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Floristic diversity and pressure factors in the Lagdo council forest (North Cameroon)

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Abstract

The council of Lagdo is located in the North of Cameroon. It has a rich diversity of plant species. These species are subject to several pressures of anthropic and natural origin. The aim of this study is to characterise this flora and determine the pressure factors affecting it. An ethnobotanical survey was carried out among 210 people. A floristic inventory was carried out in a 50x50m^2 plot following layons 10 metres wide and 50 metres long, one after the other. In each of the plant formations selected, sixteen (16) plots of 50x50m^2 were created using a double decameter, following the 10 metre wide and 50 metre long paths. The experimental design used was a block design in which the 3 plant formations (Field, Wooded Savannah, Shrub Steppe) were the main treatments and the 16 50x50m^2 plots in each plant formation were the replicates. The results of the inventory carried out on 12 ha identified 10421 individuals divided into 69 species, 48 genus and 25 families over the three plant formations (wooded savannah, shrub steppe and field). The average absolute density was 868.41 stems/ha in all plant formations. Field surveys reveal that agriculture (35%), firewood cutting (45%), carbonisation (15%) and hunting (5%) are carried out in the forest. The exacerbated anthropisation of the council area is leading to an increase in agricultural land and encouraging strong household demand for firewood. The exploitation of this council forest will lead to a reduction in its rich flora.

Key words: Pressure factors, Floristic diversity, Council forest, Lagdo, North Cameroon

INTRODUCTION

Dry forests are exceptional reservoirs of carbon and biodiversity. They provide natural resources, remnants of original formations and plant species of high socio-economic value to rural populations who depend heavily on them to meet their daily needs (Ouédraogo *et al.*,

2010). Central Africa is heavily forested, with around 57% of its surface area covered by natural forests (FAO, 2007). These forests are subject to progressive degradation. They are progressively converted to farmland, plantations, roads or modified by timber exploitation, slash-and-burn agriculture and/or other extractive activities (Clark and Sunderland, 2004). The loss of these resources weakens the ability of forest-dependent communities to derive income, food and medicine from them (Abdoulaye *et al*., 2020). Today, the rate of deforestation on the African continent is increasing (FAO, 2012). In recent decades, human pressure on ecosystems has led to a reduction in forest area and fragmentation of ecosystems (Tchotsoua and Gonné, 2010; Tchobsala, 2011). The area under cultivation is constantly changing as a result of galloping population growth, which has risen from 21% in 1986 to 33% in 2016 (Wangbé *et al.,* 2020). In Lagdo, the anthropisation of the environment due to the increase in the size of the population, the growth in agricultural land and the high demand for firewood in households is putting unprecedented pressure on the council forest. Poor management of the forest is an asset for local people, who contribute directly to the degradation of biodiversity through actions such as excessive tree felling, bush fires, farming, which leads to significant deforestation, and overgrazing. The aim of this study is to characterise the flora and identify the pressure factors affecting the Lagdo council forest. It is being carried out in the context of a natural resource crisis in a sensitive area, namely the Bénoué watershed.

MATERIAL AND METHODS

The investigations took place in the Sudano-Sahelian zone, more precisely in the northern region, Department of Bénoué, Lagdo district, located between latitude 8°.53 North and longitude 13°.58 East (**Figure 1**). The climate is of the Sudano-Sahelian type, characterised by two seasons: a long dry season lasting around 7 months (November-May) and a short rainy season lasting 5 months (May-October). Average annual rainfall is around 950mm. The region is subject to high temperatures. The average annual temperature over 30 years (1989-2019) is around 30°C (Wangbé *et al.,* 2020). The relief of the locality is dominated by hills, but there are also mountain ranges and inselbergs. The vegetation in this area has several variants. The hydrographic network is essentially made up of seasonal rivers. There is also an artificial reservoir built on the Benoué. The basin is used for agricultural and pastoral activities, as well as fishing, small-scale trade and handicrafts.

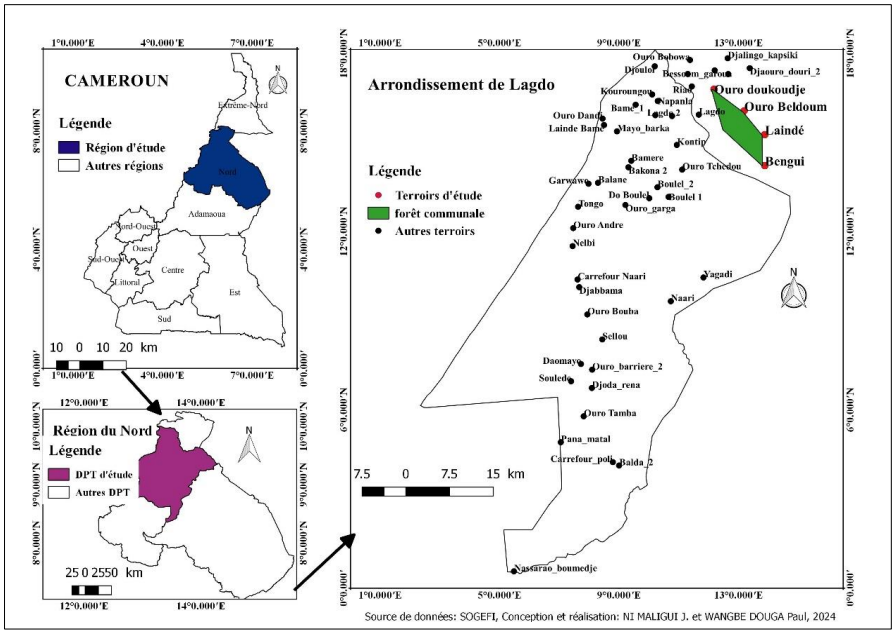


Figure 1. Location of the study area

The data was collected in two successive phases. The first stage was based on surveys followed by field visits to identify the pressures on forest vegetation. A sample of 210 people was surveyed in 4 riverside villages: Ouro doukoudjé (70); Ouro Beldoum (45); Laindé (55) and Bengui (44). The aim was to gain an insight into local perceptions of the factors causing forest degradation. A Garmin camera and GPS were used to acquire images and geographical coordinates of the study area. The second phase consisted of collecting field data on woody species. The plot method was used to carry out the floristic survey. This consisted of using a string to mark out an area measuring 50 x 50m^2, within which a floristic inventory was carried out by following paths 10m wide and 50m long. In each of the plant formations selected, 16 plots of 50x50m^2 were created using a double decameter, following the 10m wide and 50m long paths. The experimental design used was a block design in which the 3 plant formations (Field, Wooded Savannah, Shrub Steppe) were the treatments and the 16 plots of 50x50m^2 in each plant formation were the replicates. On each 50x50m^2 plot, all the woody plants were inventoried. Dendrometric parameters such as diameter at breast height (DBH) for woody trees with a height ≥130m and the number of woody trees were counted. For trees whose diameters could not be measured at 1.30m height as a result of footings or buttresses and deformation. The measurement was taken 50 cm above the buttresses or footings and deformations. To identify signs of anthropisation of the vegetation (pruning, skinning, burning, cutting, disease), the method of Ouédraogo *et al* (2010) was used. It consists of

observing traces and counting the number of diseased individuals out of the total number of individuals in a plot.

For the quantitative assessment and analysis of floristic diversity, it was necessary to calculate certain parameters. To carry out these calculations, the inventory sheets were first analysed manually and then entered into an Excel spreadsheet. The concepts covered included :

-The main structural characteristics :

-**absolute density:** the formula for absolute density is as follows **D = N / S** where **N=** number of species in the environment studied; **S=** surface area occupied by the species; **D=** density. It indicates the average value of the number of individuals per sample unit. In this study, it was calculated per hectare according to (Jiagho *et al*., 2016).

In order to show the distribution of trees by diameter class, the data collected during the inventories were divided into classes in the different plant formations, ranging from ten to ten according to the following table

Observed diameter classes

Classe 0 : [Φ <10]
Classe I : [10-20]
Classe II : [> 20]

-**The Ecological Importance Value Index (EIVI)** is the sum of relative density, relative frequency and relative cover

IVIE (%) = RF+RD+RDe with IVIE: Ecological Importance Value Index, **RF**: Relative Frequency, **RD**: Relative Dominance**, ReD**: Relative Density.

The main floristic characteristics:

-**The Shannon index:** The Shannon diversity index, **ISH: ISH = - ∑ Ni/N log2 Ni/N** where Ni=efficiency of species i; N=efficiency of all species. ISH is expressed in bits. It is the most widely used and recommended index in comparative stand studies, as it enables us to assess the weight of the species in the land cover. It is even higher when a large number of species are involved in land use.

-**Piélou's equitability EQ: EQ= ISH/ log2 N**, corresponds to the ratio between the observed diversity and the maximum possible diversity in the number of species (N). A low equitability, i.e. tending towards 0, corresponds to the importance of a few dominant species and towards 1 when a maximum number of species participate in the cover (Rocklin, 2002).

RESULTS

Floristic composition and characteristics of the Lagdo council forest

A total of 10421 individuals in 25 families, 48 genus and 69 species were inventoried in the Lagdo council forest (**Table 1**). The most represented families are Fabaceae (17 species), followed by Combretaceae (09 species), Anacardiaceae (6 species) and Rubiaceae (3 species). Next come Annonaceae, Burceraceae, Capparaceae, Euphorbiaceae, Meliaceae and finally Myrtaceae.

Table 1: Species inventoried in the Council Forest

Family	Genus	Species
Anacardiaceae	*Lannea*	*Lannea acida*
		Lannea barteri
		Lannea fruticose
		Lannea microcarpa
		Lannea schimperi
	Sclerocarya	*Sclerocarya birrea*
Annonaceae	*Annoana*	*Annona senegalensis*
	Hexalabus	*Hexalabus monopetalus*
Apocynaceae	*Adenium*	*Adenium obaesum*
	Holarrhena	*Holarrhena floribunda*
Balanitaceae	*Balanites*	*Balanites aegyptiaca*
Bignoniaceae	*Kegelia*	*Kigelia africana*
	Steryospermum	*Steryospermum kunthianum*
Burceraceae	*Boswellia*	*Boswellia dalziellii*
	Commiphora	*Commiphora africana*
Capparaceae	*Capparis*	*Capparis sepiaria*
	Maerua	*Maerua crassifolia*
Combretaceae	*Anogeissus*	*Anogeissus leiocarpus*
	Combretum	*Combretum molle*
		Combretum glutinosum
		Combretum fragrans
		Combretum collinum
		Combretum nigricans
	Terminalia	*Terminalia albida*
		Terminalia macroptera
	Guiera	*Guiera senegalensis*
Celastraceae	*Maytenus*	*Maytenus senegalensis*
Clusiaceae	*Gardenia*	*Gardenia acuela*
Euphorbiaceae	*Bridelia*	*Bridelia ferruginea*
	Hymenocardia	*Hymenocardia acida*
Bombacaceae	*Bombax*	*Bombax costatum*
Moraceae	*Ficus*	*Ficus glumosa*
		Ficus trichopoda
		Ficus abutilifollia
Myrtaceae	*Syzygium*	*Syzygium guineense*
Proteaceae	*Protea*	*Protea madiensis*
Rubiaceae	*Crosopteryx*	*Crosopteryx febrifuga*
	Breonadia	*Breonadia salicina*

	Feretia	*Feretia apodanthera*
	Mitragyna	*Mitragyna inermis*
Rhamnaceae	*Ziziphus*	*Ziziphus mauritiana*
		Ziziphus mucronata
Sterculiaceae	*Sterculia*	*Sterculia segitera*
Tilliaceae	*Grewia*	*Grewia flavescens*
Ulmaceae	*Celtis*	*Celtis integrifolia*
Verbenaceae	*Vitex*	*Vitex doniana*
		Vtex madiensis
Ebenaceae	*Diospyros*	*Diospyros mespiliformis*
Meliaceae	*Khaya*	*Khaya senegalensis*
	Pseudocedrela	*Pseudocedrela kotschyi*
Fabaceae	*Acacia*	*Acacia gerardii*
		Acacia seyal
		Acacia hockii
		Acacia senegal
		Acacia polyacantha
	Entada	*Entada Africana*
		Entada abyssinica
	Bauhinia	*Bauhinia rufescens*
	Detarium	*Detarium microcarpum*
	Dalbergia	*Dalbergia melanoxylon*
	Piliostigma	*Piliostigma thonningii*
		Piliostigma reticulatum
	Prosopis	*Prosopis Africana*
		Prosopis juliflora
	Daniella	*Daniellia olivei*
	Senna	*Senna singuena*
	Tamarindus	*Tamarindus indica*
Olacaceae	*Ximenia*	*Ximenia americana*
25	**48**	**69**

Floristic diversity of the study area

Floristic diversity varies according to the different formations inventoried. The tree savannah has 4524 individuals and 26 genus compared with the other formations, the shrub steppe with 3991 individuals and the field with 1906 individuals (**Table 2**). The inventories show that the tree savannah has a high density of trees, which is richer in terms of phytodiversity than the other formation.

Table 2. Floristic richness according to plant formations

Plant formations	**Wooded savannah**	**Shrub steppe**	**Field**	**Total**
Individuals	4524	3991	1906	**10421**
Absolute density (stems/ha)	1131	997.75	476.5	**868.41**
Species	27	28	26	**69**
Genus	26	25	22	**48**
Families	15	13	16	**25**

Floristic characteristics: Shannon and Piélou indices

The diversity indices calculated vary considerably from one plant formation to another. **Figure 2** shows the Shannon and Piélou index values. The value of the Shannon index calculated in the different formations varies from 3.04 bit to 1.74 bit. The highest value is found in the tree savannah. On the other hand, Piélou's equitability fluctuates between 0.47 and 0.29, with the lowest value observed in the field, while the tree savannah always records the highest value. The Pielou equitability values are much closer to 0, which means that the phenomenon of dominance by a few species is more marked in these strata. The index values confirm the difference in plant potential between the formations studied.

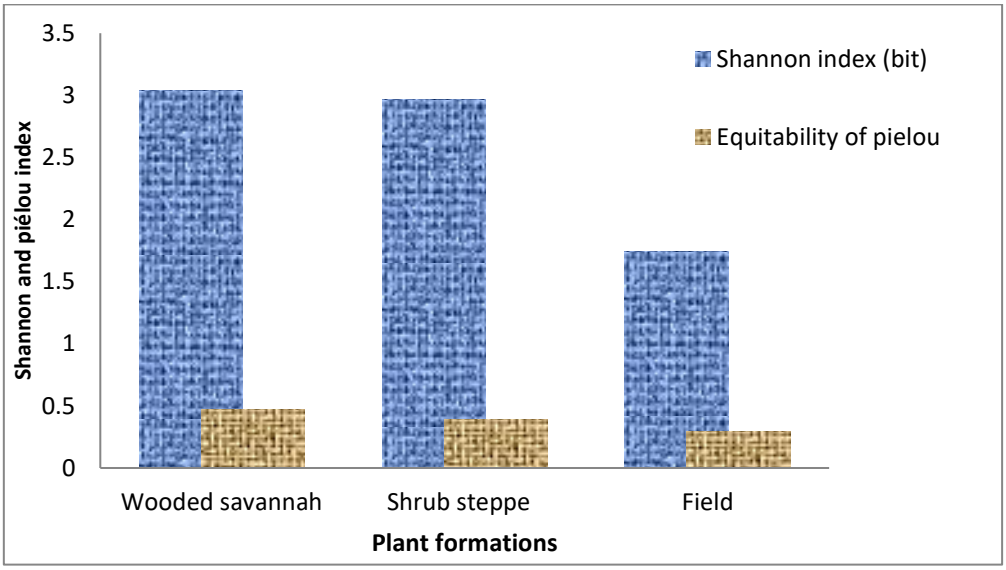


Figure 2. Value of the Shannon and Piélou indices

Structural characteristics: **diameter classes and Ecological Importance Value Index (EIVI)**

The diametric structure of the individuals shows different curves depending on the formations inventoried. **Figure 3** shows that the distribution of trees in the different plant formations presents an exponential curve. The highest value of individuals is found at class 0 in the three plant formations, the largest of which is found in the savannah.

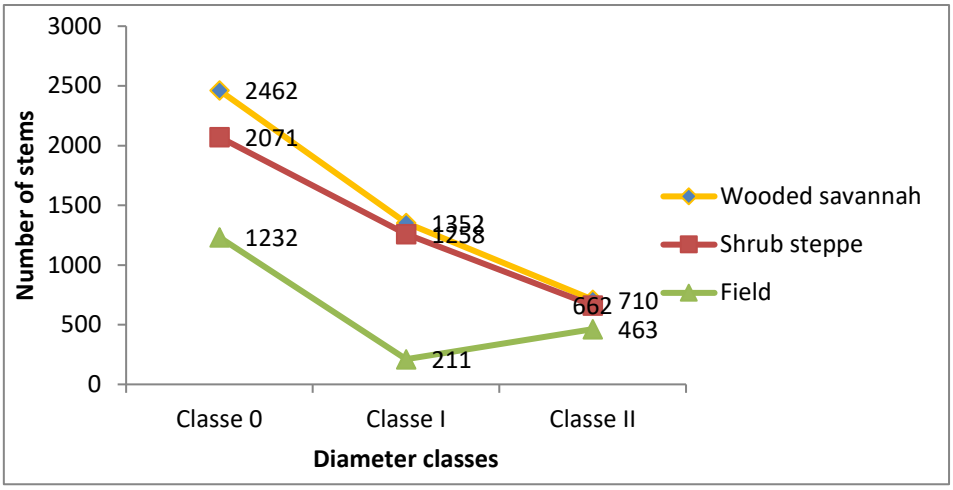
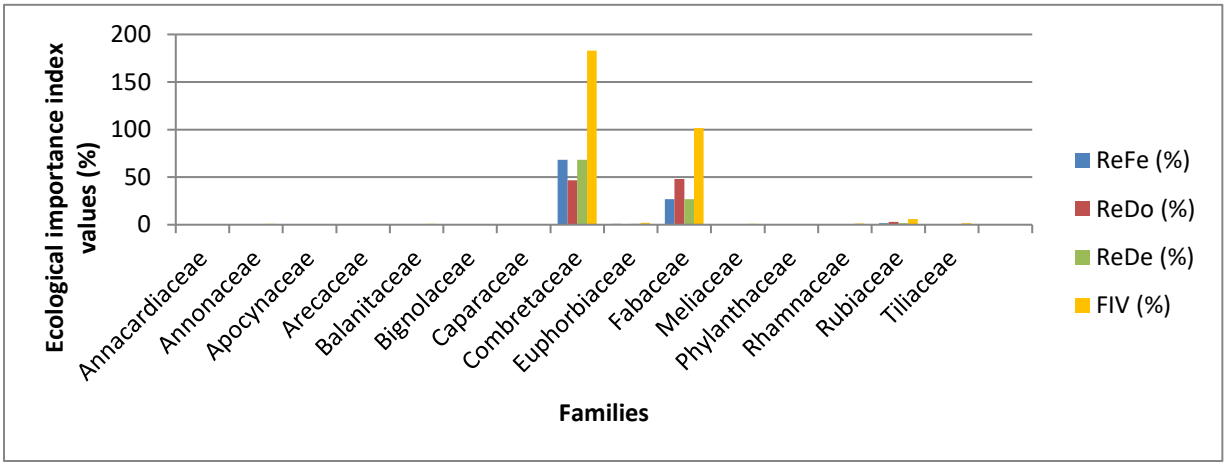


Figure 3. Distribution of individuals by diameter class in plant formations

Figure 4 shows that the Combretaceae and Fabaceae families come out on top in terms of relative frequency, relative dominance and relative density. They represent 183.06% and 101.67% of the ecological importance index, respectively. They are followed in descending order by Rubiaceae (6.04%), Euphorbiaceae (2.01%) and Tiliaceae (1.5%). The significant presence of these families could be explained on the one hand by the low rainfall and very high temperatures that reflect the aridity of the Sudano-Sahelian climate that characterises this zone. On the other hand, APG III (Angiosperms Phylogeny Group) groups Caesalpiniaceae, Mimosaceae and Papilionaceae into a single family, Fabaceae.

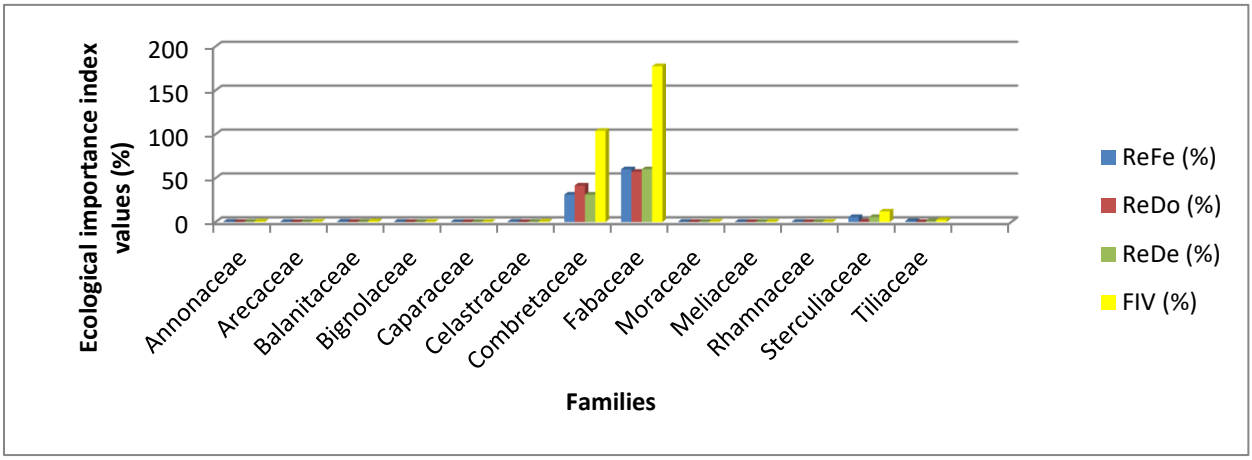


ReFe: Relative frequency; ReDo: Relative dominance; ReDe: Relative density.

Figure 4 : Index of the ecological importance of families in the tree savannah

The ecological importance index of the families varies from 177.47% to 0.2% (**Figure 5**). The most represented families, in descending order, are Fabaceae (177.47%), Combretaceae (103.9%), Sterculiaceae (12.06%) and Celastraceae (0.71%). The dominance

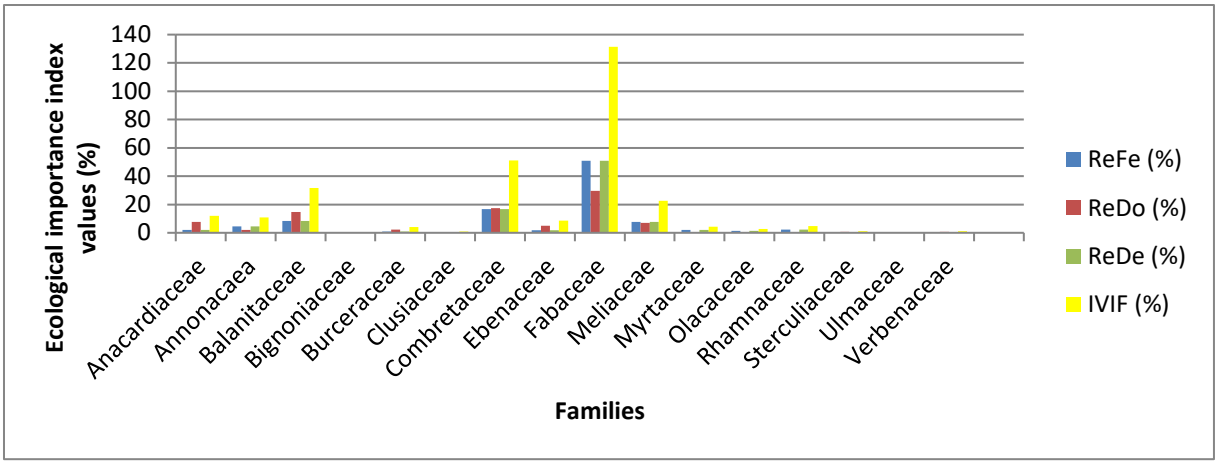
of the large Fabaceae family in this stratum could be explained by the environmental conditions, which remain favourable to the adaptation of certain species of the sub-families. In the fields, although Fabaceae and Combrétacées are represented, there is a considerable presence of families characteristic of species of socio-economic importance.



ReFe: Relative frequency; ReDo: Relative dominance; ReDe: Relative density.

Figure 5 : Family ecological importance index in shrub steppe

Figure 6 shows the ecological importance index values for the families in the fields. These values range from 0.4 to 131.28%. The Fabaceae family has the highest index of importance (131.28%), while the Ulmaceae family has the lowest (0.4). The families that are moderately represented are: Balanitaceae (31.22%), Meliaceae (22.65%), Anacardiaceae (11.91%), Annonaceae (10.87%) and Ebenaceae (8.55%). The presence of these families, which are moderately represented in this stratum, can be explained by the socio-economic and ecological importance that farmers attach to certain species. In fact, certain valuable species are kept in the fields by farmers to maintain soil fertility, provide shade and collect non-timber forest products.



ReFe: Relative frequency; ReDo: Relative dominance; ReDe: Relative density.

Figure 6 : Ecological importance index for families in the field

Pressures on the council forest

The Lagdo council forest faces a number of pressures. Anthropogenic pressures are a major threat to the survival of the forest.

The effects of Agriculture

Farming is the most common activity in the commune. It is extensive, but requires large areas of land. The depletion of available land is forcing many farmers to acquire new areas for cultivation. Similarly, because of the difficulty of accessing land due to land saturation, people are clearing the interior of the forest to plant crops. The following sector diagram highlights the agricultural pressures on the forest (**Figure 7**).

Figure 7 shows the local population's perception of the effects of farming on woody plants in the forest. It shows that 54% of farmers clear vegetation to extend their crop plots, 25% use fires and 21% clear woody vegetation (**Photo 1**). These pressures on vegetation can be explained by the increase in population size and poor farming practices. This pushes farmers to conquer new plots of arable land.

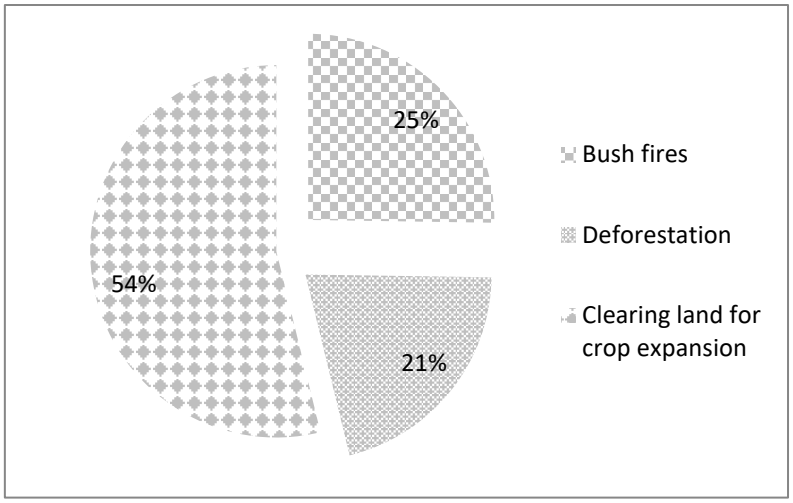


Figure 7. Farming practices

Photo 1 shows the action of bush fires in the forest. These fires are usually set in the dry season during field preparation by farmers, hunters and, in rare cases, orchestrated by cigarette smokers. The repeated use of these fires has harmful effects on the natural regeneration of woody plants and also on animal biodiversity.

Photo 1 : Bush fires in the council forest

Firewood collection and carbonisation

Local residents use firewood and fuelwood for their socio-economic needs. They usually fell trees and supply Lagdo and the surrounding area with charcoal and firewood. These almost permanent actions contribute to the destruction and regression of the forest's potential.

Charcoal is produced inside the forest (**Photo 2**)**.** The crisis in the source of energy (firewood) and poverty in the area are driving young people to cut down trees in order to satisfy their

needs. The proliferation of these sites in the forest is a pressure factor on woody species and is contributing to the decline and disappearance of certain species. Surveys of forest residents reveal that only hardwoods that are difficult to consume are used most by charcoal burners: *Prosopis africa, Terminalia glaucessens, Daniellia oliveri.*

Photo 2. Carbonisation site

Damaging effects of pastoral practices

Livestock farming in the study area is essentially extensive and relies on the use of natural pastures by the animals. These animals graze the bush and their repeated passage through the council forest contributes to the reduction in the area of vegetation, the denudation of the soil and the weakening of naturally regenerating tree stumps.

Analysis of **Figure 8** shows that the density of goats per hectare is 0.027, that of cattle is 0.023 and that of sheep is 0.011. This density is used to assess the animal load in the area. The total density in the zone is 0.061, i.e. 6.1 Tropical Livestock Units (TLU)/ha. In short, when an area is densely stocked, the pressure on resources is high.

Figure 8: Density of livestock in the area

DISCUSSION

This study identified 10421 individuals divided into 25 families, 48 genus and 69 species in all the strata (wooded savannah, shrub steppe and field) inventoried in the council forest. This is evidence of a wealth of flora. The results obtained are almost similar to those of Sani *et al.* (2013), in the Mozogo-Gokoro National Park (62 woody species and 26 families), slightly higher than those of Jiagho (2018) on the outskirts of the Waza National Park located in the same agro-ecological zone (52 species, 42 genus and 21 families) and remain lower than those of Grévin et *al*. (2021). These authors recorded 367 species in 267 genus grouped into 79 families in the Mabi classified forest in Côte d'Ivoire. These different results can be explained by the differences in the sampling methods used and the pressure factors on the sites studied. The diversity indices (Shannon and Piélou) calculated vary from one plant formation to another. The highest value is found in the wooded savannah. On the other hand, Piélou's equitability fluctuates between 0.47 and 0.29, with the lowest value observed in the field, while the tree savannah always records the highest value. The maximum values of the Shannon index and Piélou equitability, which are close to 1, confirm a high floristic diversity and a good distribution of species within each plant formation. The Shannon diversity index obtained in this study is relatively close to that found by Issifou et *al* (2019) and Ngassaki *et al* (2023) in the vegetation of the middle Sota basin in northern Benin and in a forest in Congo, respectively.

The diametric structure of the stand shows an exponential curve that falls very rapidly as one moves from one class to the next. This result could be due to the fact that the plants in the area have undergone a great deal of anthropogenic disturbance, which is in the process of being restored, and is also characteristic of an ecosystem belonging to an ecological zone where the

trajectory of the stands generally leads to the dominance of shrubs. This observation has been made by several authors, including Jiagho *et al* (2016), Ndzai (2020) and Ngassaki *et al* (2023).

The values of the indices of ecological importance of the families vary from one formation to another. In all strata, the Fabaceae and Combretaceae dominate over the other families. These families have already been shown to characterise savannah vegetation in Côte d'Ivoire (Guillaumet and Adjanohoun, 1971; Koulibaly, 2008; Soro et *al*., 2021). Our results corroborate those of Kambale et *al*. (2016), who showed in their studies that the Fabaceae family and the Combrétaceae are dominant in the Kponyo forest in Congo. The similarity of our results confirms the hypothesis put forward by Dimobé *et al.* (2012), which states that Combrétacées and Mimosacées are indicative of a generally dry climate.

Our investigation revealed that the extension of agricultural land, the cutting of firewood, carbonisation and overgrazing are all activities carried out in the council forest. The effects of these human activities are contributing effectively to the decline in floristic richness in the study area. The results of the work are in line with those obtained by MINEPDED (2017) and Jiagho et *al.* (2021), who revealed that demography and agricultural activities are among the main drivers of deforestation and degradation of woody cover in Cameroon. Indeed, population growth leads to an increase in the need for agricultural products, which often results in an increase in the area under cultivation to the detriment of the forest or forest degradation. In the same vein, Wangbé (2020) has shown that deforestation or the degradation of vegetation can be explained by the extension of agricultural areas, the cutting of firewood and the construction of housing. Similarly, the practice of nomadism and sedentarisation in a context of grazing crisis is forcing nomadic herders to graze their animals in the aforementioned forest. Nomadic and transhumant herders arrive with large numbers of animals during the dry season, leading to overgrazing and consequent degradation of pastoral resources (Bonnet, 2003; Dongmo, 2009). Feeding these large herds forces farmers to supplement their animals' diet with wood fodder.

CONCLUSION

This study has enabled us to understand the variability of floristic diversity and to identify the pressure factors on the Lagdo council forest in a context of environmental crisis. Floristic richness varies from one plant formation to another (wooded savannah, shrub steppe and field). In the forest under investigation, the Fabaceae and Combretaceae families are the most represented because they are more resistant to the climatic conditions of the

environment. This work shows that the extension of agricultural areas, overgrazing, the cutting of firewood and charcoal production are all human activities that exert pressure on the council forest. This study will help to attract decision-makers to set up a management and conservation plan for the forest, while involving local people in participatory management.

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