

Effect of Human Activities on the Degradation of Vegetation Cover in the Sudano-Guinean Savannahs of Adamaoua, Cameroon

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Abstract: The high savannahs of Guinea are highly diverse and play an important role in maintaining biodiversity. However, they are periodically subjected to various pressures that sometimes have a negative impact on the productivity of these ecosystems. The aim of this study was to assess the impact of logging and bush fires on the regeneration dynamics of plant species in the high savannahs of Adamaoua, Cameroon. To this end, 18 square plots, each measuring 10 metres on a side, were delimited in both a shrub and tree savannah, following a randomised block experimental set-up with the different anthropogenic actions applied as treatments (logging without fire, logging with fire and control). During the two years of experimentation, the rate of erosion and biological degradation were assessed by simple observation, as well as some anthropisation indices. The results showed that 100% of the sites where wood was cut without fire (CSF) and cut with fire (CAF) had a flat surface in the tree savannas, unlike the shrub savannas where only the CAF and the control site (T) were all 66.67% flat. In the shrub savannah, zero erosion had the same rate (66.67%) for the three different treatments. However, it was 100% for the CSF treatments, 66.67% for the control sites and 33.33% for the CAF sites in the shrub savannas. The fine structure is represented in all treatments; it is 100% in the CAF treed savannah treatments and 66.67% in the CSF shrub and tree savannah treatments. Ground cover by vegetation is very high, at 100% in the treed savannah, 66.67% in the CSF and 33.33% in the CAF and T treatments in the shrub savannah. Regardless of the type of savannah, grazing is the most common activity, with a rate of 66.67%. The presence of termite mounds (33.33%), anthills (33.33%) and wood cuttings (33.33%) is moderately represented. The rate of soil degradation by livestock is 66.67% at the CSF and CAF sites, but 100% at the T site. In the wooded savannah, this rate is 100% in the CSF and CAF sites, but T is only impacted by livestock at a rate of 66.67%. There has been a remarkable increase in the area of shrub savannah (129411 ha), and a 14.56% reduction in the area of gallery forests between 2007 and 2017.

Keywords: Anthropogenic Actions, Degradation, Sudano-Guinean Savannahs, Adamawa, Cameroon

1. Introduction

The vegetation of sub-Saharan Africa in general and that of Cameroon in particular is faced with deforestation, which

manifests itself in the depletion of natural resources due to the unpredictable increase in population [2]. The rural environment has always served as a place of production (provisioning), refuge, recreation and leisure for the

neighbouring towns. Current population growth, estimated at 3.5% in the Sahelian zone [7], is leading to intense exploitation, which in turn is causing ecological imbalances (disappearance of wildlife, reduction in grazing and vegetation, soil exhaustion) that are often irreversible. The old systems for exploiting and managing natural resources have therefore become obsolete in the face of growing demand for food, medicines, firewood and the introduction of new crops. This anthropogenic pressure on plant cover is responsible for soil degradation and climate change [32]. This is leading to an increase in arable land [1], the retreat of bush, a reduction in fallow time [14] and the accelerated destruction of plant cover [4, 41]. Indeed, the rate of degradation of these forests and the threat of ecological extinction of the resources in which they abound are at the heart of international concerns about sustainable management [13].

The main cause of deforestation is the expansion of agricultural activities. Tchobsala [36] has shown that logging is at the root of the accelerated degradation of the plant resources available in the peri-urban savannahs of Ngaoundéré. Savannahs are fragile ecosystems based on the coexistence of a herbaceous layer and a woody layer. They are dynamic systems whose evolution depends on the intensity of environmental factors (logging, drought, fire, livestock and agriculture) [7]. However, these areas are undergoing a reduction in woodland cover as a result of the massive increase in the area sown to crops, a marked intensification in the harvesting of gathering products, intensive and uncontrolled cutting of wood and increased pressure on pastoral resources. This results in a decline in plant cover [19], environmental degradation and lower yields, hence the need for sustainable management [5]. In addition, several authors believe that factors such as overpopulation, agriculture and timber exploitation are at the root of the transformation and degradation of the Guinean savannas [35, 40, 29, 38].

On the other hand, wood is the main source of domestic energy in the Adamaoua region (90% of the population use firewood) [36]. It has thus been shown that in this part of the country, the continuing regression of the forest is due to the combined effects of logging, bush fires and overgrazing [36]. Numerous studies have shown that most plant formations are maintained in their current state by fire and are therefore considered to be non-climatic [39, 18, 24]. This situation, coupled with climate change in recent years, has worsened and led to more extreme poverty among rural populations [15]. Furthermore, the role of bushfires in the dynamics of regeneration of savannah vegetation has not yet been well established, especially as regards the way in which they are used. Bushfires can cause disruption to the biogeochemical cycles of vegetation. This can have negative and/or positive impacts on the yield of natural ecosystems. On the basis of this observation, a study was carried out on the sustainable use and management of plant cover in these ecosystems. A study of the correlation between "cutting, fire and vegetation regeneration dynamics" suggests that, although fire is

recognised as a factor in explaining savannah vegetation dynamics, its importance and role are still not clearly defined [24].

Despite the importance of regeneration in the vegetation dynamics of environmentally stressed savannas, very few studies have been carried out on the factors influencing vegetation regeneration in savannas, particularly in the Sudano-Guinean savannas of Adamaoua. Ntoupka [30] studied the dynamics of a wooded savannah in the Sudano-Sahelian zone of northern Cameroon under the combined effects of grazing, fire and wood cutting; Ndam [28] studied tree regeneration, vegetation dynamics and the maintenance of biodiversity in Mount Cameroon; Fayé [16] in Senegal studied the dynamics of natural regeneration of vegetation and Tchobsala [36] studied the influence of logging on vegetation dynamics in the peri-urban area of Ngaoundéré. The general objective of this work is to assess the impact of the woodcutting and bushfire complex on the regeneration dynamics of the vegetation cover of the high wet savannahs of Adamaoua, Cameroon. Specifically, the aim is to determine the influence of logging and bush fires on the biophysical environment of the shrub and tree savannahs of the Ngaoundéré savannahs and to characterise changes in the vegetation cover of these savannahs over a decade.

2. Methodology

2.1. Presentation and Geographical Location of the Study Area

The study area is in transition between the Sudano-Sahelian north and the forested south. Adamaoua is known as Cameroon's "water tower", as many of the country's rivers have their source in this region. The region's rivers flow into three different basins: the River Niger, Lake Chad and the Atlantic Ocean. It is one of the most geologically diverse regions in Cameroon [3]. It has a rich hydrography, several types of soil and rock, a varied climate and diverse vegetation.

Located in Central Africa and in the centre of Cameroon, Adamaoua is one of Cameroon's most important cattle-breeding areas [37]. It is located between latitude 7° 26' 16" North and longitude 13° 33' 34" East and occupies virtually the centre of Cameroon. The Adamaoua region covers around 62,000 km² [23], making it Cameroon's main cattle breeding area. It is located in the northern part of Cameroon. Adamaoua borders the Central African Republic to the east and Nigeria to the west. This mountainous area marks the border between the forested Cameroon of the south and the savannahs of the north. This creates the conditions for an original Sudano-Guinean climate characterised by high rainfall, fluctuating between 1,400 and 2,000 mm per year, low and not very variable temperatures (average annual temperature of 23°C), and a strong contrast between two seasons [9] (Figure 1).

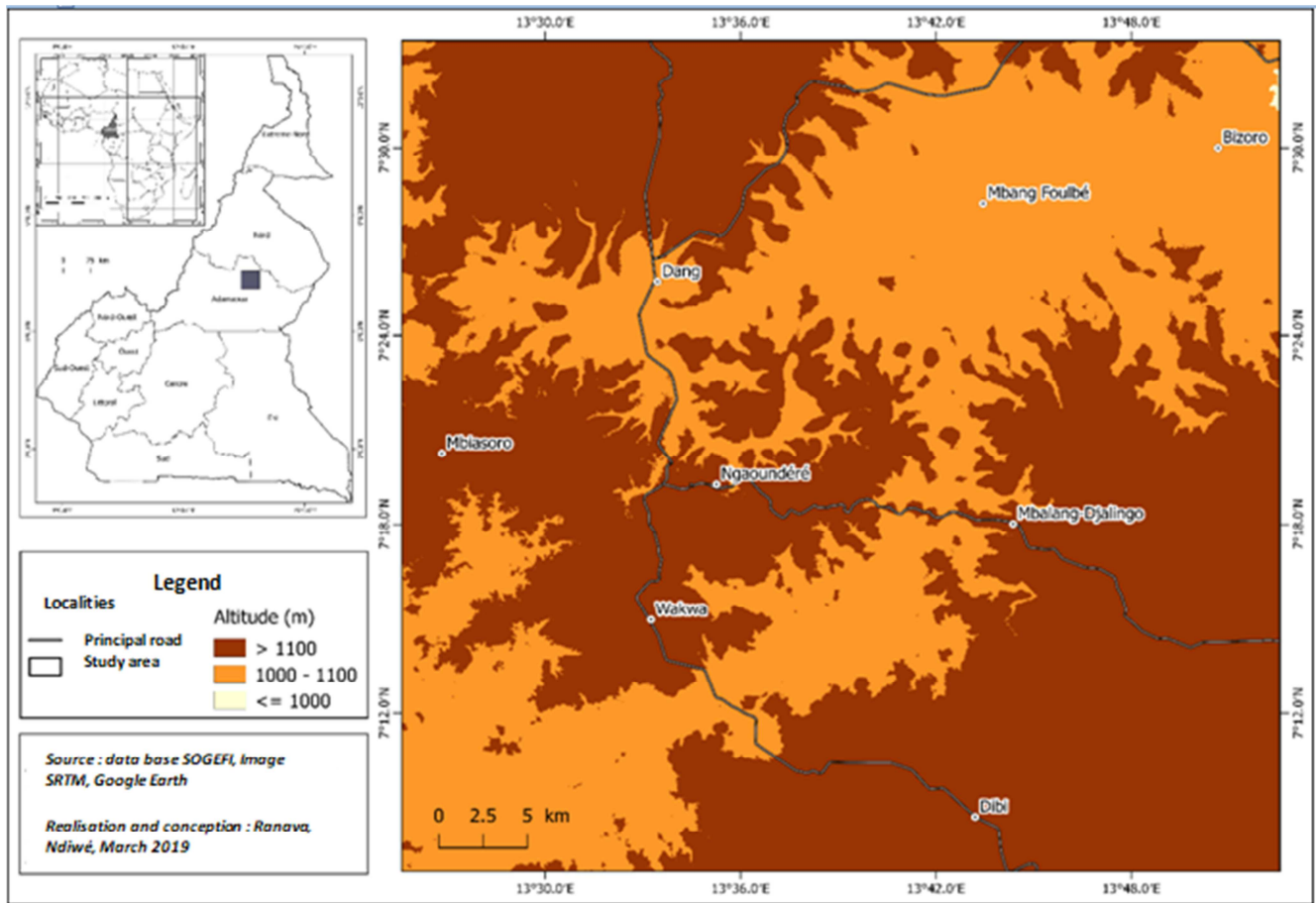


Figure 1. Location of the study area.

Table 1. Rainfall and temperature in Adamaoua (Ngaoundéré) from 2007 to 2017.

Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Precipitations (mm)	1455	1456	1458	1560	1580	1647	1669	1642	1646	1647	1645
Temperatures (°C)	28.09	29	28.25	28.67	29.08	28	30.25	31.08	31.08	31.16	29.83

Source: ASECNA, Ngaoundéré, 2007 to 2017

2.2. Choice of Study Sites

The choice of experimental sites focused essentially on the two types of vegetation found in the Adamaoua region (shrub savannah and tree savannah) and spread over the five (5) departments that make up the administrative subdivision of this region: Djerem, Faro and Deo, Mayo-Banyo, Mbere and Vina. As a result, the site location focused on the floristic homogeneity of the savannas, their distance from arable plots, their distance from the animal corridor and on forestry operations.

2.3. Experimental Set-Up and Monitoring

The experimental set-up consisted of 18 square plots, 10 m on each side, separated by firebreaks 10 m wide and extending in the direction of the slope (if any). Treatments such as cut wood with fire (CWF), cut wood without fire (CWF) and a control (no treatment) were applied in a

completely randomised block design.

In each site, in addition to the control site, we set controlled fires in both the tree and shrub savannas. For comparison purposes, in both the shrub and tree savannas, we had three felling sites without fire, three felling sites with fire and three control sites (Table 2).

After the timber had been cut in the two types of savannah studied, the first step was to make observations of the biophysical environment of the various study sites over a period of 12 months (period of free and unprotected regeneration) and then to capture satellite images of our study area at specific periods thereafter.

The observations consisted of surveys of the various sites. Elements such as the geomorphology of the site, traces of erosion at the sites, the texture of the soil at the various sites, the coverage of the soil by vegetation, the presence of evidence of biological degradation and grazing at the sites, and some signs of anthropisation were the focus of these observations.

Landsat 7 and 8 software were used to highlight and capture satellite images from 2007 and 2017, in order to

make comparisons relating to vegetation as a function of the years in our different study sites.

Table 2. Experimental design.

	Section without fire (CSF)			Fired section (CAF)			Control (T)		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Wooded savannahs									
Shrubby savannahs									

2.4. Data Processing and Analysis

The data were processed using Excel spreadsheets. The various analyses were carried out using Statgraphic plus 17.1.08 software, which was used to compare averages between sites, and Landsat 7 and 8 (2007 and 2017) for digital processing of satellite images and mapping. A set of operations was applied for the diachronic analysis: The operation consists of making radiometric corrections and extracting the Spot image, and the study window centred on the area. Geometric corrections were carried out using Landsat 8 as the reference image. Colour compositions were also produced. The image was then enhanced to facilitate visual interpretation and the identification of land-use classes. In support of the initial results (coloured compositions). The Normalized Difference Vegetation Index, enabled better discrimination of land use classes by reducing confusion [22].

3. Results

3.1. Influence of Logging and Fire on Biophysical Environments

3.1.1. Soil Geomorphology

Overall, more than 72% of the sites have a flat physiognomy (Figure 2). In the wooded savannah, the sites where there was cutting without fire (CSF) and those where there was cutting with fire (CAF) are completely flat (100%), as is the control site (T) 66.67%. However, in the shrub savannah, the sites where there has been cutting with fire (CAF) and the control site (T) are all practically 66.67% flat, and the site where there has been cutting without fire (CSF) is 33.33% flat. Less than 30% of the land is flooded, on the upper slope, mid-slope and lower slope.

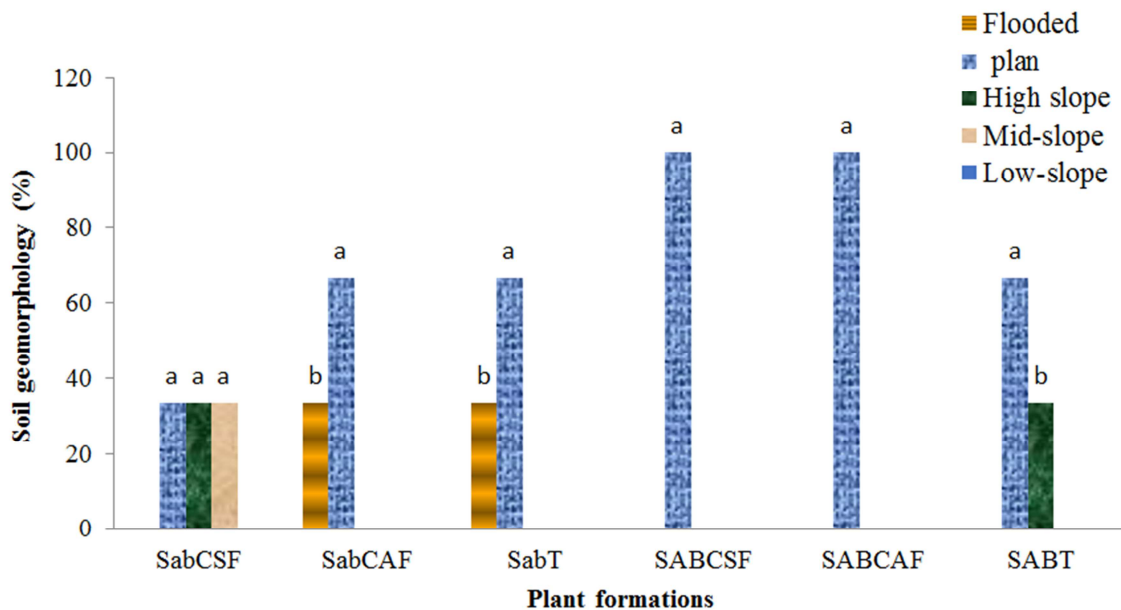


Figure 2. Soil geomorphology.

SabCSF = shrub savannah cut without fire; SabCAF = shrub savannah cut with fire; SabT = shrub savannah control; SABCSF = shrub savannah cut without fire; SABCAF = shrub savannah cut with fire; SABT = shrub savannah control.

3.1.2. Soil Erosion

Figure 3 shows the erosion rate according to the different plant formations. In the shrub savannah, zero erosion has the same rate (66.67%) in the three different sites (CSF, CAF and T). Rainwater sheet erosion was 33.33% in the sites that had been logged without fire (CSF) and the control (T). Only

the site that had been logged with fire (CAF) showed gully erosion at a rate of 33.33%. In the wooded savannah, zero erosion was found at a rate of 100% in the site exposed to clear-cutting (CSF), 66.67% in the control (T) and 33.33% in the site exposed to clear-cutting with fire (CAF). However, rainwater sheet erosion was 66.67% in the site that had been cut with fire (CAF), and 33.33% in the control site (T).

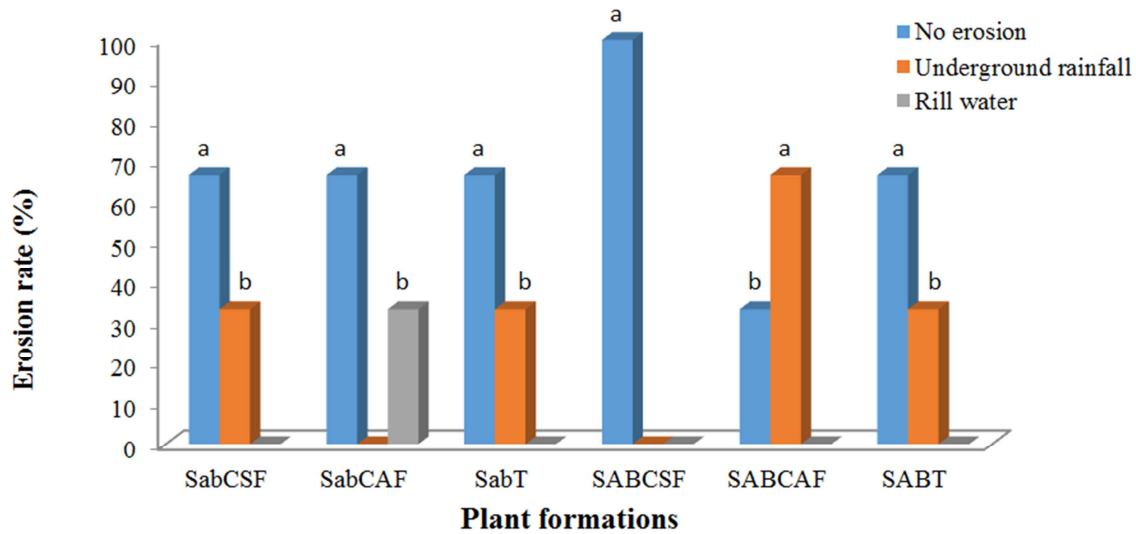


Figure 3. Soil erosion.

SabCSF = shrub savannah cut without fire; SabCAF = shrub savannah cut with fire; SabT = shrub savannah control; SABCSF = shrub savannah cut without fire; SABCAF = shrub savannah cut with fire; SABT = shrub savannah control.

3.1.3. Soil Texture

Figure 4 shows the different soil textures. The fine structure is represented in all the sites, but it is at a rate of 100% in wooded savannah that has been cut with bushfire (SABCAF); 66.67% in wooded savannah that has been logged without fire (SABCSF) and in shrub savannah that has been exposed to logging without fire (SabCSF), 33.33% in shrub savannah exposed to logging with fire (SabCAF),

the control in shrub savannah (SabT) and the control in wooded savannah (SABT). Next comes the very fine structure, represented at 33.33% in all sites except in the wooded savannah that has been logged without fire (SABCAF), which has a zero value. The medium structure has a rate of 33.33% in the two control sites of the two plant formations, while the gravelly structure is only represented in the shrub savannah that has been cut with fire (33.33%).

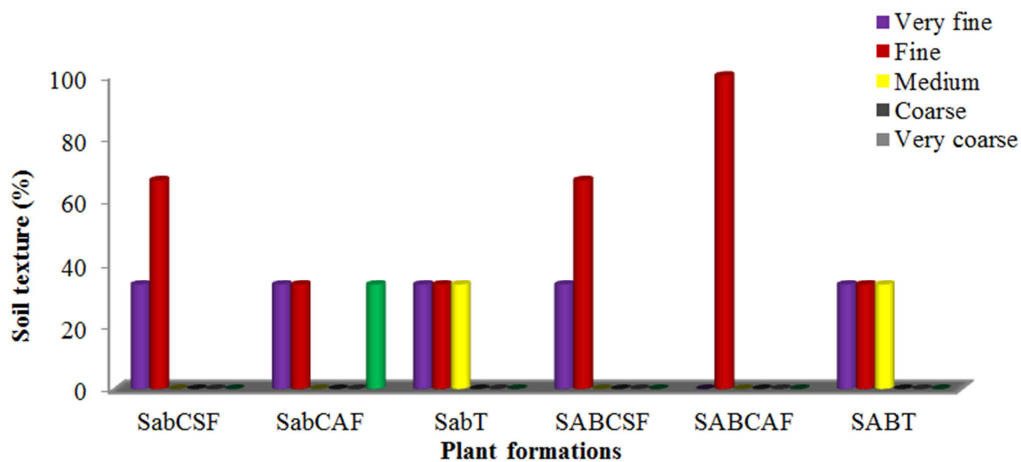


Figure 4. Soil texture at the sites.

SabCSF = shrub savannah cut without fire; SabCAF = shrub savannah cut with fire; SabT = shrub savannah control; SABCSF = shrub savannah cut without fire; SABCAF = shrub savannah cut with fire; SABT = shrub savannah control. Very fine = clayey-silty; Fine = clayey-sandy, silty-clayey; Medium = silty, fine silty-sandy; Coarse = silty-sandy or sandy-sandy; Very coarse = sandy; Gravelly = gravelly.

3.1.4. Soil Cover by Vegetation in the Rainy Season

Soil cover by vegetation as shown in Figure 5 is very high (100%) in all the tree savannah sites. In the shrub savannah, it was very high (66.67%) in the site that had been cut without fire (CSF) and in the control (T) at a rate of 33.33%.

It is highest in the shrub savannah that has been logged with fire (66.67%), then in the shrub savannah that has been logged without fire (CSF) (33.33%), and in the control (33.33%). On the other hand, cover is only present in two sites, namely in the shrub savannah that has been cut with fire and in the control for the same value (33.33%).

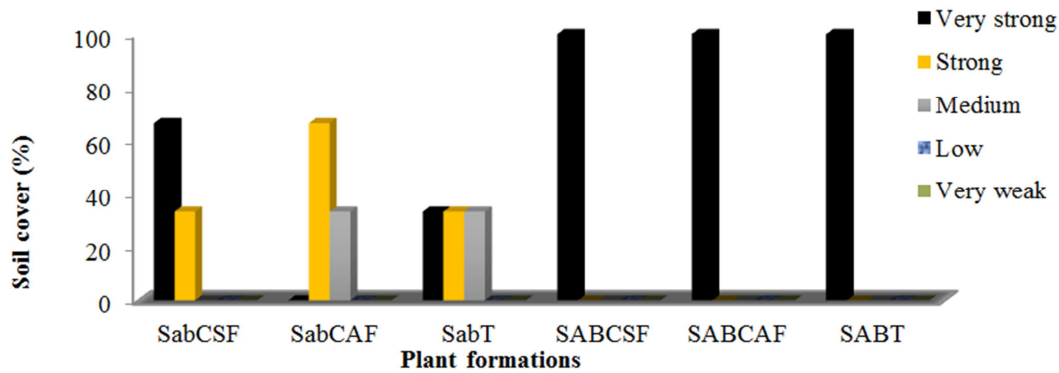


Figure 5. Rate of vegetation cover of sites.

SabCSF = shrub savannah cut without fire; SabCAF = shrub savannah cut with fire; SabT = shrub savannah control; SABCSF = shrub savannah cut without fire; SABCAF = shrub savannah cut with fire; SABT = shrub savannah control.

3.1.5. Traces of Biological Activities on the Sites

Traces of biological activity at the sites are shown in Figure 6. Regardless of the type of savannah, grazing is the most common activity with a rate of 66.67%. The presence of termite mounds (33.33%), anthills (33.33%), wood cuttings (33.33%) etc. is moderately represented.

In the shrub savannah, the most common activities are earthworms (33.33%), ants (33.33%), livestock (33.33%) and

logging by humans (33.33%). In the wooded savannah, grazing by livestock is more represented (66.67%), followed by all the other activities (33.33%), in particular wood cutting, signs of ant hills, termite mounds and earthworms. Overall, traces of biological activity are more numerous in the shrub savannah sites, with the majority showing traces of grazing (66.67%).

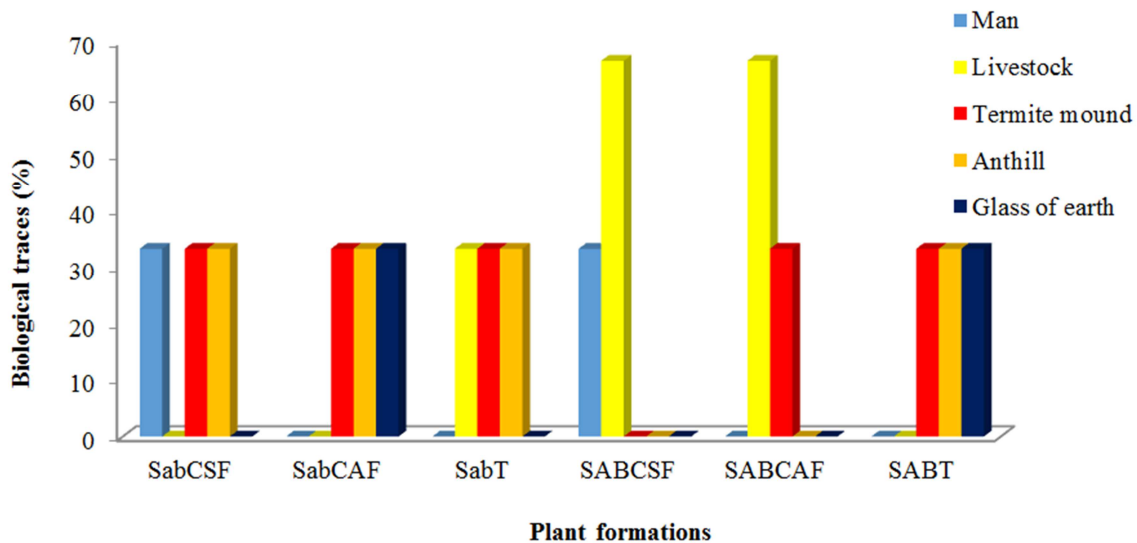


Figure 6. Traces of biological activity.

SabCSF = shrub savannah cut without fire; SabCAF = shrub savannah cut with fire; SabT = shrub savannah control; SABCSF = shrub savannah cut without fire; SABCAF = shrub savannah cut with fire; SABT = shrub savannah control.

3.1.6. Degradation of Sites by Grazing

Site degradation by livestock is shown in Figure 7. In the shrub savannah, this rate was 66.67%, particularly in the site that had been subjected to cutting without fire and the site that had been subjected to cutting with fire, but it was 100%

in the control site (T). In the wooded savannah, this rate is 100% in the sites having been subjected to felling without fire and with fire, but the control (T) on the other hand is just impacted by livestock farming at a rate of 66.67%.

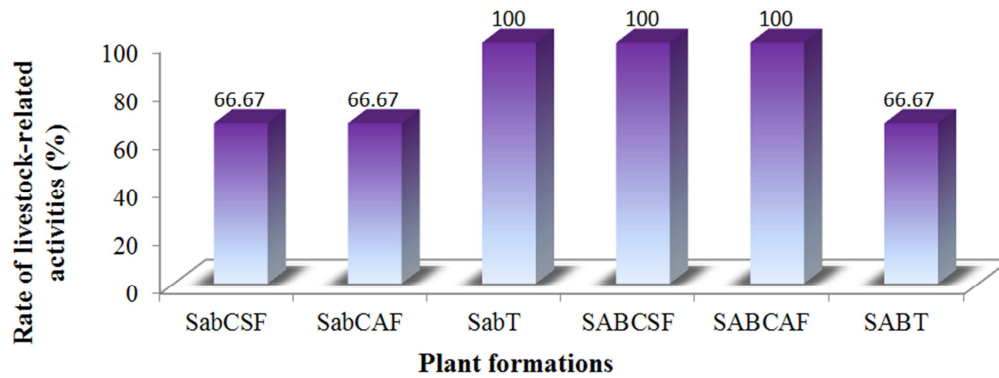


Figure 7. Degradation of sites by grazing.

SabCSF = shrub savannah cut without fire; SabCAF = shrub savannah cut with fire; SabT = shrub savannah control; SABCSF = shrub savannah cut without fire; SABCAF = shrub savannah cut with fire; SABT = shrub savannah control.

3.1.7. Indices of Anthropisation of Ligneous Plants

Several signs of activity on woody plants in the savannah provide information and details on the pressures to which the vegetation is subjected, such as wood cutting, pruning, trimming and barking. These are the various indicators or signs shown in Figure 8 below. In the shrub savannah, the majority of wood cuttings were 100% in sites that had been exposed to felling without fire, and 66.67% in sites that had been exposed to felling with fire. Next comes pruning in the control site (66.67%), followed by pruning and debarking at

33.33%, respectively in the sites that were exposed to cutting with fire and in the control. In the wooded savannah, pruning was practised at all sites, with 66.67% at sites that had been exposed to cutting with fire and 33.33% at sites that had been exposed to cutting with fire and the control. Pruning was present at 33.33% in sites that had been exposed to cutting with fire and in the control; grazing was present at 33.33% in sites that had been exposed to cutting without fire and in the control at the end.

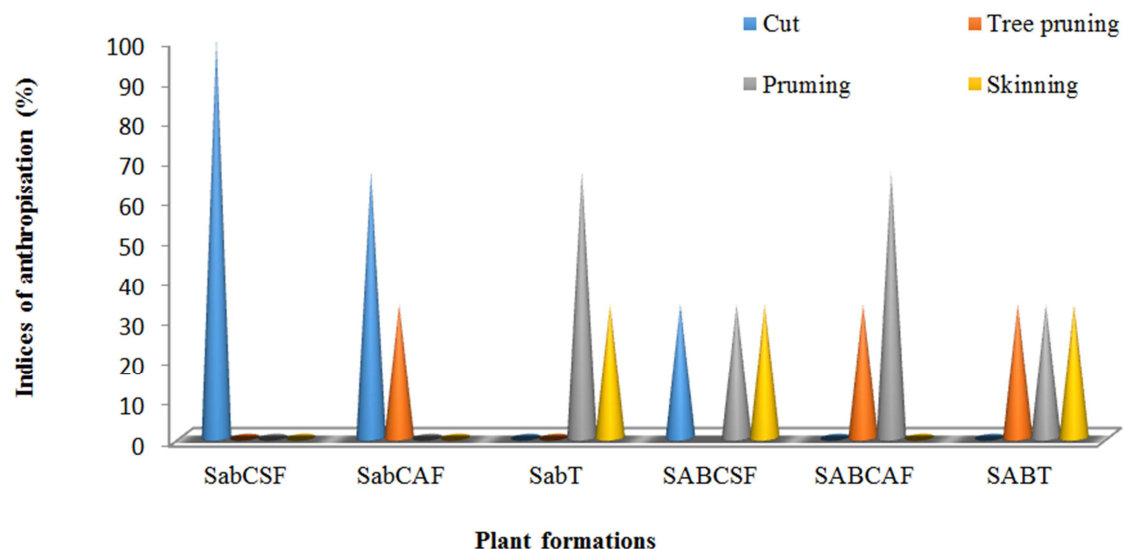


Figure 8. Anthropisation index for ligneous species.

SabCSF = shrub savannah cut without fire; SabCAF = shrub savannah cut with fire; SabT = shrub savannah control; SABCSF = shrub savannah cut without fire; SABCAF = shrub savannah cut with fire; SABT = shrub savannah control.

3.2. Changes in Vegetation Using Satellite Images (Landsat 7 and 8) from 2007 to 2017

3.2.1. Characterisation of Vegetation Types

The study area comprises 5 types of land use and vegetation formations.

1. Gallery forest: found along the watercourse and its

tributaries. It remains blue all year round;

2. Tree savannah: open canopy, individuals can reach 3-10 m in height;

3. Shrub savannah: composed of shrubs such as: *Annona senegalensis*, *Entada* sp, *Hymenocardia acida*, *Sarcocephalus latifolia*, *Parkia* sp, *Piliostigma* sp... individuals can vary between 0-2 m;

4. Grassy savannah: has a sparse shrub layer with a herbaceous carpet;
5. Buildings and bare ground: includes housing, school, road, sports and administrative infrastructure, etc.
6. Field: plot of land reserved for cultivation;
7. Water: rivers, lakes, etc.

3.2.2. Land Use Between 2007 and 2017

Table 3 summarises the areas of different landscape features obtained using Landsat image processing from 2007 to 2017. There is a significant difference between the different values in years of land cover. In 2007, built-up/undeveloped land occupied an area of 4758.9 ha (1.84%). In 2017, however, they occupied 7261.3 ha, representing 2.81%. In 2007 the fields covered 24608.2 ha (9.51%) and in 2017 the area increased to 30034.1 ha (11.61%), i.e. an

increase of 5425.9 ha. In the forest gallery the area was 43173 ha with 16.69% of the total area in 2007 and 5513.6 ha (2.13%) in 2017.

The area of wooded savannah occupied 72803.5 ha in 2007 and 62362.8 ha in 2017, with 28.14% and 24.10% respectively. This represents a decrease of 10440.7 ha or 4.04% in 10 years. In 2007, shrub savannah represented 100274.2 ha, as shown in the satellite image, i.e. 38.76% of the vegetation. We note that in 2017, shrub savannah occupies 129411 ha. This represents 50.02%, an increase of 29136.8 ha or 11.26% of the total area. Grassland formation occupied an area of 12056.5 ha in 2007, representing 4.66%. On the other hand, in 2017 on the same image, the formation occupies 23447 ha with 9.06. The surface area of the water body was 1050.2 ha in 2007, with 0.41%, and 694.7 ha with 0.27% in 2017.

Table 3. Land use between 2007 and 2017.

Theme	Land use 2007 (ha)	%	Land use 2017 (ha)	%	Differences
Built-up and bare soil	4758.9a	(1.84)	7261.3b	(2.81)	-2502.4
Field	24608.2 a	(9.51)	30034.1b	(11.61)	-5425.9
Gallery forest	43173 a	(16.69)	5513.6 b	(2.13)	35911.7
Wooded savannah	72803.5 b	(28.14)	62362.8 a	(24.10)	10440.7
Shrubby savannah	100274.2 a	(38.76)	129411 b	(50.02)	-29136.8
Grassland	12056.5 a	(4.66)	23447 b	(9.06)	-11390.5
Water body	1050.2 b	(0.41)	694.7 a	(0.27)	355.5
Total	258724.4	100.00	258724.4	100.00	

3.2.3. Change in Area Occupied in 2007 and 2017

The variation in occupied area between the study years is presented in Figure 9. The analysis of variance reveals a significant difference ($P < 0.05$) between the areas of land occupation in the two study years according to the types of occupation. Overall, of all the land cover types, it is the shrub savannah area that increases as the years go by. In 2007, shrub savannah had the largest surface area (100274.2 ha), followed by wooded savannah (72803.5 ha), gallery forest

(43173 ha), cropland (24608.2 ha), grassy savannah (12056.5 ha), built-up/bare ground (4758.9 ha) and finally watercourses (1050.2 ha). In 2017, there was an increase in the area of shrub savannah (129411 ha), followed by cropland (30034.1 ha), grassy savannah (23447 ha) and built/bare ground (7261.3 ha), and a decrease in watercourses (694.7 ha), forest gallery (5513.6 ha) and shrub savannah (62362.8 ha).

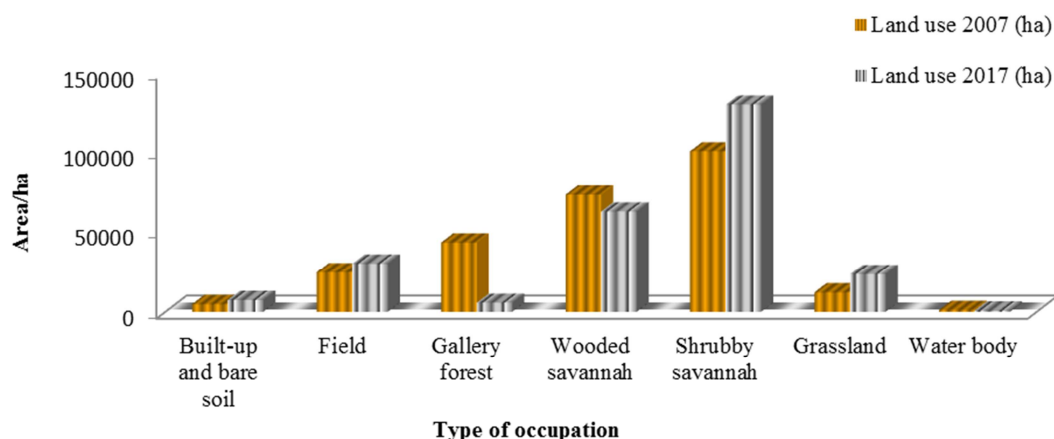


Figure 9. Increase or decrease in surface area occupied.

3.2.4. Changes in Degradation and Land Use in 2007 and 2017

Figure 10 shows the vegetation in the study area in 2007

(Figure 10A) and in 2017 (Figure 10B). Taking the 2007 vegetation as a reference, we can see that the vegetation is fairly well represented, with wooded savannahs. However, 10

years later (2017), the vegetation is changing in a regressive manner, with a reduction in the space occupied by wooded savannah. The space occupied by gallery forests is also gradually being reduced over the study period. There are many possible explanations for this dynamic (Figure 10B).

Diachronic analysis enables us to better appreciate the dynamics of plant cover occupation and the evolution of degradation over time for participatory and quantifiable management.

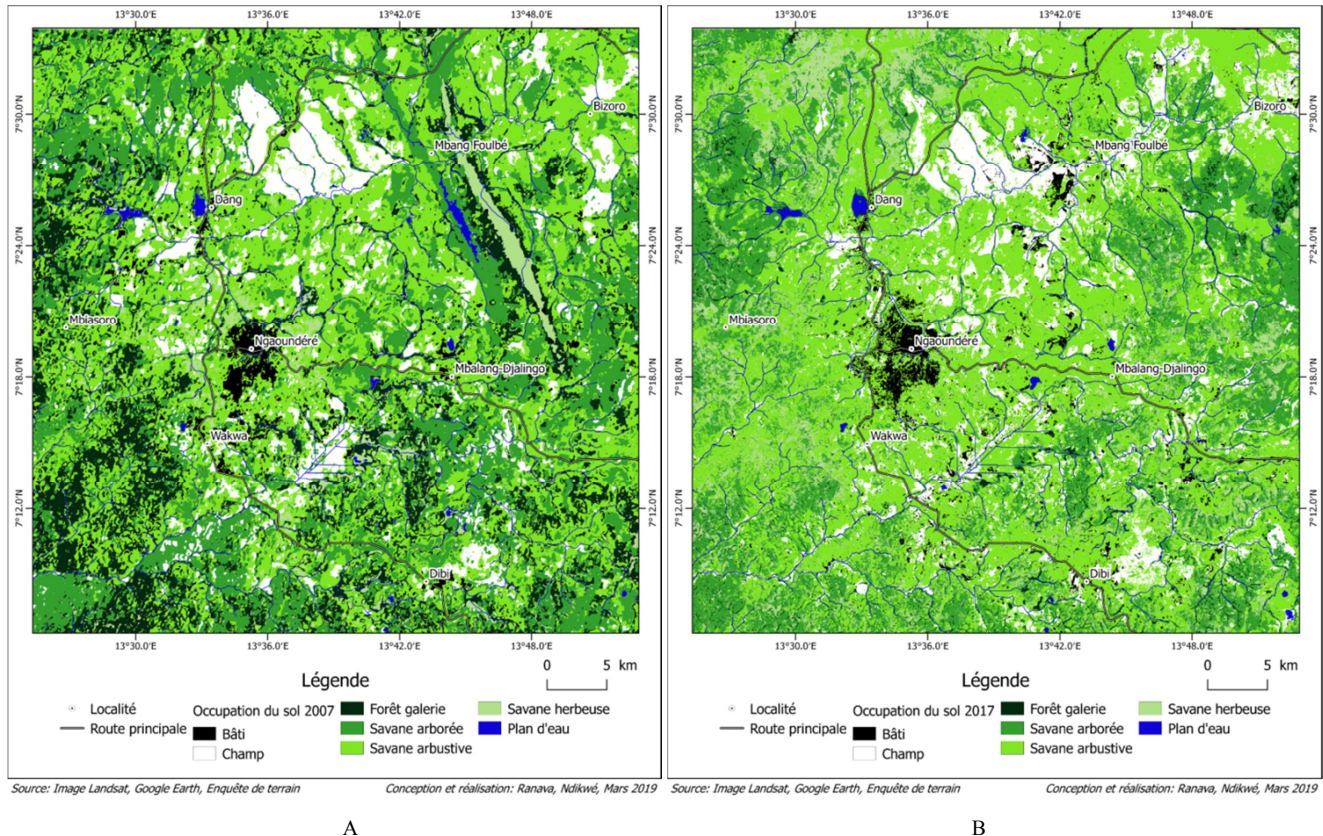


Figure 10. Land use in the study area (2007-2017).

4. Discussion

4.1. Geomorphology, Erosion and Soil Texture

The geomorphology of the soil shows that the terrain is generally flat, sometimes slightly sloping. The analysis of variance shows that there is no significant difference between the plant formations compared with the flooded, flat, high-slope, mid-slope and low-slope sites ($P = 0.99$). These results corroborate those of Boulaud A. L. who conducted a study on family farming in Cameroon, making a comparative analysis between forest and savannah [8].

As far as erosion is concern, although statistical analysis shows that there is a significant difference between the treatments within the different sites. Zero erosion is much more dominant because of the high rate of soil cover by vegetation. These results corroborate those of [6, 11] who observed the same types of erosion on the Wakwa pasture and in the forest galleries in the same region. In the same vein, [34] reported soil exposure to erosion due to livestock trampling, wood cutting and repeated bush fires. As Hamado s. et al. [21] also point in the same direction, indicating that

overgrazing and trampling by animals contribute to soil degradation by destroying vegetation and exposing soils to the effects of erosion.

In terms of soil texture, although the analysis of variance shows that there is no significant difference between the plant formations in terms of soil texture ($P > 0.05$), there is also a significant difference between the different textures within each formation. The soils are predominantly sandy-clay. The conclusion drawn from this analysis is that the textures encountered are multiple and are due to environmental conditions. These results are in line with those of [8], who observed that soil texture varies depending on the zone, from sandy soils to black soils rich in organic matter. [26] also show the advanced state of degradation of hardened soils in the Sahelian zone of the Far North of Cameroon.

4.2. Soil Cover by Vegetation in the Rainy Season and Biological Activities

The analysis of variance shows that there is a significant difference between types of cover in the shrub savannah ($P < 0.05$) but no significant difference between types of cover in the tree savannah ($P > 0.05$). It is important to note that, in the rainy season, vegetation is generally abundant in the Sudano-

Guinean savannahs. This generally results in total or partial ground cover. Very high ground cover and high ground cover are due to the abundance of woody and herbaceous vegetation, especially in tree savannas. Trees and shrubs are dominant in the latter, whereas in the shrub savannah herbaceous plants are more abundant, followed by shrubs. Along the same lines as the results obtained in this study, [12] states that total ground cover by vegetation is not confirmed and that environmental growing conditions sometimes constitute a limiting element or factor for vegetation. Generally speaking, there is no significant difference in the traces of biological activity between the two savannas, although there are several biological components active in the two types of savannas.

4.3. Degradation of Sites by Grazing

Taken in a particular way, the phenomenon of grazing is much higher in the study area due to the fact that Adamaoua is the area par excellence for livestock (cattle) in Cameroon [40] and causes an enormous effect of extensive degradation of the plant cover [25]. Many authors have demonstrated the influence or impact of livestock on vegetation degradation. In particular, the work of [34], which is similar to the observations made in our case, reveals that the regular passage of livestock is materialised by trampling and the presence of dung. Similarly, [20] shows that the influence of large herbivores on tree regeneration is slowed down in some places and even stopped in others because of trampling (41.34%) in the Sudano-Sahelian zone of Cameroon. As well as [27] refer to the presence of grazing activities in the savannahs of Ngaoundéré. To obtain precise information on the state of degradation of our sites, it was necessary to calculate anthropisation indices.

4.4. Anthropisation Indices for Ligneous Species

The analysis of variance shows that there is no statistically significant difference in the degree of anthropisation of species in their environment ($P = 1.00$). Pruning and trimming are mainly carried out by herders to feed their livestock. [31] has shown that pastoralists in dry tropical zones use pruning to increase the availability of fodder at the end of the dry season and in the rainy season. However, the bark from woody plants is used to make a decoction to combat certain diseases (traditional medicine). This is how the IPCC (2007) shows that plant formations that are anthropised suffer a reduction in the diameters of the thicket and, consequently, the land area.

4.5. Changes in Vegetation Based on Satellite Images (Landsat. 7 and 8) from 2007 to 2017

4.5.1. Characterisation and Land Use and Differences Between 2007 and 2017

This study highlights several types of vegetation. Overall, there was an increase of 2502.4 ha in 2017 due to population growth, the increase in the number of built-up areas, and the creation of roads and infrastructure. The results obtained here

are similar to those obtained by [10] in the Mbam et Djerem National Park (Cameroon) on the dynamics of savannah vegetation in relation to bushfire use. Bare ground was 65321.32 ha in 2000 and 1756.99 ha in 2015. This can also be explained by the trampling of animals in the study area due to overgrazing.

This change over the 10-year period is due to the fact that animals need to move the soil in order to feed themselves. In the same vein, [33] estimates that every year the area of farmland increases in response to the growing demand for food and the revolution in cash crops. The gallery forests are not spared by these activities, which degrade the vegetation.

There has been a 14.56% reduction in gallery forest area in 10 years due to market gardening along watercourses on the Adamaoua high plateau. This decline can be explained by the fact that off-season crops are grown along rivers.

This downgrading of the wooded savannah is due to the recurrent practice of wood cutting, bush fires and abusive exploitation, leading to a change in the physiognomy of the vegetation from trees to shrubs. These results differ from those of [20], who showed that in the wooded savannah, the area has increased in 30 years, which is a longer interval, because it is protected by the government and certain organisations.

The extension of the shrub savannah can be interpreted by the degradation of the tree savannah, which is causing it to lose its condition, or by the fact that in this area regeneration is accelerated for certain species found in the grassy savannahs and in the fields that have been abandoned or left fallow. This extension of the grassland surface justifies the fact that *Brachiara* sp is grown in the area for fodder.

The decline in the surface area of the water body can be explained by soil erosion, which fills up the watercourses, and the phenomenon of anthropisation by the grasses that invade the lakes. The analysis of variance shows that there is no significant difference ($P = 1$) between 2007 and 2017 and between the different occupations.

4.5.2. Change in Occupied Area in 2007 and 2017

The observed regression in surface area between this interval is due to deforestation of plant cover, anthropisation of ecosystems and climate change. Homogeneity shows that there is no significant difference ($0.00 > 1.0000$) in 10 years and according to the different land uses.

In 2017 there was a densification of vegetation compared to 2007 when the physiognomy was enlightening. This trend in degradation is not identical for all ecosystems or types of formation. Some formations are becoming denser in terms of vegetation, while others are losing some. The vegetation index close to minus one (-1) is devoid of vegetation cover, while that close to one (1) is covered by vegetation. The area lost by certain land cover classes has been mutated into other types of formation. Figure 10A is darker than figure 10B, which means that the vegetation is degrading rapidly, and is therefore moving from gallery forest to shrub savannah. Infrastructure, new cropland and grazing areas increased in 2017. This increase can be seen in the patches in Figure 10B.

5. Conclusion

At the end of this study, which aimed to assess the impact of logging and bush fires on the dynamics of vegetation regeneration in the Guinean high savannas, it was found that, in the tree savannah, the sites where logging was carried out without fire (CSF) and those where logging with fire was carried out (CAF) were completely flat (100%); in the shrub savannah, the sites where CAF was carried out and the control site (T) were all flat at almost 66.67%. In the shrub savannah, zero erosion had the same rate (66.67%) in the three different sites (CSF, CAF and T). In the tree savannah, zero erosion was 100% at the CSF site, 66.67% at the T site and 33.33% at the CAF site. The fine structure is represented in all sites, but at a rate of 100% in the CAF tree savannah, 66.67% in the CSF tree savannah and in the CSF shrub savannah. Ground cover by vegetation is very high, at 100% in wooded savannah, 66.67% in CSF shrub savannah and 33.33% in CAF and T. Regardless of the type of savannah, grazing is the most common activity, with a rate of 66.67%. The presence of termite mounds (33.33%), anthills (33.33%), wood cuttings (33.33%), etc. is moderately represented. The rate of degradation of the sites by livestock is 66.67% in the CSF site, and that which has been subjected to a CAF but is 100% represented in the T site. In the wooded savannah, this rate is 100% in the CSF and CAF sites, but T, on the other hand, is just impacted by livestock at a rate of 66.67%. There has been a remarkable increase in the surface area of shrub savannah (12.911 ha), and a 14.56% reduction in the surface area of gallery forests between 2007 and 2017. This study focused on the impact of logging and bush fires on the regeneration dynamics of the high wet savannah vegetation of Adamaoua. For the sustainable management of natural resources, it is recommended to limit the repetitive cutting of wood using the rotary method.

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