. F. (2010). Contribution to the Survey of the Food Regime of the Elephant Forest (Loxodonta africana cyclotis) in the Peripheral Zone of the National Park Ogooue Leketi. Pakistan Journal of Nutrition9 (12): 1141-1148.

Memento of the forester. (1978). Ministry of French Cooperation. 894p

Mirko, M. (2005). Impact of exploitation on the forest ecosystem in the concessions of Congolaise Industrielle des Bois (CIB), 214p.

Ntoumi Franck, S. (2013). Evaluation of the environmental impacts of logging on the forest cover of the annual Kabo FMU cut. Master thesis Research: Forest Science and Environment. Institute of Rural Development: Marien Ngouabi University.66p

SICOFOR. (2006). Development plan of the Ngouongo Forest Exploitation Unit (UFE) 215p

Sist, P. (1998). Guidelines for the Application of Low Impact Exploitation Techniques (EFI) in Gabon: Objectives, Principles and Challenges. FORAFRI seminar in Libreville - session 4: exploitation, development, management, 26p.

ISSN : 0976-4550

INTERNATIONAL JOURNAL OF APPLIED BIOLOGY AND PHARMACEUTICAL TECHNOLOGY

Email : ijabpt@gmail.com

Website: www.ijabpt.com