



STATE OF LIGNEOUS RESOURCES OF FOUR PASTORAL ZONES OF BURKINA FASO: SIDERADOUGOU, NOUAHO, BARANI AND CEEKOL NAGGE

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ABSTRACT

The agrostological characteristics were studied in four pastoral zones of Burkina Faso: Sidéradougou in southern Sudanian zone, Nouaho in Sudanian zone, Barani in north sudanian zone and Ceekol Naggè in the Sahel. The objective is to establish a detailed diagnosis of the state of woody forage resources of the four areas and achieve the proposed actions to improve pastoral production. Inventory works were conducted in units concerning the four grazing areas. The results of the study show the great diversity of pastoral areas between the different agro-ecological zones. There are on average 2-6 times more diversity in the South compared to the Sahel. The density of woody species is 20 times higher in the south Sudanian pastures (1163-4991 species/ ha) compared to those in the Sahel (80-258 species/Ha). There are many constraints in pastoral areas. In the South they are more related to the management and degradation of pasture vegetation. Pastoral areas of these regions are under severe pressure marked by an invasion of the lowland units particularly rich in plant diversity for food and cash crops production by agriculturalists. In Sahel the forage production is weak due to land degradation and lack of rain. The recommended actions from the assessment work and interviews with pastoralists and taking in count existing experiences in Burkina Faso, revealed six main points: (i) the fight against bush fires, (ii) compliance with the carrying capacity, (iii) monitoring the dynamics of pastures, (iv) reforestation, (v) the restoration of degraded areas, (vi) capacity building for producers.

Mots clés : Pastoral zone, ligneous, fodder, breeder, Burkina Faso.

INTRODUCTION

In Burkina Faso, livestock systems are essentially traditional. They are mostly extensive type with herding systems dominated by practices using forage resources derived from natural pastures and fields (Grouzis 1988). Livestock has been characterized in recent years by an increase in livestock 19.5% for cattle, 30% for sheep and 27.9% for goats, main species. At the same time, these resources that form the basis of production systems experiencing severe degradation due mainly to the adverse effects of climate change but also to population pressure. It follows a strong pressure on the pastoral areas traditionally dedicated to animal production. This is manifested by the extension of the agricultural frontier into natural pastures; about 3.3% of grazing land is cultivated each year (MRA, 2004). The reduction of grazing areas and the poor quality of forage species in recent years have not really been offset by good grazing management.

The overall dynamic row to the adverse effects of drought and population pressure has led to a certain duality between agriculture and animal husbandry in all regions of Burkina Faso. Added to this, are the bad practices of farmers that lead to degradation and widespread disruption of its forage resources and their modes of operation. It is in this context that the Government of

Burkina Faso through the Ministry in charge of Animal Husbandry has undertaken the creation of pastoral zones in order to secure and develop the livestock sector. These zones are identified to be used in animal production. In order to improve the production, development and security measures are taken in each zone. Currently, Burkina Faso has about 26 functional pastoral areas and 156 other areas or potential pasture areas (DGEAP, 2012). Each of these areas needs the support of technical services, particularly livestock, associations / NGOs, farmers' unions to develop and create genuine development poles.

The objective of this work is to characterize woody forage resources in four pastoral areas representative of the country agroecological areas in order to propose some actions for improvement. This study should provide a diagnosis of the state of fodder resources of the four investigated and pastoral areas to achieve the proposed actions to contribute to the formulation of the program. Pastoral areas studied are Ceekol Naggè the Sahel, Sidéradougou to the west, Nouhao in the central east, and Barani in the north of the country.

MATERIALS AND METHODS

Location

The study was conducted in four pastoral regions distributed along the main climatic zones namely the Sahel, the Sudanese and South Sudanese (Figure 1). These are:

- Pastoral zone of Sidéradougou located in south-Sudanese zone and straddling the provinces of Comoé and Houet in western Burkina Faso.
- The valley of the Nouhao is situated in the Sudanian zone in the Central East region, straddling the provinces of Boulgou and Koulpelgo. This is an area of 200,000 hectares, drained by the Nouhao River, a tributary of the Nakambé River.
- The pastoral zone of Barani is constituted by a set of 42 villages. It is located northwest of Burkina in the department of Barani, Kossi Province. It was traditionally reserved for a rest area of the animals during the rainy season. It covers an area of 48 923.75 ha and is limited to: (i) the north by the border with the Republic of Mali, (ii) to the south, east and west by a firewall of 10m wide between the villages of Torokoto, Karékuy, Boulé, Pampakuy, Boulemporo, Kinséré, Wéréssé, Wérébèré, Koube and Illa.
- The pastoral zone of Ceekol Naggè located north of the town of Dori in Seno province between 14 ° 04'04, 8" and 14 ° 13'54" north latitude and longitudes 0 ° 13'25 .68 "East and 0 ° 04'4 .32" West. It has an area of 25,574 ha and covers 12 administrative villages and two areas of the commune of Dori;

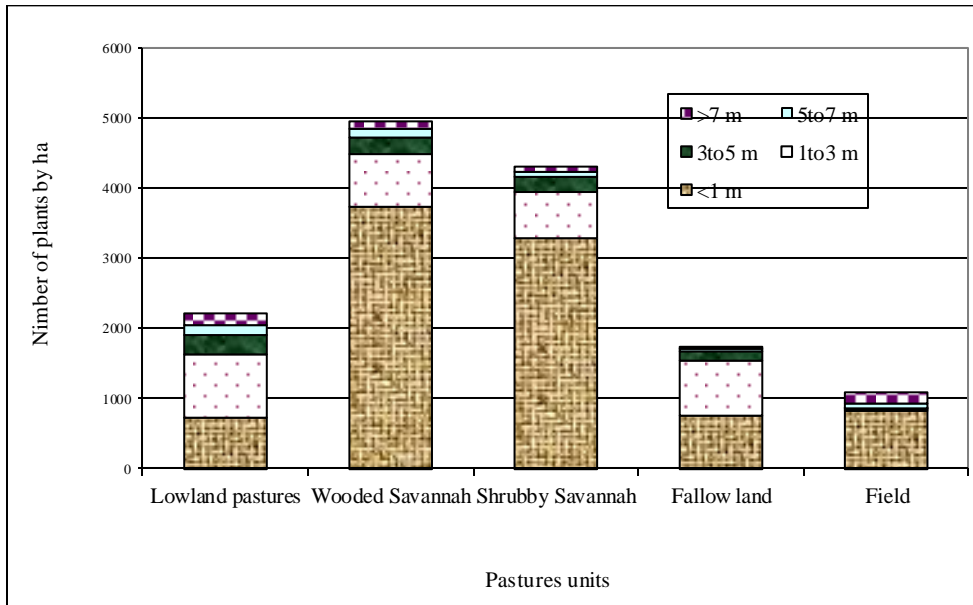


Fig. 1: Density of woody vegetation by stratum on the pasture units in the pastoral zone of Sidéradougou

Sampling for pasture assessment in pastoral areas

Based on the information collected on soil occupation maps from different pastoral areas, preliminary work was to make the choice of potential sites to study. For each area the main types of vegetation most represented were selected. Thus, in Sidéradougou and Ceekol Nagge five vegetation types were chosen by pastoral zone, six in Nouaho and eight in Barani. Concerned types of vegetation are: flooded zones, lowlands, savannas, shrublands, and types of glaze on shrub-steppe, the sandbars, the fallows, the farmlands or fields under cultivation. For each of the types of vegetation, three ecological monitoring stations have been established to cover areas or units which are most represented. On these stations, the observations consisted of floristic analysis of woody vegetation, the description of the environment, etc. The stations were representative of vegetation to which they belong. The materialization of units was done using GPS readings points.

It should be noted that by definition, the ecological station (units) means a portion of any extended territory, often restricted, in which ecological conditions are homogeneous and is characterized by a uniform vegetation (Godron et al, 1968.). In the case of this work, the size of the stations has been fixed taking into account the standards recommended by Boudet (1991) which offers $\frac{1}{4}$ to 1 ha in savannah depending on the density of woody cover and 1 ha in the Sahel. This choice has to take into account the diversity of vegetation types that are at the same time based on landforms, geomorphic units and water conditions. Woody vegetation was studied in each ecological investigation station.

Inventory of woody vegetation

For the inventory of woody vegetation, after the identification of species by their scientific names, the global recovery, the number of individuals, their height and health status were the parameters studied. These parameters characterize the vegetation types, to understand the density of species, their health status and type of pressure exerted on them.

Counting

In selected stations, the method ¼ ha or circular hectare was used for counting. Delimitation of hectare was made using a tape measure (an area of radius 1/4 or 1 hectare). For each survey, a comprehensive floristic inventory of woody vegetation was made by identification of the plant (its scientific name), the stratum (0 to 1m, 1 to 3m, 3 to 5 m, 5 to 7m, > 7m) and estimation of the vitality (regeneration, mortality) as a code defined by an inventory sheet.

Recovery of ligneous species

The recovery rate reflects the ground projection of the crowns of wood. To estimate the rate of recovery several methods exist, but the indirect method is the one that was used in this study. It is estimated on a parcel whose surface is well defined, the surface of the crowns of wood present by measuring means a representative sample of each stratum diameters. The mean diameter is determined from the measurements of two extreme dimensions (large diameter and small diameter) of the ring along an axis perpendicular. The average of these two measurements gives the average diameter of the crown. Recovery action has been performed twice for each species and stratum on each inventory station. The recovery rate (R %) was obtained as the ratio between the surface of the crowns and the surface of the plot in question. The report is reduced to 100 for the recovery rate as a percentage.

Material used and method of preliminary data processing

The material used consisted of strings of 50m long, 50m tape measures, GPS, data collection sheets and a device photographic. Add to this the literature on botany and ecology. Quantitative assessment of vegetation data were entered in the computer as Excel spreadsheet software.

RESULTS

The results of the evaluation on four pastoral areas are presented below. For the herbaceous layer, the results concern the floristic composition, pastoral value, biomass and capacities. For woody stratum, the results obtained relate to the floristic composition, density, rate of recovery, the pastoral interest and floristic dynamics through cuts, death and regeneration.

The pastoral area of Sidéradougou

Woody vegetation in the pastoral zone was evaluated on the different stations. This inventory allows showing the diversity of woody species in the pastoral zone, their specific contribution and especially their pastoral interest.

Floristic composition

Woody vegetation is about 103 species in 35 families. The importance of families varies depending on the vegetation units. From a general observation *Caesalpiniaceae* (25.3%), *Combretaceae* (15.5%), *Mimosaceae* (11.7%), *Rubiaceae* (9.3%) are the most important families in terms of contribution to the species density and those with the greatest number of species.

In the lowlands (43 species), the most important families are constituted by the *Rubiaceae* family with 8 families followed by *Caesalpiniaceae* with five families, *Combretaceae* (4 families species) and *Euphorbiaceae* (4 species). The savanna woodlands are important with 58 species. The *Combretaceae* (7), *Caesalpiniaceae* (6), *Papilionaceae* (4), *Apocynaceae* (4) are the most representative families of this unit. On shrublands (58 species) grow mainly *Combretaceae* (10), *Rubiaceae* (6), the *Mimosaceae* (5), *Caesalpiniaceae* (4) With 44 species in fallow, the important families are *Combretaceae* (8) followed by *Mimosaceae* (6), *Rubiaceae* (5), *Caesalpiniaceae* (4), etc.. In the farmlands (32 species), the spared species during clearing (Figure 4) species are especially families *Combretaceae* (4 species), *Caesalpiniaceae* (4 species) and *Mimosaceae* (6 species).

Table 1: Woody species characteristic of the units of pasture lands in the pastoral zone of Sideradougou in 2012

Lowland pastures	Shrubby Savannah	Wooded Savannah	Fallow land	Field
<i>Cassia sieberiana</i> DC. (4.7%)	<i>Detarium microcarpum</i> Guill. & Perr. (5.4%)	<i>Aformosia laxiflora</i> (Benth. ex Bak.) Harms (11.2%)	<i>Combretum nigricans</i> Lepr. ex Guill. & Perr. (4.7%)	<i>Dichrostachys</i> <i>cinerea</i> (L.) Wigt et Arn. (20.6%)
<i>Daniellia oliveri</i> (Rolfe) Hutch. et Dalz. (22.9%)	<i>Gardenia ternifolia</i> Schum. & Thonn (8.0%)	<i>Combretum molle</i> R. Br. ex G. Don (4.3%)	<i>Diospyros mespiliformis</i> Hochst. ex. A. Rich. (5.8%)	<i>Diospyros</i> <i>mespiliformis</i> Hochst. ex. A. Rich. (3.7%)
<i>Mimosa pigra</i> L. (7.1%)	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh (10.6%)	<i>Daniellia oliveri</i> (Rolfe) Hutch. et Dalz. (4.4%)	<i>Isobertinia doka</i> Craib et Stapf (15.8%)	<i>Isobertinia doka</i> Craib et Stapf (19.7%)
<i>Mitragyna inermis</i> (Willd.) Kuntze (8.4%)	<i>Pteleopsis suberosa</i> Engl. et Diels (9.4%)	<i>Dichrostachys cinerea</i> (L.) Wigt et Arn. (12.8%)	<i>Piliostigma thonningii</i> (Schumach.) Milne- Redh (10.8%)	<i>Gardenia ternifolia</i> Schum. & Thonn (3.7%)
<i>Moghania faginea</i> (Guill. & Perr.) Kuntze (8.7%)	<i>Pterocarpus erinaceus</i> Poir. (19.2%)	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh (3.9%)	<i>Securinega virosa</i> (Roxb. ex Willd.) Voigt (12.8%)	<i>Piliostigma</i> <i>reticulatum</i> DC.) Hochst. (5.5%)
<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh (5.8%)	<i>Terminalia laxiflora</i> Engl. (4.3%)	<i>Pteleopsis suberosa</i> Engl. et Diels (4.0%)	<i>Terminalia mollis</i> Laws. (16.2%)	<i>Securinega virosa</i> (Roxb. ex Willd.) Voigt (6.4%)
<i>Pseudocedrela kotschyi</i> (Schweinf.) Harms (8.0%)	<i>Vitellaria paradoxa</i> Gaertn. f. (5.3%)	<i>Vitellaria paradoxa</i> Gaertn. f. (7.0%)	<i>Vitellaria paradoxa</i> Gaertn. f. (4.8%)	<i>Vitellaria paradoxa</i> Gaertn. f. (10.0%)
<i>Vitex simplicifolia</i> Oliv. (7.1%)		<i>Saba senegalensis</i> (A. DC.) Pichon (4.2%)		<i>Terminalia laxiflora</i> Engl. (4.6%)

Specifically woody species present in most lowlands are: *Daniellia oliveri* (Rolfe) Hutch. , and Dalz. (22.9%), *Moghania faginea* (Guill. & Perr.) Kuntze (8.7), *Mitragyna inermis* (Willd.) Kuntze (8.4%), *Vitex* sp (7.1%), *Mimosa pigra* L. (7.1%), *Piliostigma thonningii* (Schumach.) Milne-Redh (5.8%). The average number of plants per hectare is 2249. The structure of the vegetation is characterized by a class of regeneration <1m.

On wooded grassland, the main woody species consist of *Dichrostachys cinerea* (L.) Wigt and Arn. (12.8%) *Aformosia laxiflora* (Benth. ex Bak.) Harms (11.2%), *Vitellaria paradoxa* Gaertn. f. (7%), *Saba senegalensis* (A. DC.) Pichon (4.2%), *Pteleopsis suberosa* Engl. and Diels (3.9%), *Securinega virosa* (Roxb. ex Willd.) Voigt (3.7%), etc. The number of plants per hectare was estimated at 4,991 on average.

Bushland is characterized by a predominance of species *Pterocarpus erinaceus* Poir. (19.2), *Piliostigma thonningii* (Schumach.) Milne-Redh (10.6%), *Pteleopsis suberosa* Engl. and Diels (9.4%), *Gardenia ternifolia* Schum. & Thonn (8%), *Detarium microcarpum* Guill. & Perr. (5.4%), *Vitellaria paradoxa* Gaertn. f. (5.3%), etc. The average number of plants per hectare is 4349 with strong variations between strata of vegetation.

The main tree species on fallow units are *Terminalia mollis* Laws. (16.2%) *Isoberlinia doka* Craib and Stapf (15.8%), *Securinega virosa* (Roxb. ex Willd.) Voigt (12.8%), *Piliostigma thonningii* (Schumach.) Milne-Redh (10.8%), *Diospyros mespiliformis* Hochst. ex. A. Rich. (5.8%), *Combretum nigricans* Lepr. ex Guill. & Perr. (4.7%), etc. The number of plants per hectare is 1757.

On grazing field units or farmlands, the most abundant species are those who were spared by the producers. They consist of *Dichrostachys cinerea* (L.) Wigt and Arn. (20.6%), *Isoberlinia doka* Craib and Stapf (19.7), *Vitellaria paradoxa* Gaertn. f. (10%), *Securinega virosa* (Roxb. ex Willd.) Voigt (6.4%), *Terminalia laxiflora* Engl. (5%). The number of plants per hectare is 1163 (Table 1).

Stratification and density of ligneous species

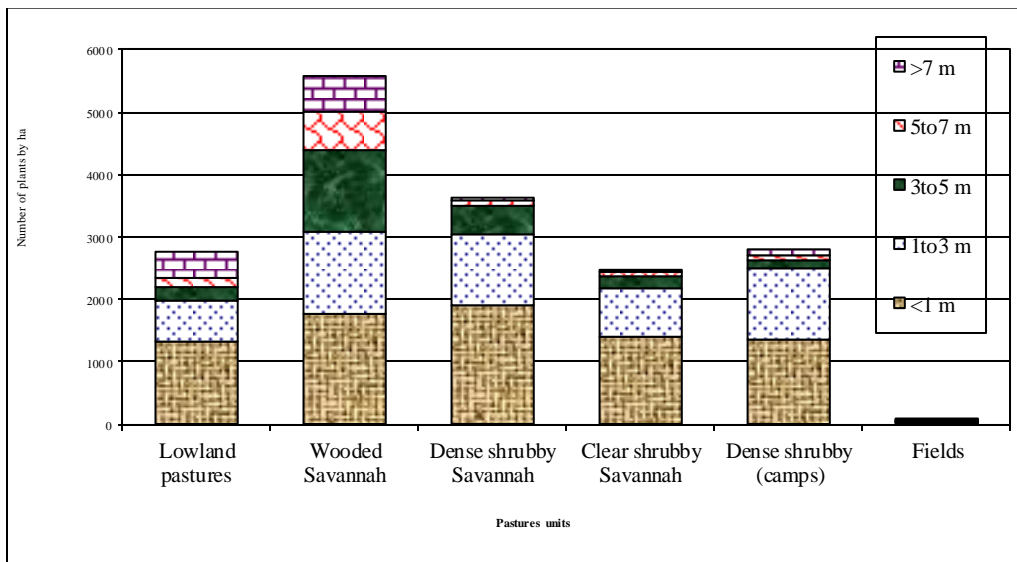


Fig. 2: Density of woody vegetation by stratum on the pasture units in the pastoral zone of Nouaho

The vertical structure of woody vegetation units studied is characterized by a variation of the different strata of vegetation from subjects <1m superiors to subjects> 7 m. The results show that plants stratum <1m are the most important in all units where they constitute between 72-76% of individuals per unit area except the lowlands and fallows or stratum between 1-3 m is greater with a representation rate between 40 and 45%. From a general observation stratum> 7 m considered as trees is small proportion. But it is more important in lowlands (7.5%), tree savannah (2.1%) and fields (14%).

The number of plants per hectare is the largest in the savannas (4991 species per ha), followed by shrub savannah (4349), the lowlands (2249), fallow (1757) and fields with only (1163) (Figure 2). The woody species recovery calculated in all units is 100% on average.

Vegetative State of ligneous

The wood of the pastoral area of Sidéradougou is healthy in overall. Observations have shown that very few plants are affected by cutting or mortality.

The proportion of dead plants was estimated at 1.9% in fallow, 0.8% in the lowlands, 0.7% in bushlands, and 0.1% in each of the other units (savanna and field). This dynamic concerns mainly *Dichrostachys cinerea* (L.) Wigt and Arn.

The proportion of woody trunks cut is low, 0.2% in the lowlands, 0.1% in the savanna woodlands and 0% in the other units. The wood cutting concerns mainly *Isobertia* species doka Craib and Stapf, *Detarium microcarpum* Guill. & Perr., *Lannea microcarpa* Engl. and K. Krause, *Acacia dudgeoni* Craib. ex Holl., *Strychnos spinosa* Lam, *Uapaca togoensis* Pax., *Pterocarpus erinaceus*, *Azelia africana* and *Khaya senegalensis*. In the opinion of producers, these species are mostly taken for various purposes (timber, medicines, fodder, charcoal).

Palatability of woody vegetation

The values reflect the palatability of forage interest of woody species in the pastoral zone. It appears from the evaluation work that the fields (25.7%) and savannas (23-26%) are the units that contain the highest proportion of highly palatable species. However, the gallery forests (63.9%) are units where the proportions of forage tree species are the lowest. Intermediate qualities vary between vegetation units (Table 2).

Table 2: Palatability of the species of woody vegetation in % of their contribution (Sidéradougou)

Palatability	Lowland pastures	Wooded Savannah	Shrubby Savannah	Fallow land	Fields
Very appetee	4.5	22.8	26.3	15.4	25.7
Appetee	21.4	39.3	39.3	45.8	36.6
Little appetee	10.2	8.4	3.3	2.2	3.2
Not appetee	63.9	29.5	31.2	36.6	34.5
Total	100	100	100	100	100

Table 3: Woody species characteristic of the units of pasturelands in the pastoral zone of Nouaho in 2012

Lowland pastures	Wooded Savannah	Dense shrubby Savannah	Clear shrubby Savannah	Dense shrubby (camps)	Fields
<i>Anogeissus leiocarpus</i> (DC.) G. & Perr. (29.6%)	<i>Anogeissus leiocarpus</i> (DC.) G. & Perr. (66.4%)	<i>Combretum glutinosum</i> Perr. ex DC. (22.4%)	<i>Combretum glutinosum</i> Perr. ex DC. (22%)	<i>Combretum glutinosum</i> Perr. ex DC. (10.1%)	<i>Combretum glutinosum</i> Perr. ex DC. (26%)
<i>Borassus</i> sp. Aff. <i>Flabellifer</i> L. (6.2%)	<i>Combretum glutinosum</i> Perr. ex DC. (3.7%)	<i>Gardenia erubescens</i> Stapf. & Hutch. (5.7%)	<i>Acacia hockii</i> De Wild. (4.1%)	<i>Acacia hockii</i> De Wild. (5.2%)	<i>Acacia hockii</i> De Wild. (6.9%)
<i>Combretum glutinosum</i> Perr. ex DC. (6.4%)	<i>Stychnos spinosa</i> Lam (4.8%)	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh (21.6%)	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh (5.9%)	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh (47.1%)	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh (24.2%)
<i>Diospyros mespiliformis</i> Hochst. ex. A. Rich. (6.1%)	<i>Dichrostachys cinerea</i> (L.) Wigt et Arn. (2.2%)	<i>Pseudocedrela kotschyi</i> (Schweinf.) Harms (7.6%)	<i>Anogeissus leiocarpus</i> (DC.) G. & Perr. (5.5%)	<i>Gardenia erubescens</i> Stapf. & Hutch. (7.1%)	<i>Lannea acida</i> A. Rich. (10.4%)
<i>Feretia apodanthera</i> Del. (7.9%)		<i>Terminalia avicenoïdes</i> Guill. et Perr. (5.5%)	<i>Pseudocedrela kotschyi</i> (Schweinf.) Harms (32.5)		<i>Lannea microcarpa</i> Engl. et K. Krause (5.2%)
<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh (6.1%)		<i>Terminalia laxiflora</i> Engl. (6.5%)			<i>Sclerocarya birrea</i> (A. Rich.) Hochst. (3.5%)
<i>Terminalia avicenoïdes</i> Guill. et Perr. (7.4%)					<i>Stereospermum kunthianum</i> Cham. (3.5%)

Pastoral zone of Nouaho

Woody vegetation is described through the floristic composition, plant diversity, densities per species, pastoral interest and vegetation dynamics.

Floristic composition

Woody vegetation is enormous with 70 species distributed in thirty families. The most important families are constituted by the *Mimosaceae* (8.2%), the *Combretaceae* (37.8%), *Rubiaceae* (6.8%), the *Anacardiaceae* (4.6%), *Caesalpiniaceae* (19.6 %), *Meliaceae* (7.8%) and *Bignoniaceae* (2.4%).

Lowland sites (52 species / ha) are the most diverse sites monitored by dense shrublands (38 species / ha) and savannas (33 species / ha). Only a few species (18 species / ha on average) are saved in the fields.

Woody vegetation in the pastoral zone of Nouaho is rich and diverse (Table 3). Specifically, the lowlands are dominated by the following species: *Anogeissus leiocarpus* (DC.) G. & Perr. (29.6%), *Feretia apodanthera* Del. (8), *Terminalia avicinioides* Guill. and Perr. (7.4%), *Diospyros mespiliformis* Hochst. ex. A. Rich. (7.1%), *Borassus flabellifer* L. (6.2%), *Piliostigma thonningii* (Schumach.) Milne-Redh (6.1%), *Combretum glutinosum* Perr. ex DC. (6.4%).

The savanna woodlands are dominated by *Anogeissus leiocarpus* (DC.) G. & Perr. (66.6%), *Strychnos spinosa* Lam (4.8%), *Combretum glutinosum* Perr. ex DC. (3.7%), *Stereospermum kunthianum* Cham. (3.3%), *Terminalia avicinioides* Guill. and Perr. (2.6%), *Annona senegalensis* Pers. (2.3%).

In dense bushlands major species are *Combretum glutinosum* Perr. ex DC. (22.4%), *Piliostigma thonningii* (Schumach.) Milne-Redh (21.6%), *Pseudocedrela kotschy* (Schweinf.) Harms (7.6%), *Terminalia laxiflora* Engl. (6.5%), *Acacia hockii* De Wild. (6.4%), *Terminalia avicinioides* Guill. and Perr. (5.5%), *Gardenia erubescens* Stapf. & Hutch. (5.7%), *Acacia gourmaensis* A. Chev. (3.6%).

For clear bushlands, the following species were mainly distinguished: *Pseudocedrela kotschy* (Schweinf.) Harms (32.5%), *Combretum glutinosum* Perr. ex DC. (22%), *Piliostigma thonningii* (Schumach.) Milne-Redh (5.9%), *Anogeissus leiocarpus* (DC.) G. & Perr. (5.5%), *Acacia hockii* De Wild. (4.1%), *Acacia gourmaensis* A. Chev. (4%), *Annona senegalensis* Pers. (3.02%), etc.

For savannah related to temporary settlements during rainy season, the inventory showed the following species: *Piliostigma thonningii* (Schumach.) Milne-Redh (47.1%), *Combretum glutinosum* Perr. ex DC. (10.1%), *Gardenia erubescens* Stapf. & Hutch. (7.1%), *Acacia hockii* De Wild. (5.2%), *Pseudocedrela kotschy* (Schweinf.) Harms (3.6%) etc.

In the farmfields (Table IX), it is mainly species such *Combretum glutinosum* Perr. ex DC. (26%), *Piliostigma thonningii* (Schumach.) Milne-Redh (24.2%) *Isobertinia doka* Craib and Stapf (10%), *Acacia hockii* De Wild. (7%), *Lannea microcarpa* Engl. and K. Krause (5.2%), *Cissus populnea* G. & Perr. (3.6%), *Adansonia digitata* L. (3.5%), *Dichrostachys cinerea* (L.) Wigt and Arn. (3.5%), *Sclerocarya birrea* (A. Rich.) Hochst. (3.5%), *Stereospermum kunthianum* Cham. (3.5%).

Stratification and density of wood

Stratification of woody vegetation in the pastoral zone of Nouaho is characterized by a change in the pasture units. Generally, the savanna with 5571 vines per hectare appears as the unit with the highest density of vegetation. This population consists of a regeneration of 32% and a stratum of trees greater than 1 m of the order of 10% (Figure 3).

This unit is followed by dense bushlands where the average density is 3624 plants/ha but with a strong recovery in the order of 52% and large trees that represent only 1% of the total number identified.

Shrublands where vegetation is strongly affected by the installation of farming camps have a high wood density of 2797 trees per ha which is essentially made up of regenerated trees (57%), many shrubs (more 31%) and few trees (1%). This unit is followed by lowland with 2757 species per ha with a regeneration reaching 48% and the highest rate of trees with 15% in woody vegetation. The agricultural land is low in woody plants with 77 plants per ha consisting mainly of saved subjects because of their interest for multiple uses certainly. The species identified are mostly large trees as the proportion of subjects greater than 5m is 19% and above 7 m is 27%. Regeneration is low and consisted mainly of regrown plants. The recovery rate of the woody species varies from 100% in the natural vegetation to about 31% in the fields.

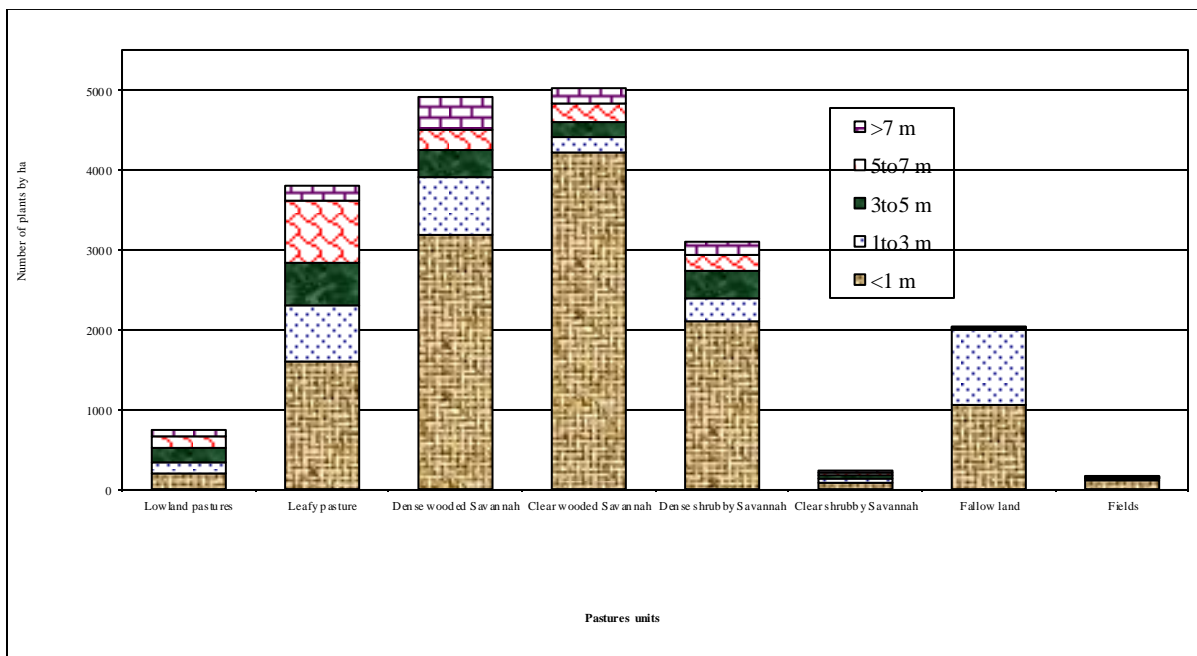


Fig. 3: Density of woody vegetation by stratum on the pasture units in the pastoral zone of Barani

Vegetative State of ligneous

Woody vegetation in the pastoral zone of Nouaho presents a variable vegetative state according to vegetation units.

Compared to plant health, it appears that the highest mortalities are recorded respectively in the low lands (4.5%), the savannas (3.6%), dense shrublands (3.1 %) and other units 0%. These mortalities are due to the effects of fire, high winds that uproot especially species like *Anogeissus leiocarpus* and various other human uses.

The proportion of woody trunks cut is also important and affects the vegetation of grazing lowland units to 7.1% of adult trees, wooded savannas to 1.3%, shrublands related to settlements to 1.5 %, other shrublands (1%). This wood cutting particularly affects *Lannea microcarpa* Engl. and K. Krause, *Annona senegalensis* Pers., *Bridelia ferruginea* Benth., *Combretum molle* R. Br ex G. Don and *Acacia dudgeoni* Craib. ex Holl. The cuts are made primarily for domestic and fodder needs.

Palatability of species of woody vegetation

Pastoral interest of identified plants is shown in Table 4. It appears that the plants spared in the field have for most of them high interest (90%). The vegetation of this unit is followed by that of

savannas (84% of palatable species) shrubs around the settlements (76% of palatable species). Shrublands (25%) and dense lowland (20%) are the units with the highest proportions of unpalatable species.

Table 4: Palatability of the species of woody vegetation in % of their contribution (Nouaho)

Palatability	Lowland pastures	Wooded Savannah	Dense shrubby Savannah	Clear shrubby Savannah	Dense shrubby (camps)	Fields
Very appetee	9.5	6.7	24.4	24.0	15.6	34.6
Appetee	62.9	84.4	50.9	34.9	75.7	57.1
Little appetee	7.6	0.0	0.1	0.0	0.5	1.7
Not appetee	20.0	8.9	24.5	41.1	8.2	6.5
Total	100	100	100	100	100	100

Pastoral zone of Barani

Floristic composition

The woody flora of the pastoral area of Barani is rich of 50 species coming from 21 families. The most important families are composed of *Combretaceae* (46%), the *Mimosaceae* (16%), the *Tiliaceae* (11%), the *Capparidaceae* (8%), the *Zygophyllaceae* (7%), *Rubiaceae* (6%). Other families are less than 2% each. There are wide variations depending on the production units.

The observations in the lowland reveal that the main species are essentially *Balanites aegyptiaca* (L.) Del. (22.8%), *Acacia ataxacantha* DC. (12.8%), *Feretia apodanthera* Del. (12.5%), *Anogeissus leiocarpus* (18.3%), *Acacia seyal* Del. (7.1%), *Combretum micranthum* G. Don (5.0%).

In the bushes, it is mostly *Grewia bicolor* Juss. (30.1%), *Acacia ataxacantha* DC. (21.7%), *Combretum micranthum* G. Don (19.0%), *Boscia senegalensis* (Pers) Lam. ex Poir. (18.9%). In dense savannas species inventoried consist mainly of *Acacia ataxacantha* DC. (25.3%), *Combretum micranthum* G. Don (22.4%), *J. Guiera senegalensis* F. Gmel. (28.9%), *Anogeissus leiocarpus* (DC.) G. & Perr. (5.3%). Clear savannas are rather populated by *Anogeissus leiocarpus* (DC.) G. & Perr. (23.2%), *Combretum micranthum* G. Don (16.3%), *Feretia apodanthera* Del. (25.4%), *Grewia bicolor* Juss. (17.1%), etc. In dense bushland, the main species are *Boscia senegalensis* (Pers) Lam. ex Poir. (26.4%), *Acacia ataxacantha* DC. (19.1%), *Grewia bicolor* Juss. (16.5%), *Combretum micranthum* G. Don (10%), *Dichrostachys cinerea* (L.) Wigt and Arn. (7.3%). In clear bushland, the inventory has especially helped to identify *Balanites aegyptiaca* (L.) Del. (31.8%), *Boscia senegalensis* (Pers) Lam. ex Poir. (13.1%), *Combretum micranthum* G. Don (10.2%), *Acacia seyal* Del. (9.7%), *Adansonia digitata* L. (7.4%), *Combretum fragans* F. Hoffm. (5.7%), *Grewia bicolor* Juss. (5.1%), etc.

Fallows are mostly colonized by *Guiera senegalensis* J. F. Gmel. (99.1%) while in the farms (Table 5), the most encountered species are *Guiera senegalensis* J. F. Gmel. (75.5%), *Sclerocarya birrea* (A. Rich.) Hochst. (5.3%), *Combretum fragrans* F. Hoffm. (4.4%) and *Combretum nigricans* Lepr. ex Guill. and Perr. (4.4%).

Table 5: Woody species characteristic of the units of pasturelands in the pastoral zone of Barani in 2012

Lowland pastures	Leafy pasture	Dense wooded Savannah	Clear wooded Savannah	Dense shrubby Savannah	Clear shrubby Savannah	Fallow land	Fields
<i>Acacia ataxacantha</i> DC. (12.8%)	<i>Acacia ataxacantha</i> DC. (21.7%)	<i>Acacia ataxacantha</i> DC. (25.3%)	<i>Anogeissus leiocarpus</i> (DC.) G. & Perr. (23.2%)	<i>Acacia ataxacantha</i> DC. (19.1%)	<i>Acacia senegal</i> (L.) Willd. (9.7%)	<i>Guiera senegalensis</i> J. F. Gmel (99.2%)	<i>Combretum fragans</i> F. Hoffm. (4.4%)
<i>Acacia seyal</i> Del. (7.1%)	<i>Boscia senegalensis</i> (Pers) Lam. ex Poir. (18.9%)	<i>Anogeissus leiocarpus</i> (DC.) G. & Perr. (5.3%)	<i>Combretum micranthum</i> G. Don (16.3%)	<i>Boscia senegalensis</i> (Pers) Lam. ex Poir. (26.4%)	<i>Acacia seyal</i> Del. (7.4%)		<i>Piliostigma reticulatum</i> DC.) Hochst. (3.5%)
<i>Anogeissus leiocarpus</i> (DC.) G. & Perr. (18.3%)	<i>Combretum micranthum</i> G. Don (19.0%)	<i>Combretum micranthum</i> G. Don (22.4%)	<i>Grewia bicolor</i> Juss. (17.1%)	<i>Combretum micranthum</i> G. Don (10.0%)	<i>Combretum fragans</i> F. Hoffm. (5.7%)		<i>Combretum micranthum</i> G. Don (4.4%)
<i>Balanites aegyptiaca</i> (L.) Del. (22.8%)	<i>Grewia bicolor</i> Juss. (30.1%)	<i>Grewia bicolor</i> Juss. (8.1%)		<i>Grewia bicolor</i> Juss. (16.5%)	<i>Balanites aegyptiaca</i> (L.) Del. (31.8%)		<i>Sclerocarya birrea</i> (A. Rich.) Hochst. (5.3%)
<i>Combretum micranthum</i> G. Don (5.0%)		<i>Guiera senegalensis</i> J. F. Gmel (29.8%)		<i>Pterocarpus lucens</i> Lepr. ex Guill. et Perr. (7.0%)	<i>Boscia senegalensis</i> (Pers) Lam. ex Poir. (13.1%)		<i>Guiera senegalensis</i> J. F. Gmel (75.4%)
<i>Grewia bicolor</i> Juss. (4.8%)					<i>Combretum micranthum</i> G. Don (10.2%)		
					<i>Grewia bicolor</i> Juss. (5.1%)		

Stratification and density of ligneous species

The vertical structure of ligneous vegetation units is characterized by a diverse class distribution of heights. In general, the proportion of the higher plants (class high maximum) is lower than those belonging to the lower classes.

The unit in which the largest number of plants per hectare has been reported is the clear bushland (5073 plants / ha) also with a regeneration record rate of 83% (Figure 4). Plants above 7 m classes do not exceed 3.8%. This unit is followed by dense bushland (4973 plants / ha) where trees are important in the middle class (26%), those of the upper class 7m reach 8.3%. Regeneration was evaluated at 64%. The density in the bush is large (3808 plants / ha) with a proportion of subjects intermediate class equal to 52%. Regeneration is significant (42%) and few trees (4.9% of identified plants).

Dense bushlands have an average density of 3,163 trees per ha consisting of 67% of regenerating trees and 4% of trees. Fallows (2015 plants / ha) consist mainly of regenerating trees (52%) and shrubs (47% of plants between 1 to 3 m height). In the lowlands, the average density is 749 trees / ha with less or well distributed in all classes.

The average regeneration assessed at 26% and trees (> 7m) to 11%. Clear shrublands (235 plants / ha) and fields (152 plants/ ha) units are provided in the least woody plants. The regeneration rate for both units respectively 52% and 73%, and the rate calculated of the trees to 11% and 6.1%. Woody recoveries are more than 100% in all units except clear bushlands, fallows and fields where they are respectively 56.9%, 76.4% and 13.8%.

Vegetative State of ligneous

Woody vegetation in pastoral areas of Barani has a vegetative state fairly well preserved. The works have revealed little mortality in vegetation units. They vary only 10% in the bushlands to 1.3% in clear bushland and 0% in fallows and farm fields. The deaths concern mainly species like *Combretum micranthum*, *Anogeissus leiocarpus*, *Combretum fragrans*. The cut rate is also low. They range from 2.4% in the fields to 0.6% in the clear bushland, 0.4% in dense savannas to less than 0.2% in all other units. The main species involved are the same as those affected by mortality.

Palatability of woody vegetation

The pastoral interest of ligneous resource has been translated into four appreciation classes of palatability and shown in Table 6. This assessment shows that vegetation grazing units do not have the same interest for livestock. Classified species as very palatable grow especially in lowland (35.4%), the bushes (31.7%), and clear shrublands (58.5%). Species considered only "palatable" are higher in fallow land (99.3%), farms (88.6%), and clear shrublands (57.7%). Species " little palatable" are the most important in dense savannas (48.5%) and bushes (42.7%) and lowlands (20.6%). There are few species considered "not palatable" '. In general, the level of palatability of species is high in this pastoral zone.

Table 6: Palatability of the species of woody vegetation in % of their contribution (Barani)

Palatability	Lowland pastures	Leafy pasture	Dense wooded Savannah	Clear wooded Savannah	Dense shrubby Savanna	Clear shrubby Savannah	Fallow land	Fields
Very appetee	35.4	31.7	10.7	23.9	36.4	58.5	0.5	7.0
Appetee	44.0	25.4	40.3	57.7	34.0	30.7	99.3	88.6
Little appetee	20.6	42.7	48.5	18.0	29.4	10.8	0.1	4.4
Not appetee	0.0	0.3	0.5	0.3	0.2	0.0	0.0	0.0
Total	100	100	100	100	100	100	100	100

Pastoral zone of Ceekol Naggè

In the pastoral zone, pasture units are divided into sandy loam graze, gravelly glaze, sandbars, lowlands and cultivated areas or farms. Ligneous vegetation has been evaluated in Ceekol Naggè in all units of vegetation. This assessment allows describing the floristic composition, stratification and plant density, analyzing their pastoral interest and vegetation dynamics.

Floristic composition

The ligneous flora of the pastoral zone of Ceekol Naggè has only 23 species split in 13 families. *Mimosaceae* are the most important (70%), followed distantly by *Zygophyllaceae* (7%), the Milkweed (6%), the *Capparidaceae* (4%) etc. Large variations exist between vegetation units.

The floristic composition of woody vegetation is described in Table 7. It reveals that in the lowlands, mainly *Acacia raddiana* Savi (71.2%), *Balanites aegyptiaca* (L.) Del. (16.1%), *Acacia seyal* Del. (5.2%), *Combretum aculeatum* Wind. (1.5%) are dominant. On sandbars grow *Leptadenia hastata* (Pers.) Decne (22.3%), *Acacia senegal* (L.) Willd. (18.7%), *Bauhinia rufescens* Lam. (17.2%), *Hyphaene thebaïca* (L.) Mart. (12.3%), *Balanites aegyptiaca* (L.) Del. (8%), *Combretum glutinosum* Perr. ex DC. (6.7%), *Faidherbia albida* (Del.) A. Chev. (5.6%), *Maerua crassifolia* Forsk. (5.6%), etc.

Table 7: Woody species characteristic of the units of pasturelands in the pastoral zone of Ceekol Naggè in 2012

Lowland pastures	Silting pasture	Silty Sandy glaxis pasture	Gravelly glaxis pasture	Fields
<i>Acacia raddiana</i> Savi (71.2%)	<i>Acacia senegal</i> (L.) Willd. (18.7%)	<i>Acacia raddiana</i> Savi (92.4%)	<i>Acacia raddiana</i> Savi (82.3%)	<i>Acacia raddiana</i> Savi (52.6%)
<i>Acacia seyal</i> Del. (5.2%)	<i>Balanites aegyptiaca</i> (L.) Del. (8.0%)	<i>Acacia senegal</i> (L.) Willd. (4.3%)	<i>Leptadenia hastata</i> (Pers.) Decne (3.4%)	<i>Balanites aegyptiaca</i> (L.) Del. (7.9%)
<i>Balanites aegyptiaca</i> (L.) Del. (16.1%)	<i>Bauhinia rufescens</i> Lam. (17.2%)		<i>Maerua crassifolia</i> Forsk. (12.9%)	<i>Dichrostachys cinerea</i> (L.) Wigt et Arn. (7.4%)
	<i>Combretum glutinosum</i> Perr. ex DC. (6.7%)			<i>Euphorbia balsamifera</i> Ait. (6.9%)
	<i>Faidherbia albida</i> (Del.) A. Chev. (5.6%)			<i>Hyphaene thebaïca</i> (L.) Mart. (3.3%)
	<i>Hyphaene thebaïca</i> (L.) Mart. (12.3%)			
	<i>Leptadenia hastata</i> (Pers.) Decne (22.3%)			
	<i>Maerua crassifolia</i> Forsk. (5.6%)			

The glazier sandbars are rather dominated mainly by *Acacia raddiana* Savi (92.4%). However, we note the presence of *Acacia senegal* (L.) Willd. A (4.3%), *Maerua crassifolia* Forsk. A (2.2%). In gravelly glaze, the vegetation is dominated by *Acacia raddiana* Savi (82.3%), *Maerua crassifolia* Forsk. (12.9%), *Leptadenia hastata* (Pers.) Decne (3.8%), etc. Farming lands is also host *Acacia raddiana* Savi (52.6%) in proportion, followed distantly by species like *Ziziphus mauritiana* Lam. (13%), *Balanites aegyptiaca* (L.) Del. (7.9%), *Dichrostachys cinerea* (L.) Wigt and Arn. (7.4%), *Euphorbia balsamifera* Ait. (6.9%), *Acacia seyal* Del. (3.1%) etc.

Stratification and density of ligneous species

Inventories showed a low density of ligneous species in the pastoral zone. The vegetation is further characterized by a low number of trees (> 7m). The rate of trees is 1.1%. The vegetation is mainly of shrubs. Specifically, the unit that has the largest number of plants is the glaze sandy - loam (258 species/ ha) with a regeneration rate equal to 41% and 56% of shrubs. Lowlands are the second unit with 224 species/ ha. The regeneration rate is 26%, the shrubs (1to 3m) of 50%. All other units in the pastoral zone have less than 80 species / ha an average and whose main plants are composed by regeneration and shrubs (Figure 4).

The recovery rate of these ligneous trees is low. It varies from 27.5% in the lowlands to 12.8% in sandy glaze - loam, 8.2% in the farms, 7.6% in sandbars and only 1.1% on gravelly glaze.

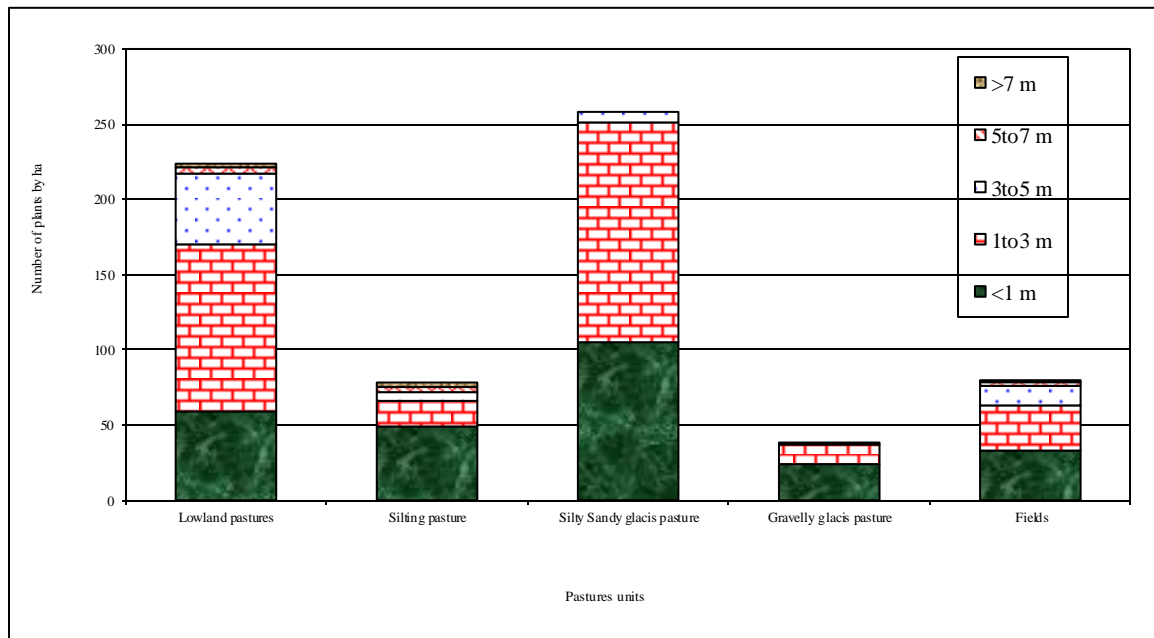


Fig. 4: Density of woody vegetation by stratum on the pasture units in the pastoral zone of Ceekol Naggè

Vegetative State of ligneous

The wood of the pastoral area of Ceekol Naggè are affected by mortality and cuts at very different levels depending on the grazing units.

Overall, the proportion of dead trees is high. This mortality is higher in the gritty glaze with 2.7% of plants; following by sandbar units with 2.3%, sandy loam glaze with 0.7% etc. The species like *Acacia raddiana*, *Acacia senegal* and *Balanites aegyptiaca* are most affected. From the interview with the producers and on our basic observations it appears that the causes are primarily related to

damage from strong winds in early rainy season and drought. The proportions of trees cut reach 4.1% in the lowlands, main pastoral grazing units in any season, 5.1% in the sandy pasture units, 2.7% in the gritty glaze. Species like *Balanites aegyptiaca*, *Acacia raddiana*, *Maerua crassifolia* are affected by the practice of cutting. The main reasons for this operation are to provide fodder to livestock.

Palatability of woody vegetation

The pastoral interest of forage species is shown in Table 8. It clearly shows that the vegetation is composed of forage trees. With the exception of sandy units (64.9%), the level of palatability of the species is very high in all vegetation units (over 90%). There are virtually no unpalatable species in the pastoral area of Ceekol Naggè.

DISCUSSIONS

Floristic diversity

Significant differences were found between the ligneous resources in pastoral areas. According to ecological gradients, differences were observed in the level of species richness, species characteristics, their palatability, etc. (Breman and De Ridder (1991), and Guinko Fontes (1995). The finding reveals that species richness is higher in shrublands and trees at all sites. These units have an average of 1.3 to 1.8 times more species than the lowlands and farms. Also when considering the gradient of the Sahel savanna, the number of species diversity decreases from 103 / ha in southern Sudanian region 70 in the Sudanian region, 50 in North Sudanian zone just 23 in the Sahel. On the other hand, there are 20 times more plants per hectare in Savannah compared to the Sahel.

Specifically it was observed a change in the species composition; woody vegetation occurs gradually with the disappearance of certain species and the emergence of other species such as *Acacia spp.* Western Sahel, the characteristic of the species of vegetation units have been different for all units and all pastoral areas. Similarly, when considering each pastoral area, the species for each unit remain well variables. Units on woody savannas, shrub and lowlands pastures generally have the greatest number of species characteristics.

Pastoral value

In terms of pastoral value, it appears that the pastures of the Sahel include more highly palatable compared to pastoral areas in the Sudanese region species. Specifically very palatable species are more palatable or only present on savannas units and farms while there are on average more unpalatable species in units of lowlands. The measurements showed a good level of vegetation cover in all areas except the Sahel where the level of uncovered soil ranges from 20 to 80%. The level of mortality and exploitation of timber has varied from one area to another. In the Sahel, it is mainly in the shallows and sandbars that the highest rates of mortality cutting were measured. In the northern Sudanian region shrubs and savannah can be seen increasingly. In Sudanian and South Sudanian areas, the shallows are the units where trees cutting practices and the phenomenon of mortality are important compared to other units. These parameters are indicators of the most exploited units and those which suffer most from the effects of deforestation.

Pasture Improvement

This inventory indicates that in the north and Sahel regions, the main constraints on trees fodder are the lack of pastures in terms of continuous grazing damage. Several reasons can explain this observation. The main ones include (i) the increasing failure and irregular rainfall, (ii) the increase in population and livestock, (iii) the lack of grazing land units. Little is being done to improve forage production and the work showed a low density and diversity of plants in pastoral areas in Ceekol Naggè and Barani.

In the Sudanese regions, farmers mostly live with the constraints of pasture degradation which result in a poor quality of browse species. Seeing in general the results, it appears that the

proportions of unpalatable species are more important in these areas. This is mainly due to the increase in animals' size which is added to increase of the farming activities. Pastures are neither managed nor monitored and the weakness of farmers' organization cannot make dynamic rangelands management and actions to be applied.

The main actions may concern mainly the increased development of forage species, improved ways of exploitation of fodder. In the Sahel, development works have shown potential for increasing the diversity of forage species (Toutain and Piot, 1980; Grouzis, 1988; Hien, 1995; Kiema, 2008). In the Sudanian zone techniques of forage implementations also show potential for improving diversity.

The pasture management provides a real asset to the use of tree fodder. Work has actually shown a diversity of woody forage species on pastoral areas. Kiema et al. (2013) showed that the contribution of wood in the dry season was 80 for sheep and 10-15% for cattle in Sahelian areas. Woody species such as *Pterocarpus lucens*, *Balanites aegyptiaca*, *Acacia seyal* *Piliostigma thonningii* provide nitrogen, vitamins and minerals that are lacking in herbaceous species in the dry season. Feeding diets can be established from these species (Ouedraogo et al, 2000. Gnanda et al, 2008. Kiema, 2008). Their judicious use in livestock nutrition will provide an extra protein, vitamins and minerals.

Strengthening capacity of farmers for ecological exploitation of this vegetation should be established. Support for the research of the best forms of exploitation is also considered.

Table 8: Palatability of the species of woody vegetation in % of their contribution (Ceekol Naggè)

Palatability	Lowland pastures	Silting pasture	Silty Sandy glacia pasture	Gravelly glacia pasture	Fields
Very appetee	97.1	64.9	99.6	96.2	88.5
Appetee	1.3	12.6	0.2	0	4.6
Little appetee	1.6	22.3	0.2	3.8	0
Not appetee	0	0.3	0	0	6.9
Total	100	100	100	100	100

CONCLUSION

The inventory works allow for making a comprehensive state of woody vegetation in four representative pastoral areas located from south to the north (South Sudanian, Sudanian, Sahelian and North Sudanian) of Burkina Faso. The results show the great diversity of pastoral areas of South Sudan part from the Sahel. There are on average 10 times more diversity in the South compared to the Sahel. There are many constraints in pastoral areas, but it is worth remembering that in the Sahel, the characteristics of woody forage resources are marked by the degradation of pastures resulting in low density. In pastoral South Sudanian region, the constraints are more related to the management and degradation of pasture vegetation. It is characterized by an invasion of the pastoral zone for food and cash crops production and degradation of units of lowlands, rich in plant diversity. The Sahelian and Sudanian regions are exposed to land pressure and degradation of forage resources. But all the pastoral areas have farmers' organizations who work at different levels for the operation and improvement. Through the strategies put in place it is a real capacity for farmers to meet the challenges of pastoral development areas. Indeed, the example of the pastoral zone of Barani in North Sudanian area with management access to the area should be noted. Indeed, the organization that manages the work in the area could impose some form of financial taxes for those who want to enter and stay in the area. The revenue is used

to facilitate the management of the pastoral zone. It also appears that the state is also absent in the areas especially with development activities and this was particularly noted in areas as Sidéradougou and Ceekol Naggè. The development of the National Pastoral Development Programme should be a springboard to play the state's real role in relation to the national policy on livestock.

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