Analysis of Specific Woody Dynamics in the Mayo Sorawel Watershed (North Cameroon)

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Abstract: ***The woody cover in the Sudano-Sahelian zone of North Cameroon includes Sudanian and Sahelian species. In the Mayo Sorawel watershed, the demographic pressure of needs and the selective cutting of woody trees by the Chaux Roca Company are causing a deterioration in woody diversity. The purpose of this article is to analyze the state of woody diversity in the watershed. On the basis of botanical surveys, surveys of 999 actors in timber operations, the Shannon diversity index, Landsat 2016 images and field surveys, it appears that the diversities are low H '<3 bit in the degraded vegetation that already covers 83.68% of the watershed. Techniques for exploiting prized species are unsustainable. Given the importance of biodiversity in the balance of ecosystems and local economies, policies to restore woody diversity are necessary in the watershed.***

Keywords: Woody diversity, anthropic pressure, selective woody cutting, Chaux Roca, Mayo Sorawel watershed, North Cameroon

1. Introduction

The increase in the number of the population in the Sudano-Sahelian zone of North Cameroon has been accompanied by the increase in the need for wood and fields. Unemployment and poverty have accelerated the business of selling wood and charcoal in recent decades. The scarcity of wood in general and that of prized species in particular has made logging techniques unsustainable. The overexploitation of prized species threatens diversity.

Biodiversity refers to all forms of life on earth and the natural characteristics it presents. Cutting down trees without respecting renewal capacities threatens the target species. Wood diversity enters ecosystem services corresponding to supply, regulation and culture which directly affect communities. The degradation of diversity in general has resulted in poorer quality of food, pharmacopoeia, the environment and at times the decline of some local economies (Rierra et al., 2004). Among the authors who were interested in the dynamics of wood diversity in this area, Boutrais et al., (1984) and Meny (1996) pointed out that the cotton development society of Cameroon (SODECOTON) in its beginnings eliminated trees in the fields. The consequence is both the loss of diversity and the decline in densities in plant formations associated with crop areas. But with the erosion and the growing infertility of the soil, SODECOTON undertook the development of natural or improved fallows with legumes Faidherbia albida or Prosopis africana (CIRAD, 2003). But the projects never understood that this area was only a relay for the populations in their descent to the south, on the richer lands of the Bénoué (Boutrais J. et al., 1984). Protecting the plant cover in general and woody diversity in particular does not therefore seem to be a priority for these populations, notes Meny (1996). A comparative analysis of the dynamics of the woody plant cover between the Mayo Figuil and Mayo Siwo watersheds (Toumba Tizi, 2003), noted a more exacerbated degradation in the Mayo Figuil watershed due to predatory exploitation of certain cash by the Chaux Roca company that Toumba Oumarou (2018) describes as an "unexpected player" in this area with fragile ecology. It must be recognized in general that African savannas are experiencing worrying degradation. The causes are extensive agriculture and the use of wood as an energy source by more than 80% of rural and urban households (Jamin et al., 2003). Indeed, faced with the selective cutting of wood by the Chaux Roca company, with the wood needs linked to population growth, how do the techniques of woody exploitation lead to the dynamics of diversity? How is the dynamic rate of the number of species in the plant formons of the watershed changing? How does wood diversity appear in the different plant formations? This article analyzes the dynamics of wood diversity in plant formations and presents the different responsible harvesting techniques in the Mayo Sorawel watershed.

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2. Materials and methods

2.1 The study area

The Mayo Sorawel watershed is located in the department of Mayo Louti, administrative region of North Cameroon (Figure 1)

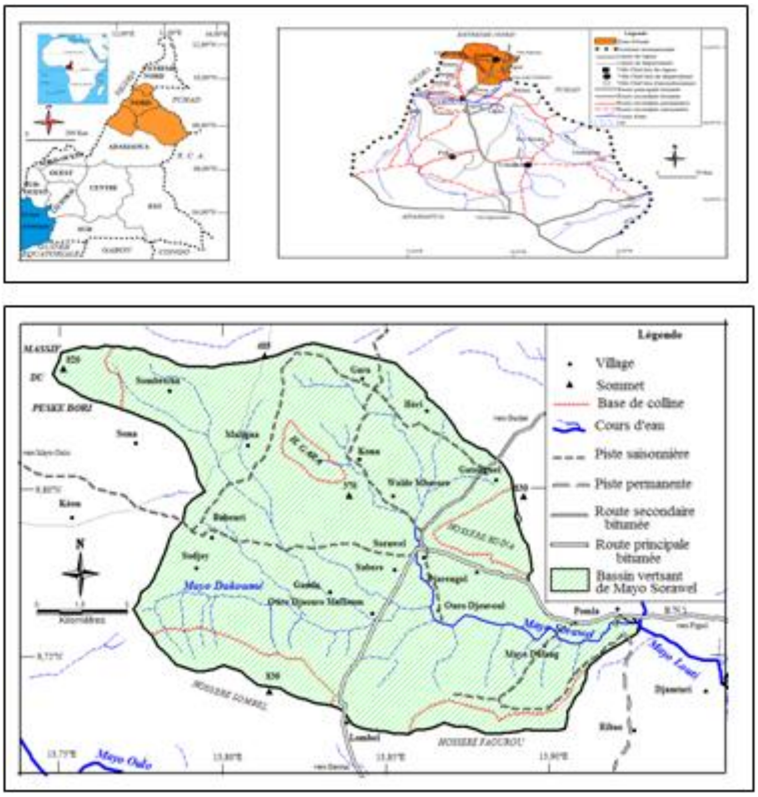

Figure 1: Location of the Mayo Sorawel watershed
Source: Garoua topographic map 1 / 200,000 and land surveys, by Toumba Tizi, December 2019

It covers 14,560 ha and lies between 9 ° 72'N-9 ° 84 'north latitude and 13 ° 74'-13 ° 92' east longitude. Letouzey (1968) cited by Boutrais et al. (1984) describes the vegetation of this Sudano-Sahelian savannah area. It is a transitional vegetation between the Sudanese savanna with Daniela oliveri and Lophira lanceolata of the Bénoué valley and that of the Sahelian thorny plains of the Diamaré plain (Boutrais et al., 1984). In this area Lestringant (1964) noted the presence of the following species: *Anogeisus leiocarpus*, *Boswellia dalzielii*, *Acacia polyacantha*, *Prosopis africana*, *Khaya senegalensis* and *Adansonia digitata*.

2.2 Methods

The methodology is based on botanical surveys in the plots, surveys of a sample of 999 woody operators, analysis of the topographic map of Garoua at 1/200,000 and the Landsat 2016 image on Google Earth , GPS ground surveys and direct field observations.

In total 304 plots of 50m x 50m (0.25 ha) were completed. They are unevenly distributed in the 7 plant formations in the watershed (Table 1).

Table 1: The number of plots and the sampling rates in relation to the areas of plant formations in the Mayo Sorawel watershed

Plant formation (2016)	Area in hectare	Number of plots completed	Rate (%)
Degraded forest gallery	148,45	4	0,67
Wooded savannah	760,05	18	0,59
Tree-planted reforestation park	516,96	11	0,53
Shrub savannah	1616,37	34	0,52
Degraded shrub savannah	3150,61	70	0,55
Growing area with some trees	8105,87	161	0,50
Bare crop area	261,69	6	0,57
Total	14560	304	0,52

The different actors are asked to quote the prized species and to say whether the distance to the collection sites has increased or decreased. Field observations focused on the exploitation methods developed by the various actors in order to identify those that lead to the extinction of species.

The data obtained were processed in Excel 2007. The treatments applied consisted of producing curves, diagrams and tables. Concretely, it is the area-species curve, the calculation of abundance-dominance, the diachronic mapping 1966-2016 of plant formations, the mathematical indices of biodiversity and the rate of dynamics which are recognized scales of interest. diversity analysis (Frontier, 1999). For cartography, MapInfo Professional 8.5 software was used.

Braun-Blanquet's abundance-dominance coefficients (Walter, 2006) are used. Diversity indices make it possible to assess the impact of disturbances on diversity. The Shannon diversity index best known and most used by specialists (Frontier, 1999) in the analysis of biological diversity is chosen.

This index is expressed in bits and the formula is:

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

with H ': Shannon biodiversity index; i: a species of the study environment; S: the specific richness or total number of species in the study environment and pi: proportion of a species "i" compared to the specific richness (S) or total number of species in the study environment. The assessment of Shannon's index is as follows:

- if H '<3bit, the floristic diversity is low;
- if 3 ≥ H '> 4bit, the floristic diversity is average;
- if H '≥ 4 bit, the floristic diversity is strong.

The dynamic rate is the difference between the mortality rate and that of regeneration. The regeneration individuals are sub-shrubs and shrubs whose h <4 m (DNCN, 2009) and the formula is:

R= (Number of individuals regenerated (h<4m)/ Total number of individuals)x 100

The mortality rate is the ratio expressed as a percentage between stumps and dead feet on the one hand and all individuals of a species on the other. It allows to appreciate the mortality of the species. The formula is:

M (%) = (Number of strains and dead individuals/ Total number of individuals) x100

The resulting rate of dynamics provides information on the degradation or restoration trend of a species.

D (%) = R(%) – M (%)

If D (%) <0, the dynamics are regressive; if D (%) = 0, the vegetation is static; if D (%)> 0, the dynamics are progressive. At the species level, it gives the dynamics of each species and then makes it possible to list all the threatened woody species.

3. Results

1) Low woody specific richness in the Mayo Sorawel watershed

In this analysis, the cumulative curve of the species and the coefficient of abundance-dominance are used to assess the specific richness of the woody plant cover of the watershed.

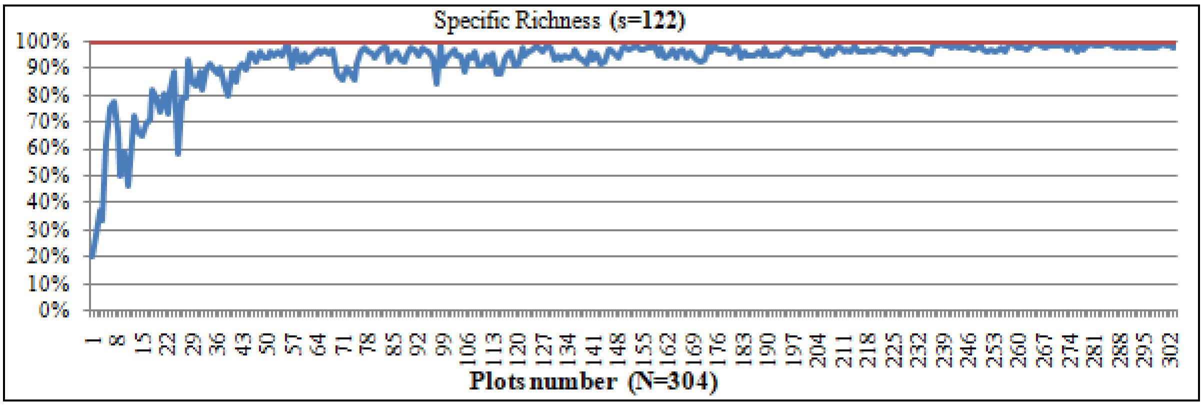

Figure 2: Cumulative curve of specific richness in the Mayo Sorawel watershed
Source: Botanical surveys, 2018

The asymptotic shape of the curve from survey 249 is proof that the 304 surveys carried out are sufficient to account for the total richness of the woody plant cover in the watershed. From this statement 249, there is no longer any real appearance of new species in the plots. In addition, the specific richness (S = 122) is very low because the average number of species per survey is only 0.40. Such a situation means that many of the prized species are extirpated by excessive exploitation.

2) The coefficient of abundance - dominance witnessing an unequal distribution of species in woody families

Abundance is linked to the family representativeness rate while dominance represents the recovery of all individuals of a given species. The scale of abundance-dominance coefficients used is that of Braun-Blanquet taken up by the National Directorate of Nature Conservation (DNCN, 2009) in Mali. The number of individuals and species in families shows a disparity (Table 2).

Table 2: Abundance-dominance of woody families in the Mayo Sorawel watershed

N°	Family	Number of feet	%	coefficients	N°	Family	Number of feet	%	coefficients
1	*Anacardiaceae*	194	4,97	1	18	*Loganiaceae*	23	0,58	+
2	*Anonaceae*	405	10,38	2	19	*Meliaceae*	180	4,61	1
3	*Apiaceae*	3	0,07	+	20	*Mimosaceae*	672	17,2	2
4	*Apocynaceae*	32	0,82	+	21	*Moraceae*	*54*	1,38	1
5	*Asclepiadaceae*	43	1,10	1	22	*Moringaceae*	1	0,02	r

6	*Balanitaceae*	91	2,33	1	23	*Myrtaceae*	15	0,38	+
7	*Bignoniaceae*	32	0,82	+	24	*Olacaceae*	32	0,82	+
8	*Bombacaceae*	43	1,10	1	25	*Palmeae*	9	0,23	+
9	*Boraginaceae*	1	0,02	r	26	*Polygalaceae*	2	0,05	+
10	*Burseraceae*	246	6,30	2	27	*Rhamnaceae*	184	4,71	1
11	*Caesalpiniaceae*	397	10,18	2	28	*Rubiaceae*	26	0,66	+
12	*Capparaceae*	25	0,64	+	29	*Sapotaceae*	20	0,51	+
13	*Celastraceae*	23	0,58	+	30	*Sterculiaceae*	64	1,64	1
14	*Combretaceae*	848	21,74	2	31	*Tiliaceae*	47	1,20	1
15	*Ebenaceae*	17	0,43	+	32	*Ulmaceae*	6	0,15	+
16	*Euphorbiaceae*	100	2,56	1	33	*Verbenaceae*	16	0,41	+
17	*Fabaceae*	48	1,23	1	**TOTAL**		3899	100	/

Source: Botanical surveys, 2018

This table shows four categories of families in the watershed: rare families with a single individual, poorly represented families with very low recovery, dispersed families with recovery <5% and families with recovery between 5–25 % of the reference surface. Rare families with a single individual “r” have a rate of 0.02% reflecting their rarity in the watershed. These are Boraginaceae and Moringaceae. The families with few individuals and a very low recovery "+" whose rate is higher than 0.02% and lower than 1% are fifteen in total and represent 45.45% of the woody families of the catchment area. These are Apiaceae, Apocynaceae and Olacaceae. The family of Balanitaceae is exclusively represented by the species *Balanites Eagyptiaca* and that of Meliaceae by two species of unequal proportion *Azadirachta indica* 141 feet and *Khaya senegalensis* with only 39 feet.

3) A regressive dynamic of wood diversity in the Mayo Sorawel watershed

The rate of specific dynamics and the Shannon diversity index are the parameters used in this analysis.

3.1 Woody diversity threatened in the watershed

The rate of regeneration R (%) and that of mortality M (%) make it possible to identify the rate of specific dynamics D (%). This makes it possible to say whether diversity is preserved in plant formation D (%)> 0 or whether it is degraded D (%) <0. The rates of species dynamics are negative in degraded plant formations and even in the reforestation park (table 3).

Table 3: Specific dynamics in the plant formations of the Mayo Sorawel watershed

Plant formations	Number of feet	number of regeneration individuals	Number of dead individuals	R (%)	M (%)	D(%) = R – M
Degraded forest gallery	121	91	98	75,20	80,99	-5,78
Wooded savannah	685	76	39	11,09	5,69	5,40
Slightly degraded shrub savannah	1163	385	101	33,10	8,68	24,41
Degraded shrub savannah	1362	885	956	64,97	70,19	-5,21
Reforestation park	60	12	25	20	41,66	-21,66
Crop area with some trees	426	415	824	97,41	193,42	-96,00
Nearly bare crop area	18	16	58	88,88	322,22	-233,33
Total	3835	1880	2101	49,02	54,78	-5,76

Source: Botanical surveys, 2019

The table shows that the dynamics of woody species are regressive at the watershed scale with D = -5.76%. The diversity of woody species is conserved D (%)> 0 only in the plant formations of shrubby savannah with little degradation D = 24.41% and wooded savannah d = 5.4%. But it is threatened D (%) <0 in almost bare crop areas D = -233.33%, crop areas with a few trees D = -96%, the reforestation park D = -21.66%, the degraded forest gallery D = -5.78% and the degraded shrub savannah D = -5.21%.

3.2 Shannon's index showing low wood diversity in degraded formations

The diversity index has low values in degraded plant formations (Table 4).

Table 4: Diversity indices in the plant formations of the Mayo Sorawel watershed

Diversity settings	Degraded forest gallery	Wooded savannah	Reforestation park	Slightly degraded shrub savannah	Degraded shrub savannah	Crop area with some trees	Nearly bare crop area
Specific wealth (S)	27	68	15	88	56	18	06
Specific frequency (N)	121	685	60	1163	1362	426	18
Shannon index $H' = -\sum Pilog_2 Pi$	3,662873	4,9485	2,9651	5,23041	2,95100	2,53004	1,97493

Source: Botanical surveys, 2019

It appears from this table that the diversity is high H ≥ ≥ 4 bit only in the slightly degraded shrub savannah formations H ’= 5.23 bit and the wooded savannah H’ = 4.94 bit. It is average with 3 ≥ H ’> 4 bit in the degraded forest gallery H’

= 3.66 bit. But the woody diversity is low H '<3bit in the reforestation parkland formations H' = 2.96 bit, the degraded shrub savannah H '= 2.95 bit, the crop area with some trees H' = 2, 53 bit and in the almost bare crop area H '= 1.97 bit. However, the current trend is towards shrinking areas of wooded formations and the scarcity of prized species.

4. Regression of wooded formations and scarcity of woody species prized in the Mayo Sorawel watershed

4.1 A diachronic dynamic 1966-2019 regressive of wooded formations

The 1966-2019 diachronic mapping of plant formations shows a regression in the areas of wooded formations in the watershed (Figure 3).

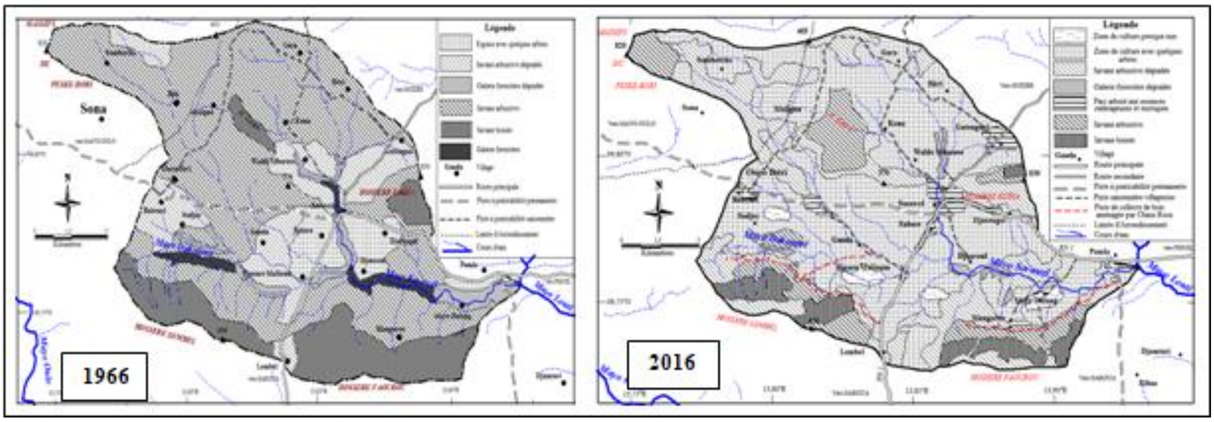

Figure 4: Regressive dynamics of wooded formations in the Mayo Sorawel watershed
Source: Garoua NC-33-VIII topographic map, scale 1/200 000 of the vertical aerial photographic cover 1966-196, Landsat images from 31/12/2016 on Google Earth and ground surveys carried out from 09 February to 04 March 2019

The figure shows that the wooded plant formations shrink from 11,507.33 ha in 1966 to only 3,041.83 ha in 2016. The degraded plant formations are increasingly vast: degraded shrubby savannah, degraded forest gallery, tree-planted reforestation park, areas of crops with a few trees and bare cultivation areas cover 83.68% of the catchment area. The regression of wooded formations is also the degradation of woody diversity in the watershed.

4.2 The scarcity of prized species confirmed by woody operators

Surveys of those involved in the exploitation of wood reveal that the prized species are rare, some almost no longer exist (Table 5).

Table 5: Scarcity of prized species confirmed by operators in watershed

Species	firewood (460 respondents)			Coal production (94 respondents)			Service wood and crafts (445 respondents)		
	N	**% 1**	**% 2**	**N**	**% 1**	**% 2**	**N**	**% 1**	**% 2**
Combretum molle	460	100	98,23	0	0	0	23	05,16	97,65
Prosopis africana	423	91,95	100	94	100	100	445	100	100
Anogeissus leiocarpus	460	100	100	94	100	100	445	100	100
Balanites Eagyptiaca	432	93,91	95,26	94	100	98	445	100	100
Acacia ataxacantha	451	98,04	91,34	67	71,27	87,32	0	0	0
Combretum lecardi	438	95,21	97,26	0	0	0	35	07,86	67,25
Sclerocarya birrea	173	37,60	78,03	64	68,08	87,65	445	100	82,35
Acacia kirkii	453	98,47	91,01	0	0	0	0	0	0
Acacia senegal	439	95,43	94,00	0	0	0	0	0	0
Strychnos spinosa	460	100	100	34	36,17	100	321	72,13	90,25
Combretum glutinosum	456	99,13	98,26	56	59,57	87,65	27	06,06	61,32
Pterocarpus erinaceus	257	55,86	80,24	94	100	100	34	07,64	100
Stereospermum kunthianum	158	34,34	76,36	88	93,61	100	24	05,39	65,32
Guiera senegalensis	354	76,95	80,00	79	84,04	100	26	05,84	100
Diospyros mespiliformis	367	79,78	87,57	89	94,68	100	445	100	100
Terminalia avicennioide	186	40,43	90,26	64	68,08	87,00	354	79,55	78,35
Combretum nioroense	458	99,56	100	35	37,23	78,35	24	05,39	52,32
Sarcocephalus latifolius	156	33,91	89,57	87	92,55	100	21	04,71	84,61
Khaya senegalensis	157	34,13	97,88	58	61,7	100	445	100	100
Entada africana	433	94,13	56,61	34	36,17	89,65	23	05,16	64,32
Andira inermis	89	19,34	87,75	87	92,55	100	320	71,91	100
Ximenia americana	420	91,3	89,25	2	02,12	58,62	24	05,39	51,32

Bauhinia rufescens	37	08,04	58,34	88	93,61	100	397	89,21	100
Burkea africana	98	21,3	72,13	62	65,95	87,32	215	48,31	100
Dalbergia melanoxylon	238	51,73	100	94	100	100	445	100	100
Isoberlinia doka	37	08,04	57,88	34	36,17	100	310	69,66	87,64

Source: Field surveys, 2019

These are the top ten most valued woody species in each of the three uses. The appreciation of the species being linked to the use, the number of species is then more than ten. The N is the number of operators surveyed who cited the species as prized in a use. Rate 1 (% 1) is that of N compared to the actors surveyed. Rate 2 (% 2) is that of operators who have recognized the rarity of the prized species by increasing the distance to collection points. The table 5 shows that several woody species are valued for all the three main uses selected. These species are *Prosopis africana*, *Anogeissus leiocarpus*, *Balanites Eagyptiaca* and *Dalbergia melanoxylon*. Almost all of the prized species are declared rare by operators, more than 50% say that the distance to collection sites has increased.

4.3 Unsustainable exploitation techniques

Field observations show that crop clearing (photo 1), charcoal production (photo 2), skinning of trunks for pharmacopoeia (photo 3) and cutting of wood fuel by Chaux Roca (photo 4) are unsustainable techniques.

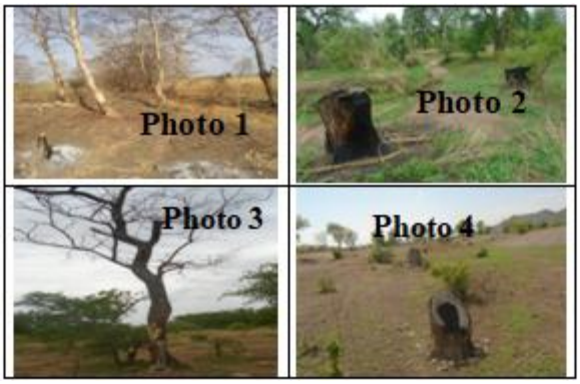

Planche 2. Exploitation of woody trees for various purposes

The photo shows a central shot of acacia polyacantha feet skinned around the trunk. In the foreground, burnt stumps. Photo 2 shows in the central plan strains of Prosopis africana burned for the production of Coal. The incineration of the strains cancels the regeneration on the strain and is a threat to the target species. Photo 3 shows a Pterocarpus erinaceus in the drying phase following the excessive harvesting of bark for the pharmacopoeia. Photo 4 illustrates a cut to ground level made by the company Chaux Roca. Releases from such strains are exposed to animal grazing and bush fires.

5. Discussion

The degradation of biodiversity is a disturbance for ecosystems and a threat to certain local economies. The woody diversity in the Mayo Sorawel watershed is deteriorating. The negative values of the species dynamic rates (D%): -5.21% in the degraded shrub savannah, -5.78% in the degraded forest gallery, -21.66% in the tree-planted reforestation park, -96% in the growing area with a few trees and -233.33% in the bare growing area show this deterioration. The low Shannon diversity index values (H '<3 bit) also characterize these degraded shrub savannah formations H' = 2.95 bit, the park planted with reforestation on dwellings H '= 2.96 bit, the area crop with some trees H '= 2.53 bit and the bare crop area H' = 1.97 bit. Degradation of woody plant cover is a general problem throughout the Sudano-Sahelian region of Africa (Yamin et al., 2002). The main cause is anthropogenic pressure due to an increasing demography which implies increasing needs for fields and wood. The production of charcoal and the cutting of fuelwood for profit which the services in charge of the forests no longer seem to control effectively (Yamin et al., 2002) are stimulated by high demand. The current trend towards the extension of fields and dwellings only increases this degradation.

In the Mayo Sorawel watershed, wood cutting techniques are unsustainable. The razor cut of the soil applied by Chaux Roca exposes discards on stumps to animal grazing and to bush fires. Coal production techniques of incinerating even the strains threaten the target species of *Prosopis africana* and *Anogeisus leiocarpus*. These unsustainable timber harvesting techniques support Garett Hardin's "stowaway" theory. The actors in their behavior seek to harvest as much wood as possible, trampling on regeneration measures. Contrary to Essogo (2010) and Djonga (2012) who think that the plants produced by Chaux Roca repair the damage of this company to the environment, the negative rate of species dynamics D = -21.66% and the low index of diversity of Shannon H '= 2.96 bit in the reforestation park means that this action does not restore woody diversity. The plants produced are essentially species from elsewhere (Yengué, 2002; Ets ROCAGLIA, 2017): Azadirachta indica native to India and Burma, Cassia seamea from India, Burma and Ceylon, and Eucalyptus camaldulensis of Australian origin (Von Maydell, 1981). In northern Cameroon, we are witnessing in towns and villages alike a sort of "Azadirachtahisation" of plant areas in residential areas, storefronts of public services and the edges of communication routes. Riera et al. (2014) explain that the introduction of new species that become invasive can be a cause of biodiversity loss insofar as it induces profound changes in communities and the functioning of ecosystems. Sounon Bouko et al. (2007) also arrived at the same result by studying the effects of land use on the flora diversity of open forests and savannas in Benin. To restore woody diversity Ganota (2016) suggests the cultivation of endangered species.

In this deterioration, the responsibilities between the actors are complex in the watershed. The stumps resulting from the cutting carried out by the company Chaux Roca are incinerated by the charcoal burners thus canceling the releases on stump. The same is true of releases from stumps resulting from cross cutting at ground level which are exposed to animal grazing and to bush fires.

6. Conclusion

From all of the above, the degradation of woody diversity (H '<3 bit) characterizes the plant formations of degraded shrub savannah, a park planted with reforestation on dwellings and the cultivated areas of the watershed. The unsustainable exploitation techniques applied by the local populations and the Chaux Roca company are the main parameters of this degradation. Biodiversity contributes to the balance of ecosystems and local economies. Given the importance of woody diversity and the ecological fragility of this area, actions to restore woody diversity must be undertaken. The production of seedlings of prized and endangered natural species, the teaching of populations of sustainable woody exploitation techniques and the practice of assisted regeneration are to be undertaken and encouraged.

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