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SPATIAL DYNAMICS OF THE GROVE AND ITS ENVIRONMENTAL IMPLICATIONS ON THE LANDSCAPE OF WESTERN HIGHLANDS OF CAMEROON

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Abstract. In order to assess the evolution of the grove within the Central Highlands of West Cameroon, population-based human investigations, remote sensing data and surveys on transects were used. Analyses of data thus generated shows that in its urbanization process, the city of Bafoussam continuously caused systematic destruction of the grove at each place of the process; the suburbs bearing the effects each time. This reality is clearly visible on the sets of aerial photographs for the years 1949 and 1964 that cover the North and South of the city. Particularly, Baleng and Bafoussam chiefdoms are the most affected. Away from this suburban environment, the landscape change is affecting just every human activity sector. Due to lack of maintenance of the coffee trees and the abandonment of formerly cultivated plots, a mosaic of resulting vegetal cover now portrays a type of mature vegetal cover. This type of rapid tree and shrub growth is demonstrated by their present heights and crown sizes that resemble those of 50 years old trees. Of note also is the fact that some groves have over the years spontaneously integrated themselves into the compound vegetation. Such adjustments are just like those along the lines of trees where the forest pioneer species seem to have found ecological conditions conducive to their establishment and growth. On more localized transects, observations show that colonization of the forest has also made significant growth progress in areas where hedges were glued to lowland gallery forests. Afforestation of anthropogenic valuable timber trees, fruit trees and shrubs as well as ornamental shrubs has also contributed to the increase in the rate of afforestation in these rural areas of the Central Highlands of West Cameroon.

Introduction

From a phyto-geographical perspective, Cameroon is divided into two main zones. In the south lies extensive blocks of the rainforest and in the north open

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formations, constituted of savannahs and woodlands. In the middle of these two major zones is an area of forest-savannah, stretching from west to east, constituting a type of transition zone between latitudes 3 ° 30'and 6 ° 30' N. As shown in Fig. 1, the semi-deciduous dense forest in this area is distributed in the form of massive confluents; those of Lom and Djerem in the East or the Mbam and Kim in the West. However vast savannah corridors curve into the thick forest blocks in the South, as is the case in the North of Yaoundé and between Bertoua and Batouri. Viewed from a wider perspective, the two formations overlap more and territories dominated by savannah, forest patches and groves dot the hills, while in the valleys, gallery forests closely cover the rivers. Naturally the forest mixes with grassy savannahs or shrub lands. If in this part of Central and Eastern territory, populations and fields are highly diluted in space because of a low density of rural population (less than 15 inhabitants / km² according to the 2006 estimates), it is not the case in the Western Highlands, which sustain some of the largest concentrations of populations of Cameroon (more than 150 inhabitants/km² on average). Here, one notices, especially with the significant human pressure on land, a strong overlapping of the forest, savannahs, cultivated fields and plantations. Given this important entanglement, Letouzey (1985) found out that this landscape was "highly domesticated". Note however that if this environment has long supported such high and varied human rural populations, without an irreversible degradation of the soil and plant resources, it is because of intensive farming techniques and conservation policies that are methodically put in place and can thus feed the large populations, while at the same time maintaining the relative stability of the other natural resources. The average annual rainfall varies little and lies between 1800 and 2000 mm/year (Fig. 1). These rains are concentrated over a long period that usually goes from March to November with peaks that fall between July and August (Suchel, 1988). The average annual temperature is around 20 °C and varies very little over the months since the annual temperature range is less than 2 °C (Olivry, 1986).

The region is covered almost entirely by lateritic soils. These are rich in minerals as is the case in the North of the city of Bafoussam, to the East of Bandjoun, across to Foumbot, then in the rest of the area where they grow on acid rocks as granites and trachytes (Segalen, 1966; Gavaud and Muller, 1979). It has often been attributed to the soil factors differing densities in the highlands where these volcanic soils are found, that human concentrations and their activities are highest. The point of such reference is the Baleng chiefdom. In and around this chiefdom, rural population densities locally reach 600 inhabitants/km² (Dongmo, 1981). History and field surveys also confirm the fact that it is on "volcanic lands" that groves in the Western Highlands thrive in their highest densities (Barbier, 1988). In Cameroon therefore, one finds that the groves around compounds and

one each side of the path or road to such compounds, the Bamileke tribe that inhabits this area has successfully and over the years shaped the groves into geometric fences. It is also under and along such reinforced groves and shrubs that farmers construct and adjust their ridges yearly; thus benefiting each time from the leaf fall that acts in the long run as green manure. The system is therefore one of original groves, and one can undoubtedly understand why lots of studies have been

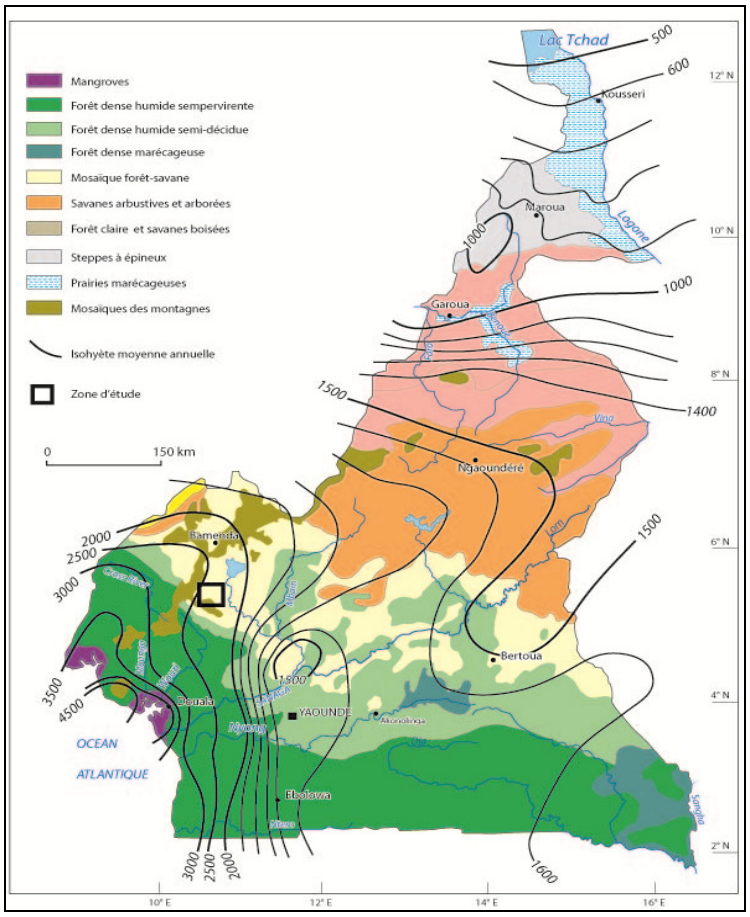

Fig. 1: Vegetation, annual precipitations and location of the study area in Cameroon (adapted from Letouzey, 1968; White, 1986; Youta Happi, 1998)

devoted to this theme. In Cameroon, only this part of the Western Highlands and then some parts of neighboring NW region presents this agrarian landscape of the grove. In this environment of compounds encircled by rows of trees and shrubs, farmers adjust ridges, which they have previously fertilized with green manure. Repeated practice over the years allows farmers to extend the crop cultivation period on the same plot without the need for long periods of fallow. Mostly, studies on the grove in this region have been focused on their ecological role (Fotsing, 1994) or degradation that cannot be identified by addressing only those aspects of their development or maintenance. And so like any living environment, the grove is undergoing great transformations for various purposes.

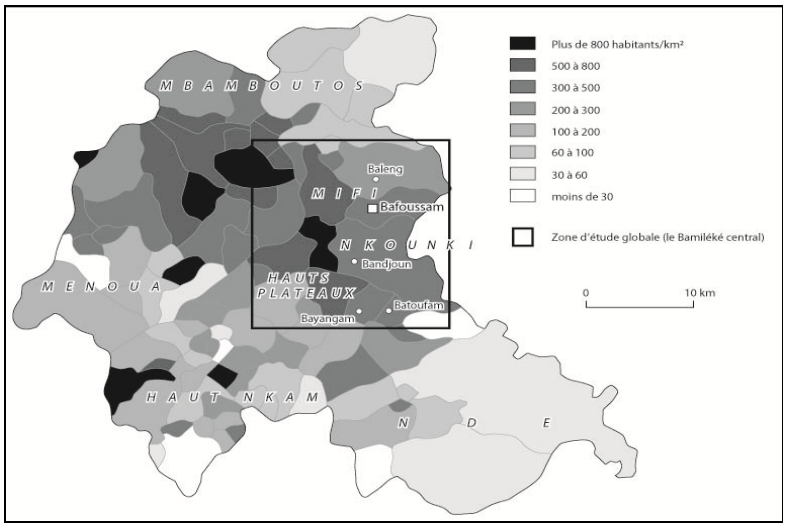

Fig. 2: Densities of the rural populations in western Highlands of Cameroon (per subdivision based on 2007 estimates). According to the National Institute of Statistics (2008).

The changes are even deeper than this region of the Highlands has one of the highest concentrations of the rural population of Cameroon. Compared to these considerations, we have chosen as sampling sites, the northern and southern suburbs of the city of Bafoussam where rural population densities locally exceed 500 inhabitants/ km². These specific sites are Baleng and Bafoussam chiefdoms. To further widen the scope of this research, a third site, located exclusively in rural areas is added. It is the Batoufam chiefdom, located further to the East (Fig. 2). Here, average rural densities across the region of the Western Highlands are around

250 inhabitants/km². The objective of this paper is to take into account the changing landscape and make an assessment of the structural dynamics of the grove during the past six decades and so establish the factors, procedures and physical and human characteristics that accounted for such remarkable structural dynamics.

The main question is how do we materialize the changes of grove in terms of the floral biodiversity and dynamics of land use.

1. Data and methodology

1.1. Tools and methods. The main tools were the topographic maps, satellite images and aerial photographs:

- Topographic maps: these maps are from 1/50 000 Bafoussam NB-32-XI-1d and Foumban NB-32-XI-1d;
- Satellite images from Google Earth are those of 2012;
- Aerial photographs at 1/50 000: they are parts of the mission of the AEF /CAM 1948/1949 (Baleng chiefdom) and CAM 1964/1965 (Bafoussam chiefdom).

1.2. Human investigations. The choice was guided by several considerations. Bafoussam is revealed as the main town in the region, and differs from other cities for its growing urban area. To narrow the field reality, we have conducted surveys coupled with human influence**.**

1.3. The botanical surveys based on transects and plots. Botanical records of transects were made during field surveys. This step has to do with a floristic inventory of woody species in 350 m hurdles at Batoufam. On transects (*T1, T2, T3, T4, T5 and T6*) performed at Batoufam species were identified. The number of species and individuals was determined. Circumferences of individuals were measured at 1.30 m above the ground. In the field, mapping the location of each individual on transects was made by estimating the same time the projection of the crowns to the ground so as to estimate later in the laboratory the linear recovery rate. At these statements statistical processing are applied, which are partly inspired by techniques of Lamotte (1962), on the one hand, and a mapping of stand structure, on the other. These two complementary approaches were applied so as to understand the organization of vegetation related to the dynamics of plant populations.

1.4. The diachronic analysis. This approach was used firstly to improve the radiometric aerial photographs from 1949 and 1964, then to redress these aerial photos and Google Earth imagery of 2008 compared to topographic maps. At the end of these treatments, the images are rendered on the same scale and geo-referenced to map coordinates in the UTM projection system. Developments and changes are easily observed and mapped.

1.5. Processing and data analysis. Data processing is basically of two types: a qualitative treatment based on the transcript and the triangulation of data, followed by a quantitative treatment. First was conducted a manual recount of one third of the questionnaire in order to retain more or less exhaustive list of variables and conditions, then a computerized counting and seizure of the questionnaire.

2. Results and discussion

2.1. The statistical report. In order to better appreciate the balance sheet and forms of evolution of the grove, it seems interesting to compare images of old and new sites. We analyzed aerial photographs of 1949 for the site of Baleng and 1964 for Bafoussam. For both sites, we used the Google Earth imagery of 2012. This is the only condition to understand the past and the present study. The reconstructions were obtained from georeferenced data. We automatically scanned slices of grove using mapping tools and geographic information systems. Applications have emerged and statistics were used to estimate the distances of each segment. Finally, we added up the distances from the grove at various dates and localities (Tab.1).

Tab. 1: Evaluation of metric lengths of hedges by location and per year

Location	Years of observation		Rate of annual change	Annual rate of change	Type of evolution
	1948/49	2012			
Chiefdom of Baleng	7207.65 m	1717 m	-120.1 m	-0.91 %	Regression
Chiefdom of Bafoussam	6630.44 m	764 m	-97.8 m	-0.97 %	Regression

Source: Aerial photographs of the AEF in 1948/49 and 1964 and satellite images of Google Earth imagery 2012.

2.2. Discussion

After 60 years, the grove fell across Baleng to 5490.64 m, ie an annual reduction of 120.11 m and a percentage of regression of 0.91%. About the chieftainship of Bafoussam, the data are nearly identical (Figure 3). In 60 years, the reduction of the grove is 5866.11 m, a decrease of 97.76 m with annual rates of decline estimated at 0.97%. Baleng chiefdom is one of the oldest of the Bamiléké plateau (Ghomsi, 1972). Dominated by a hilly topography polyconvex and humid lowlands occupied by the *Raphia* swamp or dense forest. The basalt base seems to confer to more favorable soil properties than the granites soils found in other localities as Batoufam or Batié. Between 1949 and 2012 (Fig. 4) shows, firstly, that the city of Bafoussam carried far and made this location a suburb area. Across the hedgerows remain; even if we specify that they do not look the same as in the

late 1940s. Some have expanded in width; others have disappeared along with new constructions made. Whereas in 1964 the leadership stood out clearly the grouping of houses that constituted the city of Bafoussam, in 2012 it is completely enclosed in the urban area of this regional capital of western Cameroon. However, far from the urban margins, hedgerows have remained relatively. Moreover, most have expanded especially in contact with gallery forests. Along several of these hedges, groves are located. The afforestation rate has increased significantly in the area that can be considered maintained in a rural environment.

2.2. 1.Forms of evolution of the agrarian landscape. The most notable change was the decline of hedges in favor of housing and an increase in woody cover. In rural areas, the grove was largely maintained, although it should be noted that even here, major changes in the landscape have taken place (Figures 3, 4). The changes are reflected in particular by:

2.2.1.1. Regression of the grove. Comparisons of images show that the grove has disappeared in large quantities due to the development of communication channels and habitat between 1949 and 2012 and for Baleng between 1964 and 2012 for Bafoussam (Fig. 3 and 4). At both sites, the dramatic expansion of housing occured on the northern and southern margins of the city of Bafoussam. In the surrounding countryside, a significant increase in the number of dwellings has occurred, but without significant consequence on the distribution and the length of hedges.

2.2.1.2. The maintenance and extension of hedgerow trees. It is noted that sections of abandoned farmlands were converted into thickets and patches of forest. The process is done by gradual implementation from the edge of the hedge to the heart of the concession.

2.2.1.3. Height growth of trees and hedges spread. It is found across the poles converted to shrubs in the hedges turned into real trees after 30 to 50 years. In other words, the average diameter of trees and shrubs has more than quadrupled during the same period. At the same time, the height and the crown of trees has increased remarkably and frequently giving rise to the old alignments of shrubs looking like a dense forest strips or spots and patches of dense forests to geometric shapes (Fig. 3 and 4).

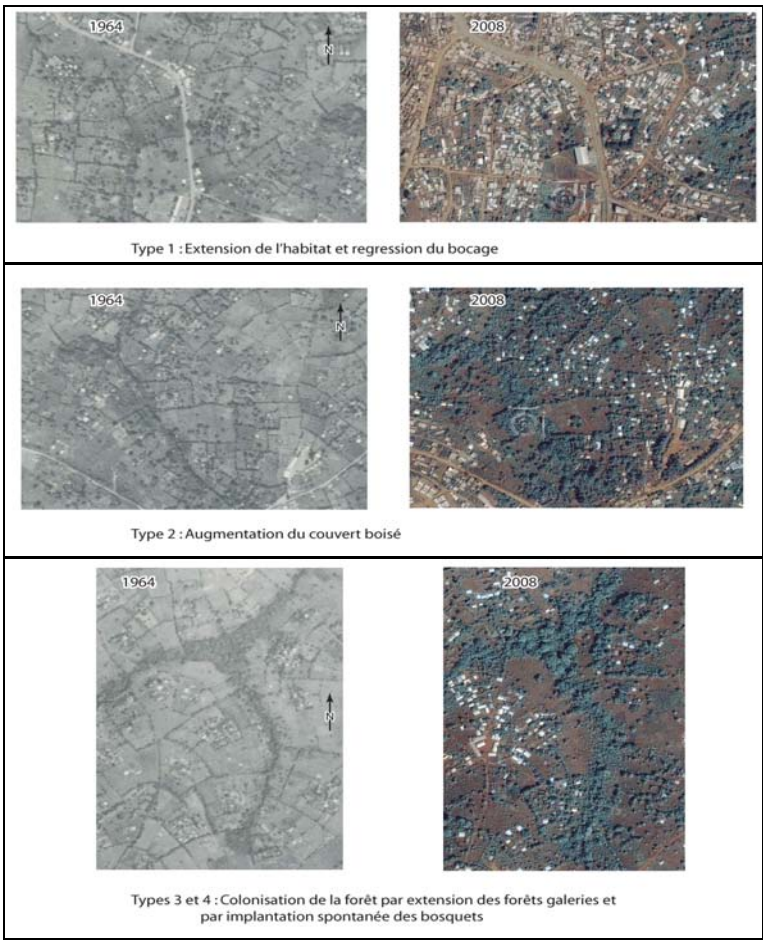

Fig. 3: The dynamic forms of the grove in the south of Bafoussam

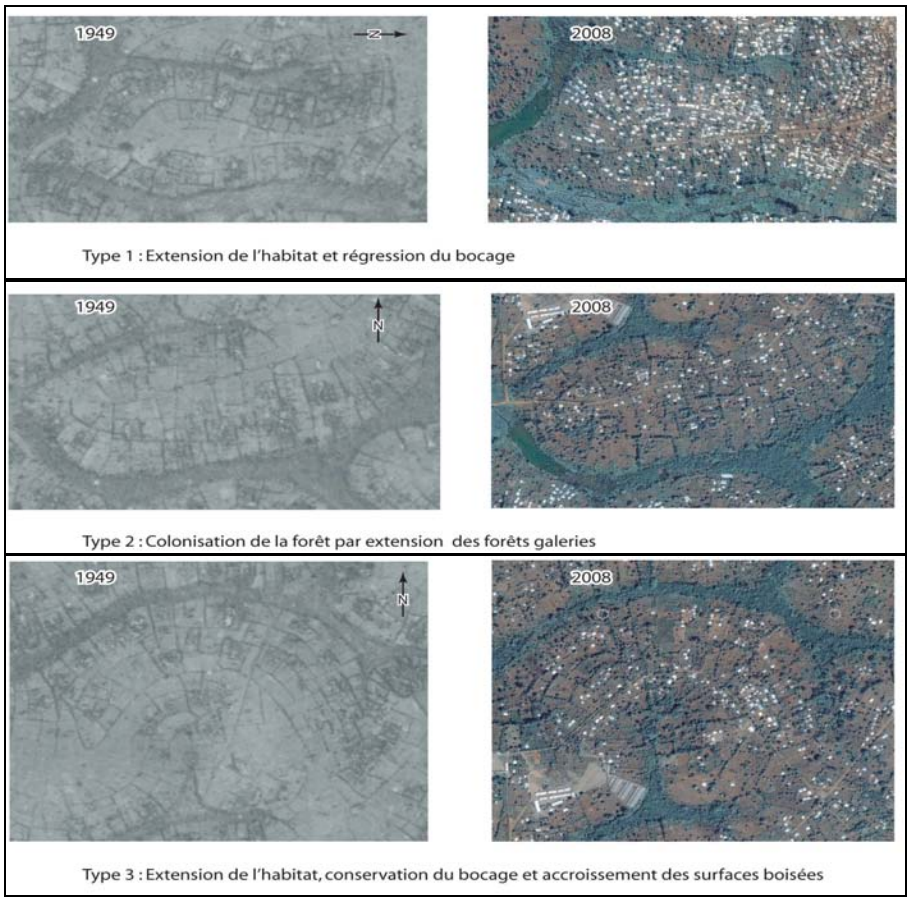

Fig. 4: The dynamic forms of the grove around Baleng

Conclusion

The study of the spatial dynamics of the grove within the central Highlands of west Cameroon shows a profound transformation of the agrarian landscape in general and hedgerows in particular. Over the past six decades, cities have largely extended their peripheries while nibbling on farmland and surrounding countryside. On urban margins, hedgerow lines actually disappeared in favor of social infrastructures (roads, schools, factories and industries) and housing. In rural areas in general, the grove were maintained in their geometric layout, although it should be noted that overall, the maintenance of hedges by making rows of ‘‘bamboo’’ is

defective because of the abandonment of goat feeding. If destructions of hedgerows were held locally for expansion needs of certain properties, there was also not far from these points of development of new hedges. A sufficiency in the rural area, the thickness of the hedges and the recovery rate of trees and shrubs has increased significantly in all. This trend is due to several factors: an ambient humid climate (over 1800 mm of rainfall per year spread over 8-9 months on average); maintenance of defective coffee and non-renewal of "bamboo" rotten along hedgerows; rural depopulation and abandonment of fields and plantations of distant clusters of houses, the abandonment of small livestock. In other words, prolonged fallow and waste land are all factors that explain the spatial dynamics of farmland to an environment where the presence of the tree is becoming increasingly prominent. Where the grove is no longer maintained, lines of farmland were converted to forest patches; synonymously with enlargement. Meanwhile, the introduction of alien species in the grove and the proliferation of fruit trees in concessions have resulted in increased overall recovery in timber lands. Locally, this increased rate of afforestation has been carried out in the campaign at the same time we witnessed the establishment of new dwellings. This suggests that population growth and expansion of housing in rural areas do not automatically regress the grove, let alone loss of forest cover. We can simply talk about a transformation of farmland in these cases and not a regression. This is especially true since the rows of trees and shrubs are in place. Moreover, even if the hedges are not shaped to prevent the straying flock, the fact remains that local.

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